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Thermodynamic Data to 20 000 K for Monatomic Gases

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June 1999

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National Aeronautics and
Space Administration

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*Arranged alphabetically by chemical symbol.

Summary

This report contains standard-state thermodynamic functions for 50 gaseous atomic elements plus deuterium and electron gas, 51 singly ionized positive ions, and 36 singly ionized negative ions. The data were generated by the NASA Lewis computer program PAC97, a modified version of PAC91 reported in McBride and Gordon (1992).

This report is being published primarily to document part of the data currently being used in several NASA Lewis computer programs. Some earlier reports published for this purpose are McBride et al. (1993a, b). Some Lewis programs that use these data are CEA, a program for performing chemical equilibrium calculations (Gordon and McBride, 1994, and McBride and Gordon, 1996); and LSENS, a general kinetics program (Radhakrishnan and Bittker, 1994).

The data are presented in tabular and graphical form and are also represented in the form of least-squares coefficients. The tables give the data as functions of temperature. The data presented here differ from data previously generated by PAC91 in several respects:

1. More recent input data are used (enthalpies of formation and electronic energy levels).
2. The temperature range is extended to 20 000 K.
3. Thermodynamic functions are fitted in three temperature intervals.
4. The "FILL" procedure has been modified.
5. The fitting technique has been modified.

These changes are discussed in the text.

The problem of divergence of the electronic partition function has been discussed in a number of articles in the literature. The cutoff procedure used in the NASA PAC91 and PAC97 programs for handling the divergence problem was initially reviewed in McBride and Gordon (1967) and is discussed herein again for completeness.

Symbols

a_i	temperature coefficients in eq. (10)
b	coefficient defined in eq. (9)
b_1, b_2	integration constants defined by eqs. (11) and (12)
$C_p^\circ(T)$	molar heat capacity at constant pressure at temperature for standard state, eq. (1)
c	speed of light
c_2	second radiation constant
$G^\circ(T)$	either $\left[G^\circ(T) - H^\circ(0)\right] + H^\circ(0)$ or $\left[G^\circ(T) - H^\circ(298.15)\right] + H^\circ(298.15)$
$G^\circ(T) - H^\circ(0)$	molar Gibbs energy at temperature T relative to enthalpy at 0 K for standard state, eq. (4)
$G^\circ(T) - H^\circ(298.15)$	molar Gibbs energy at temperature T relative to enthalpy at 298.15 K for standard state
$\Delta_f G^\circ(T)$	molar Gibbs energy of formation of a substance at temperature T from its reference elements in their standard state, eq. (19)
g_m	electronic statistical weight for mth electronic state, eq. (7)
$H^\circ(0)$	chemical energy (molar enthalpy) at 0 K for standard state
$H^\circ(298.15)$	assigned molar enthalpy at 298.15 K for standard state (equal to $\Delta_f H^\circ(298.15)$), eq. (13)

$H°(T)$	either $[H°(T) - H°(0)] + H°(0)$, eq. (16) or $[H°(T) - H°(298.15)] + H°(298.15)$, eq. (15)
$H°(T) - H°(0)$	sensible molar enthalpy at temperature T relative to molar enthalpy at 0 K for standard state, eq. (2)
$H°(T) - H°(298.15)$	sensible molar enthalpy at temperature T relative to molar enthalpy at 298.15 K for standard state
$\Delta_f H°(T)$	molar enthalpy of formation (heat of formation) of a substance at temperature T from its reference elements in their standard state, eq. (13)
h	Planck's constant
IP	ionization potential
J_m	total angular momentum quantum number, eq. (7)
K	equilibrium constant, eq. (19)
k	Boltzmann constant
L	total number of electronic states, eqs. (6) and (7)
M	molecular weight
m	running index, eqs. (6) and (7)
m_e	electron mass
m_μ	atomic mass number, eq. (5)
n	principal quantum number, eq. (9)
n_{max}	maximum principal quantum number in Bethe method, eq. (8)
p_o	standard-state pressure, eq. (5)
Q	internal partition function, eqs. (6) and (7)
Q^m	internal partition function for mth electronic state, eq. (6)
Q_e^m	electronic partition function for mth electronic state, eq. (7)
q_i	temperature exponents, eq. (10)
R	universal gas constant
r	number of coefficients of a_i, eq. (10)
S_c	Sackur-Tetrode constant defined by eq. (5)
$S°(T)$	entropy at temperature T for standard state, eq. (3)
T	temperature, K

T_1	temperature, 1 K, eq. (5)
$\varepsilon_{i,\max}$	highest observed electronic energy value for a particular n
ε_m	energy of mth electronic state, eq. (7)

Standard States, Reference States, and Fundamental Constants

The symbols and definitions used in this report follow the recommendations of Cox (1982). All species in this report are in their standard state. For gases this is the ideal gas at the standard pressure of 1 bar (10^5 Pa). All thermodynamic properties are standard molar quantities. See the section Reference Elements for the reference states of the elements.

The properties are given in the International System of Units (SI); that is, the temperatures are in kelvin (K), the energies are in joules (J), and the pressures are in bars. The fundamental constants were taken from Cohen and Taylor (1987) and are as follows:

Quantity	Symbol	Value	Unit
Molar gas constant	R	8.314510	J/(mol·K)
Sackur-Tetrode constant:			
For p_o = 100 000 Pa = 1 bar	S_c/R	–1.151693(21)	
For p_o = 101 325 Pa = 1 atm	S_c/R	–1.164856(21)	
Second radiation constant, hc/k	c_2	–0.01438769(12)	mK
Electron mass	m_e	0.0005485799039(13)	[a]u

[a]Atomic mass unit used for calculating molar masses, 1/12 mass ^{12}C.

The atomic weights were taken from De Laeter and Heumann (1991). A later set of atomic weights was published by Coplen (1996). Coplen's tables show that for six of the elements in this report minor changes were made in atomic weights from previous values given in De Laeter and Heumann (1991). The six elements are aluminum, carbon, cesium, manganese, phosphorus, and sodium. Of these, the most significant change in atomic weight was for carbon from 12.011 to 12.0107 and the next largest change was for cesium from 132.90543 to 132.90545. The changes in atomic weights for the other four elements were one or two units in the sixth decimal place. The change that the newer values of atomic weights make on $S°(T)/R$ and on $-G°(T)/R$ is –0.000037 for C, C^+, and C^- and 0.0000002 for Cs, Cs^+, and Cs^-. The atomic weight for D is taken from Wapstra (1977) and that for e^- is taken from Cohen and Taylor (1987). The weights are given in atomic mass units (u) based on ^{12}C = 12u. Atomic weights used in this report are given in table I and with least-squares coefficients in table B2.

Calculation of Ideal Gas Thermodynamic Functions

For gaseous species the thermodynamic functions may be calculated from spectroscopic constants. The properties are expressed as functions of the internal partition function Q; that is,

$$\frac{C_p^\circ(T)}{R} = T^2 \frac{d^2(\ln Q)}{dT^2} + 2T\frac{d(\ln Q)}{dT} + \frac{5}{2} \tag{1}$$

$$\frac{H^\circ(T) - H^\circ(0)}{RT} = T\frac{d(\ln Q)}{dT} + \frac{5}{2} \tag{2}$$

$$\frac{S^\circ(T)}{R} = T\frac{d(\ln Q)}{dT} + \ln Q + \frac{3}{2}\ln M + \frac{5}{2}\ln T + S_c \tag{3}$$

$$-\frac{G^\circ(T) - H^\circ(0)}{RT} = \frac{S^\circ(T)}{R} - \frac{H^\circ(T) - H^\circ(0)}{RT} = \ln Q + \frac{3}{2}\ln M + \frac{5}{2}\ln T + S_c - \frac{5}{2} \tag{4}$$

where

$$S_c = \frac{5}{2} + \ln\left[\left(\frac{2\pi m_\mu kT_1}{h^2}\right)^{3/2}\frac{kT_1}{p_o}\right] \tag{5}$$

and S_c is the Sackur-Tetrode constant. Other symbols are defined in the section Symbols. When p_o = 100 000 Pa (1 bar), S_c = –1.151693. When p_o = 101 325 bar (1 atm), S_c = 1.164856. Thus, values of $S°(T)/R$ in units of bar will be higher than corresponding values in units of atmosphere by 0.013163. The values for S_c and other fundamental constants are obtained from Cohen and Taylor (1987).

Internal Partition Functions for Monatomic Gases

The internal partition function Q in equations (1) to (4) is given by

$$Q = \sum_{m=1}^{L} Q^m \tag{6}$$

where Q_m is the internal partition function for the mth electronic state and L is the number of electronic states.

For monatomic species the internal energy consists of electronic energy only. Equation (6) then becomes

$$Q = \sum_{m=1}^{L} Q_e^m = \sum (2J_m + 1)e^{-\varepsilon_m/kT} = \sum_{m=1}^{L} g_m e^{-\varepsilon_m/kT} \tag{7}$$

where Q_e^m, J_m, ε_m, and g_m are the electronic partition function, total angular momentum quantum number, electronic energy, and statistical weight, respectively, for the mth electronic state.

Cutoff Methods

An infinite number of bound states exists below the ionization limit for a hypothetical isolated atom ($L = \infty$ in eq. (7)). Inasmuch as the partition function diverges and approaches infinity as $L \to \infty$, the summation must be cut off. Reviews of various cutoff methods may be found in the literature, such as in McChesney (1964) or Gurvich et al. (1989). These cutoff methods may be considered to be of the following types:

1. No dependence on temperature or pressure
2. Dependence on temperature only
3. Dependence on temperature and pressure (or density) and possibly degree of ionization

In the first of the three types the summation may include various numbers of levels. For example, only the ground state is used in the Saha equation (see Zemansky, 1957). The summation may be for all levels included through some selected principal quantum number. For example, in a method that we will refer to herein as "the RUSSIAN method" (Gurvich et al., 1989), only those levels within the principal quantum number of the ground state are included.

The second cutoff type is temperature dependent. One model of this type depends on a "lowered" ionization potential that is a function of temperature only. The partition function is then permitted to include only those levels below the lowered ionization potential. Myers et al. (1961) suggests that ionization potential be lowered by an amount equal to the temperature function kT. This method, which we refer to as "the TEMPER method," is the method that we have used in reports such as McBride et al. (1993a,b). Other temperature functions are summarized in McChesney (1964). A second model, which actually is a function of pressure as well as temperature, can be reduced to a function of temperature only by assigning some fixed pressure, such as 1 atm or 1 bar. An example of this is a model proposed by Bethe and discussed in Gurvich et al. (1967). At 1 atm this model reduces to

$$n_{\max} = 2.461T^{1/6} \tag{8}$$

where $n_{\max}$ is the maximum principal quantum number for any assigned temperature in equation (8). The method that uses equation (8) is referred to herein as the "BETHE method."

The three methods can lead to considerably different calculated results for the thermodynamic data. At this time there is no proof that one or the other of the methods is more nearly correct. Arguments can be made in favor of each of the three methods. Arguments for the RUSSIAN method are given in Gurvich et al. (1989). Their reasoning is that inclusion of electronic energy levels should be consistent for atomic, diatomic, and polyatomic species. If not, "this automatically introduces errors in the values of the equilibrium constants." They also state, "It is almost impossible to take account of the Rydberg electronic states in the partition functions of diatomic and especially polyatomic molecules, as for the majority of molecules there are no data for these states." And finally, "Therefore in this present edition in contrast from the previous one, in the electronic partition function and its derivatives only the valence states of the atoms (ions) are taken into account."

Both the TEMPER method and the BETHE method include energy levels for principal quantum numbers in addition to that of the ground state. The BETHE method includes more levels as temperature increases, whereas the TEMPER method includes fewer levels as temperature increases. Thus, the BETHE method results in a wider distribution of electrons over a set of energy levels with increasing temperature as opposed to the narrower distribution that results from the TEMPER method. The wider distribution is what would be expected from fundamental Boltzmann distribution principles.

The TEMPER method lowers the ionization potential as temperature increases, thus resulting in fewer energy levels being used with increasing temperature. This effect of fewer levels with increasing temperature is consistent with a chemical equilibrium model that includes Debye-Huckel plasma effects. The plasma causes a lowering of the ionization potential. Increasing temperature results in increasing amounts of ionization and plasma and therefore more lowering of the ionization potential with fewer levels being used. An example of a calculation that includes Debye-Huckel effects is given in Heimel (1971).

Calculated results using the three methods RUSSIAN, BETHE, and TEMPER are compared in the next main section to illustrate the possibly large differences in heat capacity that can be obtained.

Inclusion of Predicted Levels

In addition to the divergence problem there is the problem of whether to include observed energy levels only or to also include levels for predicted terms that, so far, have not been observed. From atomic theory, as presented in texts such as Herzberg (1944), predicted terms can be derived. These terms can be found, for example, in Herzberg (1944) and in Moore (1971). An examination of the tabulated observed terms in references such as Moore (1971) shows that many predicted terms are missing, especially for the higher quantum numbers. It has been shown that various series of levels can be represented by formulas such as the Rydberg or the Rydberg-Ritz formulas (e.g., Kuhn, 1962). An alternative but simpler technique for filling in unobserved levels was described in McBride and Gordon (1967), which gives essentially the same results as using the Rydberg-Ritz equations. This alternative technique is described next, and then a modification of the technique that is used in the current report is presented.

By examining the statistical weights g_i corresponding to predicted terms, it was determined that for a number of species the sum of the statistical weights could be expressed by the following simple function of the principal quantum number n (except for the ground-state n for most species):

$$\sum g_i = \sum \left(2J_i + 1\right) = bn^2 \tag{9}$$

Equation (9) applies only to terms arising from excitation of the emission electron and does not account for other possible terms. McBride and Gordon (1967) gives values for b and for $\sum g_i$ for the ground state for the first 20 elements. Values for elements 19 and 20 were corrected by Downey (1978), who extended the table to include all of the first 86 elements except for the lanthanide series (elements 58 through 71). The total quantum number above the ground state is given as a function of n in equation (9). However, Downey (1978) recommended that for some elements the total quantum number above the ground state should be taken as a constant value (called c^*, defined in table I) for all values of n. The Downey table is given in this report as table I.

The usefulness of equation (9) arises from the fact that including an unobserved level generally makes considerably more difference than a small error in the estimated energy for this level. McBride and Gordon (1967) used a simple procedure to include the unobserved levels. The computer program provides an option, referred to as "FILL," to determine for each n the difference in statistical weight sums between the observed levels that have been read in as input and that given by equation (9) or c^*. The program then assigns to this difference the highest observed level for the corresponding n and includes it with the observed levels.

However, the FILL option may overcompensate somewhat for the missing levels, especially at high temperatures. Therefore, the FILL option has been modified as follows:

1. For each n the difference DIF1 = $IP - \varepsilon_{i,\max}$ is calculated, where IP is the ionization potential and $\varepsilon_{i,\max}$ is the highest known energy value for that n.
2. The theoretical sum of the statistical weights $\sum g_i(\text{theor})$ can be obtained from either equation (9), $\sum g_i$ for the ground state, or the constant c^*. The difference between the theoretical sum and the actual sum for each n is calculated as follows: DIF2 = $\sum g_i(\text{theor}) - \sum g_i(\text{act})$
3. DIF1 and DIF2 are each divided by an optional factor NAL. For this report a value of NAL = 50 was used.
4. The resulting value of DIF1/NAL is added successively to $\varepsilon_{i,\max}$ until the IP value is reached. Each of these new estimated energy values is assigned the statistical weight of DIF2/NAL.

Comparison of Results Using Different Methods

For most of the species in this report there is good to excellent agreement among the three methods (RUSSIAN, BETHE, and TEMPER) in the calculated values of thermodynamic data in the temperature range 200 to 5000 or 6000 K. This temperature range covers the usual combustion problems. For example, the following are some typical maximum combustion temperatures for three types of propellant:

Propellant	Approximate maximum temperature, K
Jet fuels with air (aircraft)	2500
H_2 with O_2 (rocket upper stage)	3500
H_2 with F_2 (high-performance rocket propellant)	5400

For stoichiometric hydrocarbon-air combustion the principal atomic species among the combustion products are argon, hydrogen, and oxygen. For these three species values of $C_p^\circ(T)/R$ are identical to four decimal places in the temperature range 200 to 6000 K for all three methods with FILL or NOFILL. Therefore, in this temperature range one obtains the same combustion properties by using data obtained from any of the three methods.

However, in the high-temperature range 6000 to 20 000 K, which is the third temperature range over which our calculated data are fitted, for many species there are large differences in the data calculated by the three methods especially for the FILL option with the BETHE method. This situation is illustrated in figure 1 for aluminum. At 12 000 K for example, the calculated values of $C_p^\circ(T)/R$ are 9.4, 6.5, 4.0, and 3.5 for the BETHE (FILL), BETHE (NOFILL), TEMPER (FILL or NOFILL), and RUSSIAN (FILL or NOFILL) methods, respectively. In general, data calculated by the TEMPER method used in this report lie between the values obtained by the BETHE and RUSSIAN methods.

Sources for Input Data

Several principal sources were used to obtain the spectroscopic and enthalpy of formation data needed to perform the calculations. These sources are as follows: Moore (1970a,b), Moore (1971), Sugar and Corliss (1985), Chase et al. (1985), Cox et al. (1989), Gurvich et al. (1982, 1989), and Hotop and Lineberger (1985). Spectroscopic data for a number of species were taken from various articles in the Journal of Physical and Chemical Reference Data.

Empirical Equations for Fitting Thermodynamic Functions

Thermodynamic data for many species can be conveniently stored for use with computer programs in the form of coefficients associated with equations that fit the data. The following dimensionless form of $C_p^\circ(T)/R$ was chosen for this report:

$$\frac{C_p^\circ(T)}{R} = \sum_{i=1}^{r} a_i T^{q_i} \tag{10}$$

where $r = 7$ and the values of q_i are –2, 1, 0, 1, 2, 3, and 4. This form for $C_p^\circ(T)/R$ is the form used in the current version of the NASA Lewis Chemical Equilibrium Program (Gordon and McBride, 1994, and McBride and Gordon, 1996). Enthalpy and entropy are related thermodynamically to $C_p^\circ(T)$ as follows:

$$\frac{H^\circ(T)}{RT} = \frac{b_1}{T} + \frac{\int C_p^\circ(T)dT}{RT} \tag{11}$$

$$\frac{S^\circ(T)}{R} = b_2 + \int\left(\frac{C_p^\circ(T)}{RT}\right)dT \tag{12}$$

where b_1 and b_2 are integration constants. These are two additional coefficients to the seven coefficients in equation (10). Equations (10) to (12) are given again in appendix B (table B1) along with a listing of the least-squares coefficients (table B2) and a description of the format for these coefficients.

Reference Elements

A set of reference elements must be specified in order for enthalpies of formation and equilibrium constants to be unambiguously related to specific reactions. The reference elements for the species in this report are Ag(c), Al(c), Ar, B(c), Ba(c), Be(c), Bi(c), Br_2(c), C(c), Ca(c), Cd(c), Cl_2, Co(c), Cr(c), Cu(c), D_2, e^-, F_2, Fe(c), Ge(c), H_2, He, Hg(c), I_2(c), K(c), Kr, Li(c), Mg(c), Mn(c), Mo(c), N_2, Na(c), Nb(c), Ne, Ni(c), O_2, P(c), Pb(c), Rb(c), Rn, S(c), Sc(c), Sn(c), Sr(c), Ta(c), Ti(c), V(c), W(c), Xe, Zn(c), and Zr(c). The symbol (c) following the chemical symbol indicates a condensed phase. Those chemical symbols with no (c) following them are gases. With the exception of the inert gas Rn and Sc(c), data for the listed species are given in McBride et al. (1993a). Data for Rn are calculated in this report and data for Sc(c) were taken from Gurvich et al. (1982). Data for the other inert reference elements,

namely Ar, He, Kr, Ne, and Xe, were calculated and/or processed in this report with a somewhat different procedure than that used in McBride et al. (1993a). The phase for most of the reference elements is the condensed phase, with the same element often having several condensed phases, such as solid and liquid. The various phases for the reference elements and the temperature intervals for which they apply are also given in McBride et al. (1993a).

Assigned Enthalpy Values

For some applications, such as those discussed in Gordon and McBride (1976), it is convenient to combine sensible enthalpies and energies of chemical and physical changes into one numerical value. An arbitrary base may be adopted for assigning absolute values to the enthalpy of various substances inasmuch as only differences in enthalpies are measurable. For many years we have been selecting the arbitrary enthalpy base to be zero at 298.15 K for a set of reference elements such as those discussed in the previous section. Thus, for the assigned reference elements

$$\Delta_f H^\circ(298.15) = H^\circ(298.15) = 0 \tag{13}$$

And, in general, for all species

$$H^\circ(298.15) = \Delta_f H^\circ(298.15) \tag{14}$$

$$H^\circ(T) = H^\circ(298.15) + \left\{H^\circ(T) - H^\circ(298.15)\right\} \tag{15}$$

or

$$H^\circ(T) = H^\circ(0) + \left\{H^\circ(T) - H^\circ(0)\right\} \tag{16}$$

Enthalpies of Formation and Equilibrium Constants

Enthalpies of formation and $\log_{10} K$ for a species are calculated as a function of temperature for the formation of the species from the elements in their assigned reference states. The following is an example of how these properties can be calculated for N(g) at 1000 K:

$$\Delta_f H^\circ(1000) = H^\circ(1000)\mathrm{N}(g) - 1/2 H^\circ(1000)\mathrm{N}_2(g) \tag{17}$$

$$\Delta_f G^\circ(1000) = G^\circ(1000)\mathrm{N}(g) - 1/2 G^\circ(1000)\mathrm{N}_2(g) \tag{18}$$

By definition,

$$\log_{10} K = \frac{-\Delta_f G^\circ(T)}{2.3025851RT} \tag{19}$$

Least-Squares Coefficients

For most of the species in this report the coefficients in equations (10) to (12) were obtained by means of a least-squares fit using PAC97 (a modified version of PAC91 described in McBride and Gordon, 1992). For some species $C_p^\circ(T)/R$ is constant (2.5) over the entire temperature range, and for some others it is constant for some temperature intervals. For temperature ranges where $C_p^\circ(T)/R$ is constant the least-squares procedure was not used. Three sets of coefficients are generated to cover the temperature

range 200 (or 298.15 for ionized species) to 20 000 K. The intervals for these three sets are 200 (or 298.15 for ionized species) to 1000 K, 1000 to 6000 K, and 6000 to 20 000 K. In previous reports (e.g., McBride et al., 1993b) the functions $C_p^\circ(T)/R$, $H^\circ(T)/R$, and $S^\circ(T)/R$ were fitted simultaneously as recommended by Zeleznik and Gordon (1961). However, at the high temperatures for which data are calculated in this report, significant discontinuities in heat capacity occur with the TEMPER method, making it impossible to fit all three functions simultaneously. Therefore, in this report only $C_p^\circ(T)/R$ is least-squares fitted while $H^\circ(T)/R$ and $S^\circ(T)/R$ are obtained by integration using the $C_p^\circ(T)/R$ coefficients and the integration constants b_1 and b_2. The fit is constrained so that the coefficients reproduce the identical values at the common interval temperatures of 1000 and 6000 K. The fit was also constrained to match the original functions exactly at 298.15 K. Thus, the least-squares coefficients reproduce enthalpies of formation at 298.15 K exactly.

The discontinuities also necessitated a modification of the fitting technique. This modified technique is illustrated in figures 2 and 3. Figure 2 shows the initial results of a calculation for the properties of aluminum from 3000 to 24 000 K using the TEMPER method with FILL (NAL = 50). (Initial calculations were occasionally extended past 20 000 K to get a better fit for extrapolation purposes.) The discontinuities are obvious in the temperature range above about 5000 K. The next step in the modified technique is to combine part of the initial results at the lower temperatures, where there are no discontinuities, with the fitted data at the higher temperatures where the discontinuities do occur. The temperature at which they are combined is one in which the differences in the two sets of data are small. For aluminum the data are combined at 4900 K. The combined set of data is now referred to as "NASA Lewis data." These NASA Lewis data are then least-squares fitted to obtain the final set of least-squares coefficients. Figure 3 shows the final results of the NASA Lewis data and the fit to these data.

Discussion of Tables and Appendixes

Table I, containing FILL procedure parameters, was previously discussed in the section Inclusion of Predicted Levels. The thermodynamic data for all the species in this report are given in tables II, III, and IV and appendixes A, B, and C, which include tables A1 through A139, B1, and B2. In these tables and appendixes the species are arranged in order of chemical symbol with Ag being the first. For any element the neutral species is followed by the corresponding positively ionized species and then the negatively ionized species (if it exists).

Table II contains a summary of the thermodynamic functions at 298.15 K for all the species in this report. Included in this table are the chemical symbols, atomic number, atomic weight, $H^\circ(298.15)$, $H^\circ(298.15)-H^\circ(0)$, $C_p^\circ(298.15)$, and $S^\circ(298.15)$.

Table III contains data for the ionization potentials and electron affinities (where available) of the neutral species used in forming the first positively ionized species and the negatively ionized species. The values for the ionization potentials are given in centimeters^{-1} and kilojoules; the values for the electron affinities are in electron volts and kilojoules. Also given in this table are values for the assigned enthalpy at 0 K [$H^\circ(0)$].

Table IV gives the references for the ionization potentials and electron affinity values given in table III. Also given are references for the electronic energy levels used in the calculations and for the enthalpies of formation used to relate the neutral atomic species to their corresponding reference element (McBride et al., 1993a).

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TABLE I.—FILL PROCEDURE PARAMETERS

Atomic number	Chemical symbol	$\sum_i g_i$	*b* (or *c**)	Atomic number	Chemical symbol	$\sum_i g_i$	*b* (or *c**)
1	H	2	2	38	Sr	670	4
2	He	1	4	39	Y	1260	[a]1170
3	Li	8	2	40	Zr	3855	[a]3780
4	Be	13	4	41	Nb	7992	[a]8100
5	B	6	2	42	Mo	11676	[a]12096
6	C	15	12	43	Tc	12216	[a]12852
7	N	20	30	44	Ru	9135	[a]9720
8	O	15	40	45	Rh	4780	[a]5130
9	F	6	30	46	Pd	1666	[a]1800
10	Ne	1	12	47	Ag	394	2
11	Na	18	2	48	Cd	125	4
12	Mg	33	4	49	In	92	2
13	Al	16	2	50	Sn	351	12
14	Si	75	12	51	Sb	860	30
15	P	170	30	52	Te	1135	40
16	S	215	40	53	I	846	30
17	Cl	156	30	54	Xe	337	12
18	Ar	61	12	55	Cs	124	2
19	K	42	2	56	Ba	1138	4
20	Ca	426	4	57	La	2200	[a]1170
21	Sc	1260	[a]1170	Lanthanide series-4f shell filled			
22	Ti	3855	[a]3780	72	Hf	3855	[a]3780
23	V	7992	[a]8100	73	Ta	7992	[a]8100
24	Cr	11676	[a]12096	74	W	11676	[a]12096
25	Mn	12216	[a]12852	75	Re	12216	[a]12852
26	Fe	9135	[a]9720	76	Os	9135	[a]9720
27	Co	4780	[a]5130	77	Ir	4780	[a]5130
28	Ni	1666	[a]1800	78	Pt	1666	[a]1800
29	Cu	362	2	79	Au	434	2
30	Zn	61	4	80	Hg	205	4
31	Ga	30	2	81	Tl	132	2
32	Ge	159	12	82	Pb	591	12
33	As	380	30	83	Bi	1460	30
34	Se	495	40	84	Po	1935	40
35	Br	366	30	85	At	1446	30
36	Kr	145	12	86	Rn	577	12
37	Rb	74	2				

[a]This is the *c** value which represents the total quantum weight for each value of *n* above the ground state principal quantum number. In BLOCK DATA, these values are given as negative values in order for the PAC91 program to differentiate the *b* values from the *c** values.

TABLE II.—THERMODYNAMIC FUNCTIONS AT 298.15 K

Table No.	Atom	Atomic No.	Atomic Weight	$\Delta_f H^\circ$ kJ/mol	$H^\circ - H^\circ(0)$ kJ/mol	C_p° J/mol·K	S° J/mol·K
A1	Ag	47	107.8682	284.9	6.1974	20.786	172.998
A2	Ag^+		107.8676514	1022.0937	6.1975	20.792	167.236
A3	Ag^-		107.8687486	153.0787	6.1974	20.786	167.235
A4	AL	13	26.981539	330.0	6.9187	21.391	164.555
A5	AL^+		26.9809904	913.0151	6.1974	20.786	149.952
A6	AL^-		26.9820876	281.0901	6.7562	20.960	168.137
A7	Ar	18	39.948	0.0	6.1974	20.786	154.847
A8	Ar^+		39.9474514	1526.7784	6.2060	20.984	166.406
A9	B	5	10.811	575.5988	6.3161	20.797	153.438
A10	B^+		10.8104514	1382.3155	6.1974	20.786	138.545
A11	B^-		10.8115486	542.6315	6.2726	20.788	156.814
A12	Ba	56	137.327	185.	6.1974	20.786	170.247
A13	Ba^+		137.3264514	694.0495	6.1974	20.786	176.010
A14	Be	4	9.012182	324.	6.1974	20.786	136.276
A15	Be^+		9.0116334	1229.7013	6.1974	20.786	142.039
A16	Br	35	79.904	111.87	6.1974	20.786	175.019
A17	Br^+		79.9034514	1257.9270	6.1974	20.787	176.874
A18	Br^-		79.9045486	–219.0005	6.1974	20.786	163.493
A19	C	6	12.011	716.68	6.5359	20.839	158.102
A20	C^+		12.0104514	1809.4445	6.6493	20.974	154.664
A21	C^-		12.0115486	588.3142	6.2188	20.787	159.004
A22	Ca	20	40.078	177.8	6.1974	20.786	154.887
A23	Ca^+		40.0774514	773.8277	6.1974	20.786	160.650
A24	Cd	48	112.411	111.80	6.1974	20.786	167.750
A25	Cd^+		112.4104514	985.7543	6.1974	20.786	173.513
A26	CL	17	35.4527	121.301	6.2716	21.838	165.192
A27	CL^+		35.4521514	1378.7996	6.3863	22.959	167.558
A28	CL^-		35.4532486	–233.9580	6.1974	20.786	153.358
A29	Co	27	58.93320	428.4416	6.3598	23.024	179.520
A30	Co^+		58.9326514	1193.0033	6.2915	22.271	178.348
A31	Co^-		58.9337486	358.4144	6.3068	22.439	178.414
A32	Cr	24	51.9961	397.48	6.1974	20.786	174.313
A33	Cr^+		51.9955514	1056.5467	6.1974	20.786	173.032
A34	Cr^-		51.9966486	327.0234	6.1974	20.786	173.032
A35	Cs	55	132.90543	76.5	6.1974	20.786	175.602
A36	Cs^+		132.9048814	458.4018	6.1974	20.786	169.838
A37	Cs^-		132.9059786	24.7972	6.1974	20.786	169.839
A38	Cu	29	63.546	337.4	6.1974	20.786	166.399
A39	Cu^+		63.5454514	1089.0797	6.1974	20.786	160.636
A40	Cu^-		63.5465486	212.7186	6.1974	20.786	160.636
A41	D	1	2.014102	221.7202	6.1974	20.786	123.352
A42	D^+		2.0135534	1540.3243	6.1974	20.786	117.585
A43	D^-		2.0146506	142.7527	6.1974	20.786	117.592

TABLE II.—THERMODYNAMIC FUNCTIONS AT 298.15 K (Continued)

Table No.	Atom	Atomic No.	Atomic Weight	$\Delta_f H°$ kJ/mol	$H°–H°(0)$ kJ/mol	$C_p°$ J/mol·K	$S°$ J/mol·K
A44	e^-	0	0.000548579903	0.0	6.1974	20.786	20.979
A45	F	9	18.9984032	79.38	6.5185	22.747	158.752
A46	F^+		18.9978546	1766.8163	6.7107	23.497	161.730
A47	F^-		18.9989518	–255.0921	6.1974	20.786	145.578
A48	Fe	26	55.845	415.471	6.8503	25.675	180.490
A49	Fe^+		55.8444514	1184.2178	6.9357	26.068	181.858
A50	Fe^-		55.8455486	393.3380	6.6418	25.023	180.200
A51	Ge	32	72.61	367.8	7.3986	30.733	167.909
A52	Ge^+		72.6094514	1134.9844	6.2058	21.025	168.093
A53	Ge^-		72.6105486	245.4025	6.9809	21.985	180.831
A54	H	1	1.00794	217.9988	6.1974	20.786	114.718
A55	H^+		1.0073914	1536.2459	6.1974	20.786	108.948
A56	H^-		1.0084886	139.0313	6.1974	20.786	108.961
A57	He	2	4.002602	0.0	6.1974	20.786	126.154
A58	He^+		4.0020534	2378.5215	6.1974	20.786	131.915
A59	Hg	80	200.59	61.38	6.1974	20.786	174.972
A60	Hg^+		200.5894514	1074.6431	6.1974	20.786	180.735
A61	I	53	126.90447	106.76	6.1974	20.786	180.789
A62	I^+		126.9039214	1121.3510	6.1974	20.786	182.644
A63	I^-		126.9050186	–194.5956	6.1974	20.786	169.262
A64	K	19	39.0983	89.0	6.1974	20.786	160.342
A65	K^+		39.0977514	514.0075	6.1974	20.786	154.578
A66	K^-		39.0988486	34.4181	6.1974	20.786	154.579
A67	Kr	36	83.80	0.0	6.1974	20.786	164.086
A68	Kr^+		83.7994514	1356.9539	6.1974	20.786	175.613
A69	Li	3	6.941	159.3	6.1974	20.786	138.783
A70	Li^+		6.9404514	685.7194	6.1974	20.786	133.018
A71	Li^-		6.9415486	93.4747	6.1974	20.786	133.020
A72	Mg	12	24.3050	147.1	6.1974	20.786	148.649
A73	Mg^+		24.3044514	891.0470	6.1974	20.786	154.412
A74	Mn	25	54.93805	282.40	6.1974	20.786	173.718
A75	Mn^+		54.9375014	1005.8713	6.1974	20.786	175.000
A76	Mo	42	95.94	658.50	6.1974	20.786	181.953
A77	Mo^+		95.9394514	1349.0129	6.1974	20.786	180.671
A78	Mo^-		95.9405486	580.3246	6.1974	20.786	180.671
A79	N	7	14.00674	472.68	6.1974	20.786	153.302
A80	N^+		14.0061914	1882.1276	7.1165	21.285	159.799
A81	N^-		14.0072886	473.5375	6.4983	21.009	159.930
A82	Na	11	22.989768	107.5	6.1974	20.786	153.719
A83	Na^+		22.9892194	609.5429	6.1974	20.786	147.955
A84	Na^-		22.9903166	48.4534	6.1974	20.786	147.956

TABLE II.—THERMODYNAMIC FUNCTIONS AT 298.15 K (Continued)

Table No.	Atom	Atomic No.	Atomic Weight	$\Delta_f H°$ kJ/mol	$H°–H°(0)$ kJ/mol	$C_p°$ J/mol·K	$S°$ J/mol·K
A85	Nb	41	92.90638	723.1131	8.3541	30.159	186.262
A86	Nb^+		92.9058314	1393.6047	8.5891	30.291	182.978
A87	Nb^-		92.9069286	631.0540	8.6538	28.948	186.097
A88	Ne	10	20.1797	0.0	6.1974	20.786	146.330
A89	Ne^+		20.1791514	2086.9659	6.3042	22.120	158.310
A90	Ni	28	58.6934	430.1166	6.8250	23.361	182.193
A91	Ni^+		58.6928514	1172.5946	6.2058	20.990	174.574
A92	Ni^-		58.6939486	311.7644	6.2072	21.018	174.580
A93	O	8	15.9994	249.1750	6.7254	21.912	161.060
A94	O^+		15.9988514	1568.7872	6.1974	20.786	154.961
A95	O^-		15.9999486	101.8462	6.5708	21.685	157.797
A96	P	15	30.973762	316.5	6.1974	20.786	163.200
A97	P^+		30.9732134	1336.4535	8.1419	25.859	166.971
A98	P^-		30.9743106	238.8268	6.7479	22.169	169.126
A99	Pb	82	207.2	195.2	6.1974	20.786	175.377
A100	Pb^+		207.1994514	916.9965	6.1974	20.786	181.140
A101	Pb^-		207.2005486	153.8819	6.1974	20.786	186.903
A102	Rb	37	85.4678	80.9	6.1974	20.786	170.095
A103	Rb^+		85.4672514	490.1291	6.1974	20.786	164.332
A104	Rb^-		85.4683486	27.8185	6.1974	20.786	164.332
A105	Rn	86	222.0176	0.0	6.1974	20.786	176.238
A106	Rn^+		222.0170514	1043.2703	6.1974	20.786	187.764
A107	S	16	32.066	277.17	6.6574	23.674	167.832
A108	S^+		32.0654514	1282.4964	6.1974	20.786	163.632
A109	S^-		32.0665486	70.3685	6.4649	22.783	164.923
A110	Sc	21	44.95591	377.7003	7.0023	22.103	174.788
A111	Sc^+		44.9553614	1017.1452	7.1619	21.762	178.338
A112	Sc^-		44.9564586	352.5588	6.1974	20.786	187.196
A113	Si	14	28.0855	450.	7.5503	22.251	167.982
A114	Si^+		28.0849514	1242.5080	7.3429	24.336	163.429
A115	Si^-		28.0860486	308.8175	6.1974	20.786	161.979
A116	Sn	50	118.710	301.2	6.2147	21.260	168.495
A117	Sn^+		118.7094514	1015.9499	6.1974	20.786	174.193
A118	Sn^-		118.7105486	179.4959	6.4904	24.464	181.197
A119	Sr	38	87.62	160.5	6.1974	20.786	164.642
A120	Sr^+		87.6194514	716.1663	6.1974	20.786	170.405
A121	Ta	73	180.9479	782.5186	6.1996	20.858	185.221
A122	Ta^+		180.9473514	1549.6793	6.3378	23.109	183.387
A123	Ta^-		180.9484486	745.4694	6.4161	24.561	174.563
A124	Ti	22	47.867	473.	7.5391	24.430	180.296
A125	Ti^+		47.8664514	1137.6240	7.8998	26.186	183.591
A126	Ti^-		47.8675486	459.2038	7.5626	22.835	183.714

TABLE II.—THERMODYNAMIC FUNCTIONS AT 298.15 K (Concluded)

Table No.	Atom	Atomic No.	Atomic Weight	$\Delta_f H°$ kJ/mol	$H°–H°(0)$ kJ/mol	$C_p°$ J/mol·K	$S°$ J/mol·K
A127	V	23	50.9415	517.2671	7.9071	26.012	182.301
A128	V^+		50.9409514	1173.7454	7.8978	23.150	183.378
A129	V^-		50.9420486	460.3861	7.8783	23.049	183.438
A130	W	74	183.84	851.2435	6.2165	21.306	173.957
A131	W^+		183.8394514	1627.8410	6.2213	21.372	179.739
A132	W^-		183.8405486	766.3915	6.1974	20.786	188.782
A133	Xe	54	131.29	0.0	6.1974	20.786	169.686
A134	Xe^+		131.2894514	1176.5522	6.1974	20.786	181.212
A135	Zn	30	65.39	130.40	6.1974	20.786	160.993
A136	Zn^+		65.3894514	1043.0001	6.1974	20.786	166.756
A137	Zr	40	91.224	599.3186	6.8156	26.642	181.346
A138	Zr^+		91.2234514	1246.2463	7.4719	28.283	183.642
A139	Zr^-		91.2245486	552.9524	7.7495	28.693	185.765

TABLE III.—IONIZATION POTENTIALS, ELECTRON AFFINITIES, AND ASSIGNED ENTHALPIES AT 0 K

Table No.	Atom	Atomic No.	Ionization Potential cm^{-1}	Ionization Potential kJ/mol	Electron Affinity eV	Electron Affinity kJ/mol	$H°(0)$ kJ/mol
A1	Ag	47	61106.50	730.9962			278.7026
A2	Ag^+		173300.				1015.8962
A3	Ag^-				1.302	125.6239	146.8813
A4	AL	13	48278.480	577.5390			323.0813
A5	AL^+		151862.5				906.8177
A6	AL^-				0.441	42.5500	274.3339
A7	Ar	18	127109.9	1520.5724			–6.1974
A8	Ar^+		222848.2				1520.5724
A9	B	5	66928.10	800.6380			569.2827
A10	B^+		202887.4				1376.1181
A11	B^-				0.277	26.7264	536.3589
A12	Ba	56	42035.14	502.8521			178.8026
A13	Ba^+		80686.87				687.8521
A14	Be	4	75192.64	899.5039			317.8026
A15	Be^+		146882.86				1223.5039
A16	Br	35	95284.8	1139.8596			105.6726
A17	Br^+		175870.				1251.7296
A18	Br^-				3.365	324.6731	–225.1979
A19	C	6	90820.42	1086.4537			710.1441
A20	C^+		196664.7				1802.7952
A21	C^-				1.2629	121.8513	582.0954
A22	Ca	20	49305.95	589.8303			171.6026
A23	Ca^+		95751.87				767.6303
A24	Cd	48	72538.8	867.7569			105.6026
A25	Cd^+		136374.74				979.5569
A26	CL	17	104591.0	1251.1865			115.0294
A27	CL^+		192070.				1372.4133
A28	CL^-				3.617	348.9874	–240.1554
A29	Co	27	63400.	758.4326			422.0818
A30	Co^+		137795.				1186.7118
A31	Co^-				0.661	63.7768	352.1076
A32	Cr	24	54575.6	652.8693			391.2826
A33	Cr^+		132966.				1050.3493
A34	Cr^-				0.666	64.2592	320.8260
A35	Cs	55	31406.432	375.7044			70.3026
A36	Cs^+		202263.				452.2044
A37	Cs^-				0.471630	45.5054	18.5998
A38	Cu	29	62317.44	745.4823			331.2026
A39	Cu^+		163669.2				1082.8823
A40	Cu^-				1.228	118.4840	206.5212
A41	D	1	109708.608	1312.4067			215.5228
A42	D^+						1534.1269
A43	D^-				0.754209	72.7701	136.5553

TABLE III.—IONIZATION POTENTIALS, ELECTRON AFFINITIES, AND ASSIGNED ENTHALPIES AT 0 K (Continued)

Table No.	Atom	Atomic No.	Ionization Potential cm^{-1}	Ionization Potential kJ/mol	Electron Affinity eV	Electron Affinity kJ/mol	$H°(0)$ kJ/mol
A44	e^-	0					–6.1974
A45	F	9	140524.5	1681.0467			72.8615
A46	F^+		282058.6				1760.1056
A47	F^-				3.399	327.9536	–261.2895
A48	Fe	26	63737.	762.4640			408.6207
A49	Fe^+		130563.0				1177.2821
A50	Fe^-				0.163	15.7271	386.6962
A51	Ge	32	63713.24	762.1798			360.4014
A52	Ge^+		128521.3				1128.7786
A53	Ge^-				1.2	115.7824	238.4216
A54	H	1	109678.764	1312.0497			211.8014
A55	H^+						1530.0485
A56	H^-				0.754209	72.7701	132.8339
A57	He	2	198310.76	2372.3240			–6.1974
A58	He^+		438908.85				2372.3240
A59	Hg	80	84184.1	1007.0657			55.1826
A60	Hg^+		151280.				1068.4457
A61	I	53	84295.1	1008.3936			100.5626
A62	I^+		154304.				1115.1536
A63	I^-				3.0591	295.1582	–200.7930
A64	K	19	35009.8140	418.8101			82.8026
A65	K^+		255100.				507.8101
A66	K^-				0.50147	48.3845	28.2207
A67	Kr	36	112914.40	1350.7565			–6.1974
A68	Kr^+		196475.4				1350.7565
A69	Li	3	43487.15	520.2220			153.1026
A70	Li^+		610079.0				679.5220
A71	Li^-				0.6180	59.6279	87.2773
A72	Mg	12	61671.05	737.7498			140.9026
A73	Mg^+		121267.64				884.8496
A74	Mn	25	59959.4	717.2739			276.2026
A75	Mn^+		126145.0				999.6739
A76	Mo	42	57204.3	684.3155			652.3026
A77	Mo^+		130300.				1342.8155
A78	Mo^-				0.746	71.9780	574.1272
A79	N	7	117225.7	1402.3311			466.4826
A80	N^+		238750.50				1875.0111
A81	N^-				–0.07	–6.7540	467.0392
A82	Na	11	41449.44	495.8455			101.3026
A83	Na^+		381390.2				603.3455
A84	Na^-				0.547930	52.8672	42.2560

TABLE III.—IONIZATION POTENTIALS, ELECTRON AFFINITIES, AND ASSIGNED ENTHALPIES AT 0 K (Continued)

Table No.	Atom	Atomic No.	Ionization Potential cm^{-1}	Ionization Potential kJ/mol	Electron Affinity eV	Electron Affinity kJ/mol	$H^\circ(0)$ kJ/mol
A85	Nb	41	55511.	664.0592			714.7590
A86	Nb^+		115500.				1385.0156
A87	Nb^-				0.893	86.1614	622.4002
A88	Ne	10	173929.70	2080.6617			–6.1974
A89	Ne^+		330391.0				2080.6617
A90	Ni	28	61600.	736.8998			423.2916
A91	Ni^+		146541.56				1166.3888
A92	Ni^-				1.156	111.5370	305.5572
A93	O	8	109837.02	1313.9428			242.4496
A94	O^+		283270.9				1562.5898
A95	O^-				1.4611215	140.9768	95.2754
A96	P	15	84580.83	1011.8116			310.3026
A97	P^+		159451.5				1328.3116
A98	P^-				0.7465	72.0263	232.0789
A99	Pb	82	59819.4	715.5991			189.0026
A100	Pb^+		121243.				910.7991
A101	Pb^-				0.364	35.1207	147.6845
A102	Rb	37	33690.81	403.0317			74.7026
A103	Rb^+		220048.				483.9317
A104	Rb^-				0.48592	46.8841	21.6211
A105	Rn	86	86692.5	1037.0728			–6.1974
A106	Rn^+						1037.0728
A107	S	16	83559.1	999.5890			270.5126
A108	S^+		188232.7				1276.2990
A109	S^-				2.077120	200.4116	63.9036
A110	Sc	21	52922.0	633.0879			370.6980
A111	Sc^+		103237.1				1009.9833
A112	Sc^-				0.188	18.1392	346.3614
A113	Si	14	65747.76	786.5180			442.4497
A114	Si^+		131838.14				1235.1651
A115	Si^-				1.385	133.6322	302.6201
A116	Sn	50	59231.8	708.5698			294.9853
A117	Sn^+		118017.0				1009.7525
A118	Sn^-				1.2	115.7824	173.0055
A119	Sr	38	45932.0	549.4689			154.3026
A120	Sr^+		88964.0				709.9689
A121	Ta	73	63600.	760.8251			776.3190
A122	Ta^+		130700.				1543.3415
A123	Ta^-				0.322	31.0683	739.0533
A124	Ti	22	55010.	658.0659			465.4609
A125	Ti^+		109494.				1129.7242
A126	Ti^-				0.079	7.6223	451.6412

TABLE III.—IONIZATION POTENTIALS, ELECTRON AFFINITIES, AND ASSIGNED ENTHALPIES AT 0 K (Concluded)

Table No.	Atom	Atomic No.	Ionization Potential cm^{-1}	Ionization Potential kJ/mol	Electron Affinity eV	Electron Affinity kJ/mol	$H°(0)$ kJ/mol
A127	V	23	54360.	650.2902			509.3600
A128	V^+		118200.				1165.8476
A129	V^-				0.525	50.6548	452.5078
A130	W	74	64400.	770.3953			845.0270
A131	W^+		142760.				1621.6197
A132	W^-				0.815	78.6355	760.1941
A133	Xe	54	97834.0	1170.3548			–6.1974
A134	Xe^+		171068.4				1170.3548
A135	Zn	30	75769.33	906.4027			124.2026
A136	Zn^+		144892.6				1036.8027
A137	Zr	40	53506.0	640.0740			592.5030
A138	Zr^+		105900.				1238.7744
A139	Zr^-				0.426	41.1027	545.2029

TABLE IV.—REFERENCES FOR ELECTRONIC ENERGY LEVELS, IONIZATION POTENTIALS, ELECTRON AFFINITIES, AND ENTHALPIES OF FORMATION AT 298.15 K

Table No.	Atom	Electronic Energy Levels	Ionization Potential	Electron Affinity	$\Delta_f H°(298.15)$
A1	Ag	Moore,1971	Moore,1971		Cox,1989
A2	Ag^+	Moore,1971	Moore,1971		
A3	Ag^-			Hotop,1985	
A4	AL	Kaufman,1991b	Kaufman,1991b		Cox,1989
A5	AL^+	Kaufman,1991b Moore,1971	Kaufman,1991b		
A6	AL^-	Chase,1985		Hotop,1985	
A7	Ar	Moore,1971			Ref. Element
A8	Ar^+	Moore,1971,1970a	Moore,1970a		
A9	B	Odintzova,1979	Odintzova,1979		Martin,1998
A10	B^+	Moore,1971	Moore,1970a		
A11	B^-	Hotop,1985		Hotop,1985	
A12	Ba	Moore,1971 Gurvich,1996	Moore,1970a		Gurvich,1996
A13	Ba^+	Moore,1971	Moore,1971		
A14	Be	Kramida,1997	Kramida,1997		Cox,1989
A15	Be^+	Moore,1971	Moore,1970a		
A16	Br	Moore,1971,1970a	Moore,1970a		Cox,1989
A17	Br^+	Moore,1971,1970a	Moore,1970a		
A18	Br^-			Hotop,1985	
A19	C	Moore,1970b	Moore,1970b		Douglas,1955
A20	C^+	Moore,1970b	Moore,1970b		
A21	C^-	Hotop,1985		Hotop,1985	
A22	Ca	Sugar,1985	Sugar,1985		Cox,1989
A23	Ca^+	Sugar,1985	Sugar,1985		
A24	Cd	Moore,1971	Moore,1971		Cox,1989
A25	Cd^+	Moore,1971	Moore,1971		
A26	CL	Moore,1971,1970a	Moore,1970a		Cox,1989
A27	CL^+	Moore,1971,1970a	Moore,1970a		
A28	CL^-			Hotop,1985	
A29	Co	Sugar,1985	Sugar,1985		Hultgren,1973
A30	Co^+	Sugar,1985	Sugar,1985		
A31	Co^-	Hotop,1985		Hotop,1985	
A32	Cr	Sugar,1985	Sugar,1985		Chase,1985
A33	Cr^+	Sugar,1985	Sugar,1985		
A34	Cr^-			Hotop,1985	
A35	Cs	Moore,1971	Moore,1970a		Cox,1989
A36	Cs^+	Moore,1971	Moore,1971		
A37	Cs^-			Hotop,1985	
A38	Cu	Sugar,1990	Sugar,1990		Cox,1989
A39	Cu^+	Sugar,1990	Sugar,1990		
A40	Cu^-			Hotop,1985	

TABLE IV.—REFERENCES FOR ELECTRONIC ENERGY LEVELS, IONIZATION POTENTIALS, ELECTRON AFFINITIES, AND ENTHALPIES OF FORMATION AT 298.15 K (Continued)

Table No.	Atom	Electronic Energy Levels	Ionization Potential	Electron Affinity	$\Delta_f H°(298.15)$
A41	D	Moore,1972	Moore,1972		Herzberg,1970
A42	D^+				
A43	D^-			Hotop,1985	
A44	e^-				Ref. Species
A45	F	Moore,1971,1970a	Moore,1970a		Cox,1989
A46	F^+	Moore,1971,1970a			
A47	F^-			Hotop,1985	
A48	Fe	Sugar,1985	Sugar,1985		Hultgren,1973
A49	Fe^+	Sugar,1985	Sugar,1985		
A50	Fe^-	Hotop,1985		Hotop,1985	
A51	Ge	Sugar,1993	Sugar,1993		Gurvich,1991
A52	Ge^+	Sugar,1993	Sugar,1993		
A53	Ge^-	Hotop,1985		Hotop,1985	
A54	H	Moore,1972	Moore,1972		Herzberg,1970
A55	H^+				
A56	H^-			Hotop,1985	
A57	He	Moore,1971	Moore,1970a		Ref. Element
A58	He^+	Moore,1971	Moore,1970a		
A59	Hg	Moore,1971	Moore,1971		Cox,1989
A60	Hg^+	Moore,1971	Moore,1971		
A61	I	Moore,1971,1970a	Moore,1970a		Cox,1989
A62	I^+	Moore,1971,1970a	Moore,1970a		
A63	I^-			Hotop,1985	
A64	K	Sugar,1985	Sugar,1985		Cox,1989
A65	K^+	Sugar,1985	Sugar,1985		
A66	K^-			Hotop,1985	
A67	Kr	Sugar,1991	Sugar,1991		Ref. Element
A68	Kr^+	Sugar,1991	Sugar,1991		
A69	Li	Moore,1971	Moore,1970a		Cox,1989
A70	Li^+	Moore,1971	Moore,1971a		
A71	Li^-			Hotop,1985	
A72	Mg	Kaufman,1991a	Kaufman,1991a		Cox,1989
A73	Mg^+	Kaufman,1991a	Kaufman,1991a		
A74	Mn	Sugar,1985	Sugar,1985		Desai,1987
A75	Mn^+	Sugar,1985	Sugar,1985		
A76	Mo	Sugar,1988	Sugar,1988		Desai,1987
A77	Mo^+	Sugar,1988	Sugar,1988		
A78	Mo^-			Hotop,1985	
A79	N	Moore,1975	Moore,1975		Cox,1989
A80	N^+	Moore,1975	Moore,1975		
A81	N^-	Chase,1985		Hotop,1985	

TABLE IV.—REFERENCES FOR ELECTRONIC ENERGY LEVELS, IONIZATION POTENTIALS, ELECTRON AFFINITIES, AND ENTHALPIES OF FORMATION AT 298.15 K (Continued)

Table No.	Atom	Electronic Energy Levels	Ionization Potential	Electron Affinity	$\Delta_f H°(298.15)$
A82	Na	Martin,1981	Martin,1981		Cox,1989
A83	Na^+	Martin,1981	Martin,1981		
A84	Na^-			Hotop,1985	
A85	Nb	Moore,1971	Moore,1970a		Gurvich,1982
A86	Nb^+	Moore,1971	Moore,1970a		
A87	Nb^-	Hotop,1985		Hotop,1985	
A88	Ne	Moore,1971	Moore,1970a		Ref. Element
A89	Ne^+	Moore,1971,1970a	Moore,1970a		
A90	Ni	Litzen,1993	Litzen,1993		Hultgren,1973
A91	Ni^+	Sugar,1985	Sugar,1985		
A92	Ni^-	Hotop,1985		Hotop,1985	
A93	O	Moore,1976	Moore,1976		Brix,1954
A94	O^+	Martin,1993	Martin,1993		
A95	O^-	Gurvich,1989		Hotop,1985	
A96	P	Martin,1985	Martin,1985		Cox,1989
A97	P^+	Martin,1985	Martin,1985		
A98	P^-	Hotop,1985		Hotop,1985	
A99	Pb	Moore,1971,1970a	Moore,1970a		Gurvich,1991
A100	Pb^+	Moore,1971,1970a	Moore,1970a		
A101	Pb^-			Hotop,1985	
A102	Rb	Moore,1971	Moore,1970a		Cox,1989
A103	Rb^+	Moore,1971	Moore,1970a		
A104	Rb^-			Hotop,1985	
A105	Rn	Moore,1971	Moore,1971		Ref. Element
A106	Rn^+	Moore,1971	Moore,1971		
A107	S	Martin,1990	Martin,1990		Cox,1989
A108	S^+	Martin,1990	Martin,1990		
A109	S^-	Hotop,1985		Hotop,1985	
A110	Sc	Sugar,1985	Sugar,1985		Gurvich,1982
A111	Sc^+	Sugar,1985	Sugar,1985		
A112	Sc^-	(a)		Hotop,1985	
A113	Si	Martin,1997	Martin,1997		Cox,1989
A114	Si^+	Martin,1983	Martin,1983		
A115	Si^-	Chase,1985		Hotop,1985	
A116	Sn	Moore,1971	Moore,1971		Cox,1989
A117	Sn^+	Moore,1971	Moore,1971		
A118	Sn^-	Hotop,1985		Hotop,1985	
A119	Sr	Moore,1971	Moore,1970a		Gurvich,1996
A120	Sr^+	Moore,1971	Moore,1971		
A121	Ta	Moore,1971	Moore,1971		Gurvich,1982
A122	Ta^+	Moore,1971	Moore,1971		
A123	Ta^-	Hotop,1985		Hotop,1985	

TABLE IV.—REFERENCES FOR ELECTRONIC ENERGY LEVELS, IONIZATION POTENTIALS, ELECTRON AFFINITIES, AND ENTHALPIES OF FORMATION AT 298.15 K (Concluded)

Table No.	Atom	Electronic Energy Levels	Ionization Potential	Electron Affinity	$\Delta_f H°(298.15)$
A124	Ti	Sugar,1985	Sugar,1985		Cox,1989
A125	Ti^+	Sugar,1985	Sugar,1985		
A126	Ti^-	Hotop,1985		Hotop,1985	
A127	V	Sugar,1985	Sugar,1985		Gurvich,1982
A128	V^+	Sugar,1985	Sugar,1985		
A129	V^-	Hotop,1985		Hotop,1985	
A130	W	Moore,1971,1970a	Moore,1971		Gurvich,1982
A131	W^+	Moore,1971	Moore,1971		
A132	W^-	Hotop,1985		Hotop,1985	
A133	Xe	Moore,1971	Moore,1970a		Ref. Element
A134	Xe^+	Moore,1971,1970a	Moore,1971		
A135	Zn	Sugar,1995	Sugar,1995		Cox,1989
A136	Zn^+	Sugar,1995	Sugar,1995		
A137	Zr	Moore,1971	Hackett,1986		Gurvich,1982
A138	Zr^+	Moore,1971	Moore,1970a		
A139	Zr^-	Hotop,1985		Hotop,1985	

[a]Statistical weight taken from isoelectronic series.

Appendix A
Tables of Thermodynamic Properties
(Tables A1 Through A139)

This appendix presents the main tables of thermodynamic properties. The species are arranged in the same alphabetic order as the previous tables. The functions given are $C_p^\circ(T)$, $H^\circ(T) - H^\circ(298.15)$, $S^\circ(T)$, $-[G^\circ(T) - H^\circ(298.15)]/T$, $H^\circ(T)$, $\Delta_f H^\circ(T)$, and $\log_{10} K$. These functions are given for the following temperature schedule in units of kelvin: 0, 100, 200, 298.15, every 100 kelvin from 300 to 6000, every 200 kelvin from 6000 to 8000, and every 500 kelvin from 8000 to 20 000 K.

TABLE A1.—THERMODYNAMIC PROPERTIES FOR Ag

T	C_p°	$H^\circ - H^\circ(298.15)$	S°	$-[G^\circ - H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10} K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	278.703	284.448	----------	0
100	20.786	–4.119	150.291	191.479	280.781	285.484	–142.1619	100
200	20.786	–2.040	164.699	174.900	282.860	285.297	–67.6132	200
298.15	20.786	0.000	172.998	172.998	284.900	284.900	–43.0983	298.15
300	20.786	0.038	173.127	172.999	284.938	284.891	–42.7905	300
400	20.786	2.117	179.107	173.814	287.017	284.415	–30.3991	400
500	20.786	4.196	183.745	175.354	289.096	283.886	–22.9773	500
600	20.786	6.274	187.535	177.078	291.174	283.297	–18.0393	600
700	20.786	8.353	190.739	178.806	293.253	282.644	–14.5198	700
800	20.786	10.432	193.515	180.475	295.332	281.925	–11.8866	800
900	20.786	12.510	195.963	182.063	297.410	281.138	–9.8441	900
1000	20.786	14.589	198.153	183.564	299.489	280.285	–8.2148	1000
1100	20.786	16.667	200.134	184.982	301.567	279.362	–6.8860	1100
1200	20.786	18.746	201.943	186.321	303.646	278.372	–5.7824	1200
*1300	20.786	20.825	203.607	187.588	305.725	266.189	–4.8754	1300
1400	20.786	22.903	205.147	188.788	307.803	264.928	–4.1132	1400
1500	20.786	24.982	206.581	189.927	309.882	263.666	–3.4558	1500
1600	20.786	27.061	207.923	191.010	311.961	262.405	–2.8833	1600
1700	20.786	29.139	209.183	192.042	314.039	261.144	–2.3806	1700
1800	20.786	31.218	210.371	193.028	316.118	259.882	–1.9359	1800
1900	20.786	33.296	211.495	193.970	318.196	258.621	–1.5399	1900
2000	20.786	35.375	212.561	194.874	320.275	257.359	–1.1853	2000
2100	20.786	37.454	213.575	195.740	322.354	256.098	–0.8660	2100
2200	20.786	39.532	214.542	196.573	324.432	254.837	–0.5771	2200
2300	20.786	41.611	215.466	197.374	326.511	253.575	–0.3147	2300
2400	20.787	43.690	216.351	198.147	328.590	252.314	–0.0753	2400
2500	20.787	45.768	217.199	198.892	330.668	251.053	0.1438	2500
2600	20.787	47.847	218.015	199.612	332.747	249.791	0.3450	2600
2700	20.788	49.926	218.799	200.308	334.826	248.530	0.5304	2700
2800	20.789	52.005	219.555	200.982	336.905	247.269	0.7017	2800
2900	20.790	54.083	220.285	201.635	338.983	246.008	0.8603	2900
3000	20.792	56.163	220.990	202.269	341.063	244.747	1.0077	3000
3100	20.795	58.242	221.671	202.884	343.142	243.486	1.1448	3100
3200	20.799	60.322	222.332	203.481	345.222	242.226	1.2727	3200
3300	20.804	62.402	222.972	204.062	347.302	240.966	1.3922	3300
3400	20.811	64.482	223.593	204.628	349.382	239.707	1.5041	3400
3500	20.820	66.564	224.196	205.178	351.464	238.448	1.6090	3500
3600	20.831	68.646	224.783	205.715	353.546	237.191	1.7076	3600
3700	20.846	70.730	225.354	206.238	355.630	235.935	1.8004	3700
3800	20.863	72.816	225.910	206.748	357.716	234.680	1.8878	3800
3900	20.885	74.903	226.452	207.246	359.803	233.427	1.9703	3900
4000	20.911	76.993	226.981	207.733	361.893	232.177	2.0482	4000
4100	20.941	79.085	227.498	208.209	363.985	230.930	2.1220	4100
4200	20.977	81.181	228.003	208.674	366.081	229.686	2.1918	4200
4300	21.019	83.281	228.497	209.130	368.181	228.445	2.2581	4300
4400	21.068	85.385	228.981	209.575	370.285	227.210	2.3210	4400
4500	21.123	87.495	229.455	210.012	372.395	225.979	2.3808	4500

TABLE A1.—THERMODYNAMIC PROPERTIES FOR Ag (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	21.186	89.610	229.920	210.439	374.510	224.754	2.4376	4600
4700	21.257	91.732	230.376	210.859	376.632	223.536	2.4918	4700
4800	21.337	93.862	230.825	211.270	378.762	222.326	2.5434	4800
4900	21.426	96.000	231.265	211.674	380.900	221.124	2.5926	4900
5000	21.525	98.147	231.699	212.070	383.047	219.932	2.6397	5000
5100	21.634	100.305	232.127	212.459	385.205	218.749	2.6846	5100
5200	21.753	102.474	232.548	212.841	387.374	217.579	2.7276	5200
5300	21.884	104.656	232.963	213.217	389.556	216.420	2.7687	5300
5400	22.025	106.851	233.374	213.586	391.751	215.275	2.8081	5400
5500	22.145	109.085	233.784	213.950	393.985	214.169	2.8459	5500
5600	22.290	111.307	234.184	214.308	396.207	213.051	2.8821	5600
5700	22.454	113.544	234.580	214.660	398.444	211.948	2.9169	5700
5800	22.635	115.798	234.972	215.007	400.698	210.862	2.9503	5800
5900	22.833	118.071	235.361	215.349	402.971	209.795	2.9824	5900
6000	23.048	120.365	235.746	215.686	405.265	208.749	3.0132	6000
6200	23.525	125.021	236.510	216.345	409.921			6200
6400	24.062	129.779	237.265	216.987	414.679			6400
6600	24.652	134.650	238.014	217.613	419.550			6600
6800	25.288	139.643	238.760	218.224	424.543			6800
7000	25.963	144.768	239.502	218.821	429.668			7000
7200	26.670	150.030	240.244	219.406	434.930			7200
7400	27.403	155.437	240.984	219.979	440.337			7400
7600	28.156	160.993	241.725	220.542	445.893			7600
7800	28.922	166.700	242.466	221.094	451.600			7800
8000	29.697	172.563	243.208	221.638	457.463			8000
8500	31.635	187.896	245.067	222.961	472.796			8500
9000	33.522	204.189	246.929	224.241	489.089			9000
9500	35.301	221.400	248.790	225.484	506.300			9500
10000	36.931	239.465	250.642	226.696	524.365			10000
10500	38.378	258.300	252.480	227.880	543.200			10500
11000	39.623	277.809	254.295	229.040	562.709			11000
11500	40.651	297.887	256.080	230.177	582.787			11500
12000	41.455	318.423	257.828	231.292	603.323			12000
12500	42.033	339.305	259.532	232.388	624.205			12500
13000	42.390	360.420	261.189	233.464	645.320			13000
13500	42.530	381.658	262.792	234.521	666.558			13500
14000	42.464	402.915	264.338	235.558	687.815			14000
14500	42.204	424.090	265.824	236.576	708.990			14500
15000	41.762	445.088	267.248	237.575	729.988			15000
15500	41.154	465.825	268.608	238.555	750.725			15500
16000	40.395	486.217	269.903	239.514	771.117			16000
16500	39.502	506.197	271.132	240.454	791.097			16500
17000	38.492	525.700	272.297	241.373	810.600			17000
17500	37.380	544.672	273.397	242.273	829.572			17500
18000	36.184	563.066	274.433	243.152	847.966			18000
18500	34.920	580.844	275.408	244.011	865.744			18500
19000	33.604	597.977	276.322	244.849	882.877			19000
19500	32.252	614.443	277.177	245.667	899.343			19500
20000	30.878	630.227	277.976	246.465	915.127			20000

***Assigned reference element phase change at 1235.08 K**

TABLE A2.—THERMODYNAMIC PROPERTIES FOR Ag^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.198	----------	----------	1015.896	1015.444	----------	0
298.15	20.792	0.000	167.236	167.236	1022.094	1022.094	–171.4535	298.15
300	20.792	0.038	167.364	167.236	1022.132	1022.124	–170.3493	300
400	20.990	2.124	173.362	168.053	1024.217	1023.732	–125.8268	400
500	22.282	4.272	178.151	169.606	1026.366	1025.352	–99.0708	500
600	26.008	6.662	182.498	171.394	1028.756	1027.153	–81.2041	600
700	32.603	9.571	186.970	173.296	1031.665	1029.409	–68.4171	700
800	40.848	13.239	191.855	175.306	1035.333	1032.357	–58.8029	800
900	48.479	17.720	197.124	177.435	1039.814	1036.052	–51.3011	900
1000	53.576	22.849	202.523	179.674	1044.943	1040.327	–45.2764	1000
1100	55.506	28.328	207.744	181.991	1050.422	1044.885	–40.3260	1100
1200	54.798	33.862	212.559	184.341	1055.955	1049.427	–36.1826	1200
*1300	52.461	39.234	216.860	186.680	1061.328	1042.617	–32.6850	1300
1400	49.416	44.331	220.639	188.974	1066.424	1046.452	–29.6873	1400
1500	46.283	49.115	223.940	191.197	1071.208	1049.975	–27.0801	1500
1600	43.391	53.595	226.833	193.336	1075.689	1053.194	–24.7915	1600
1700	40.876	57.805	229.386	195.383	1079.899	1056.143	–22.7662	1700
1800	38.760	61.784	231.661	197.337	1083.878	1058.860	–20.9611	1800
1900	37.013	65.570	233.708	199.198	1087.663	1061.384	–19.3420	1900
2000	35.585	69.197	235.569	200.971	1091.291	1063.750	–17.8814	2000
2100	34.424	72.696	237.276	202.659	1094.789	1065.987	–16.5571	2100
2200	33.480	76.089	238.855	204.269	1098.183	1068.119	–15.3507	2200
2300	32.712	79.397	240.326	205.805	1101.491	1070.166	–14.2471	2300
2400	32.086	82.636	241.705	207.273	1104.730	1072.144	–13.2335	2400
2500	31.574	85.818	243.004	208.676	1107.912	1074.065	–12.2993	2500
2600	31.153	88.954	244.233	210.020	1111.048	1075.939	–11.4354	2600
2700	30.807	92.052	245.403	211.309	1114.145	1077.775	–10.6342	2700
2800	30.520	95.117	246.518	212.547	1117.211	1079.580	–9.8889	2800
2900	30.282	98.157	247.584	213.737	1120.251	1081.358	–9.1939	2900
3000	30.083	101.175	248.607	214.882	1123.269	1083.114	–8.5442	3000
3100	29.916	104.175	249.591	215.986	1126.268	1084.853	–7.9353	3100
3200	29.777	107.159	250.539	217.051	1129.253	1086.576	–7.3637	3200
3300	29.659	110.131	251.453	218.080	1132.225	1088.286	–6.8258	3300
3400	29.559	113.092	252.337	219.075	1135.185	1089.985	–6.3188	3400
3500	29.475	116.043	253.192	220.037	1138.137	1091.676	–5.8400	3500
3600	29.403	118.987	254.022	220.970	1141.081	1093.358	–5.3871	3600
3700	29.342	121.924	254.827	221.874	1144.018	1095.034	–4.9580	3700
3800	29.290	124.856	255.608	222.752	1146.950	1096.704	–4.5509	3800
3900	29.246	127.783	256.369	223.604	1149.876	1098.370	–4.1640	3900
4000	29.208	130.705	257.108	224.432	1152.799	1100.031	–3.7960	4000
4100	29.175	133.624	257.829	225.238	1155.718	1101.689	–3.4454	4100
4200	29.147	136.540	258.532	226.022	1158.634	1103.343	–3.1110	4200
4300	29.123	139.454	259.218	226.786	1161.547	1104.995	–2.7916	4300
4400	29.102	142.365	259.887	227.531	1164.459	1106.645	–2.4863	4400
4500	29.085	145.274	260.541	228.257	1167.368	1108.293	–2.1942	4500
4600	29.069	148.182	261.180	228.966	1170.276	1109.939	–1.9143	4600
4700	29.056	151.088	261.805	229.658	1173.182	1111.584	–1.6459	4700
4800	29.045	153.993	262.416	230.334	1176.087	1113.228	–1.3884	4800
4900	29.036	156.897	263.015	230.995	1178.991	1114.871	–1.1410	4900
5000	29.027	159.800	263.602	231.642	1181.894	1116.512	–0.9031	5000

TABLE A2.—THERMODYNAMIC PROPERTIES FOR Ag^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	29.020	162.703	264.176	232.274	1184.797	1118.153	–0.6743	5100
5200	29.015	165.605	264.740	232.893	1187.698	1119.794	–0.4539	5200
5300	29.010	168.506	265.292	233.499	1190.600	1121.434	–0.2415	5300
5400	29.006	171.407	265.835	234.093	1193.500	1123.073	–0.0367	5400
5500	29.002	174.307	266.367	234.675	1196.401	1124.712	0.1610	5500
5600	28.999	177.207	266.889	235.245	1199.301	1126.351	0.3519	5600
5700	28.997	180.107	267.403	235.805	1202.201	1127.989	0.5363	5700
5800	28.995	183.006	267.907	236.354	1205.100	1129.627	0.7147	5800
5900	28.994	185.906	268.403	236.893	1208.000	1131.265	0.8872	5900
6000	28.993	188.805	268.890	237.422	1210.899	1132.903	1.0543	6000
6200	28.992	194.604	269.841	238.453	1216.697			6200
6400	28.992	200.402	270.761	239.448	1222.496			6400
6600	28.992	206.200	271.653	240.411	1228.294			6600
6800	28.993	211.999	272.519	241.342	1234.093			6800
7000	28.995	217.798	273.359	242.245	1239.891			7000
7200	29.053	223.657	274.186	243.122	1245.751			7200
7400	29.062	229.469	274.982	243.972	1251.562			7400
7600	29.072	235.282	275.757	244.799	1257.376			7600
7800	29.082	241.097	276.512	245.602	1263.191			7800
8000	29.092	246.915	277.249	246.384	1269.008			8000
8500	29.119	261.467	279.013	248.252	1283.561			8500
9000	29.146	276.033	280.678	250.008	1298.127			9000
9500	29.173	290.613	282.255	251.664	1312.707			9500
10000	29.199	305.206	283.752	253.231	1327.300			10000
10500	29.224	319.812	285.177	254.719	1341.906			10500
11000	29.248	334.430	286.537	256.134	1356.524			11000
11500	29.271	349.060	287.838	257.485	1371.154			11500
12000	29.294	363.701	289.084	258.776	1385.795			12000
12500	29.316	378.354	290.280	260.012	1400.448			12500
13000	29.338	393.017	291.431	261.198	1415.111			13000
13500	29.360	407.692	292.538	262.339	1429.785			13500
14000	29.384	422.378	293.606	263.437	1444.471			14000
14500	29.409	437.076	294.638	264.495	1459.169			14500
15000	29.437	451.787	295.635	265.516	1473.880			15000
15500	29.468	466.513	296.601	266.503	1488.606			15500
16000	29.503	481.255	297.537	267.459	1503.348			16000
16500	29.542	496.014	298.445	268.384	1518.108			16500
17000	29.586	510.795	299.328	269.281	1532.889			17000
17500	29.635	525.597	300.186	270.152	1547.690			17500
18000	29.689	540.424	301.021	270.998	1562.517			18000
18500	29.748	555.276	301.835	271.820	1577.370			18500
19000	29.817	570.164	302.629	272.621	1592.258			19000
19500	29.886	585.077	303.404	273.400	1607.171			19500
20000	29.965	600.030	304.161	274.160	1622.124			20000

*Assigned reference element phase change at 1235.08 K

TABLE A3.—THERMODYNAMIC PROPERTIES FOR Ag^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	146.881	158.824	----------	0
298.15	20.786	0.000	167.235	167.235	153.079	153.079	–21.4012	298.15
300	20.786	0.038	167.364	167.236	153.117	153.032	–21.2358	300
400	20.786	2.117	173.344	168.051	155.196	150.477	–14.6249	400
500	20.786	4.196	177.982	169.591	157.274	147.869	–10.7262	500
600	20.786	6.274	181.772	171.315	159.353	145.202	–8.1734	600
700	20.786	8.353	184.976	173.043	161.432	142.470	–6.3836	700
800	20.786	10.432	187.752	174.712	163.510	139.672	–5.0672	800
900	20.786	12.510	190.200	176.300	165.589	136.807	–4.0639	900
1000	20.786	14.589	192.390	177.801	167.668	133.875	–3.2781	1000
1100	20.786	16.667	194.371	179.219	169.746	130.874	–2.6493	1100
1200	20.786	18.746	196.180	180.558	171.825	127.805	–2.1373	1200
*1300	20.786	20.825	197.844	181.825	173.903	113.543	–1.7378	1300
1400	20.786	22.903	199.384	183.024	175.982	110.203	–1.4166	1400
1500	20.786	24.982	200.818	184.163	178.061	106.863	–1.1465	1500
1600	20.786	27.061	202.160	185.247	180.139	103.523	–0.9175	1600
1700	20.786	29.139	203.420	186.279	182.218	100.183	–0.7219	1700
1800	20.786	31.218	204.608	187.265	184.297	96.843	–0.5536	1800
1900	20.786	33.296	205.732	188.207	186.375	93.503	–0.4082	1900
2000	20.786	35.375	206.798	189.110	188.454	90.163	–0.2820	2000
2100	20.786	37.454	207.812	189.977	190.532	86.823	–0.1719	2100
2200	20.786	39.532	208.779	190.810	192.611	83.483	–0.0756	2200
2300	20.786	41.611	209.703	191.611	194.690	80.143	0.0089	2300
2400	20.786	43.690	210.588	192.384	196.768	76.803	0.0832	2400
2500	20.786	45.768	211.436	193.129	198.847	73.463	0.1486	2500
2600	20.786	47.847	212.252	193.849	200.926	70.123	0.2063	2600
2700	20.786	49.926	213.036	194.545	203.004	66.783	0.2573	2700
2800	20.786	52.004	213.792	195.219	205.083	63.443	0.3023	2800
2900	20.786	54.083	214.521	195.872	207.161	60.103	0.3420	2900
3000	20.786	56.161	215.226	196.506	209.240	56.763	0.3771	3000
3100	20.786	58.240	215.908	197.121	211.319	53.423	0.4081	3100
3200	20.786	60.319	216.568	197.718	213.397	50.083	0.4353	3200
3300	20.786	62.397	217.207	198.299	215.476	46.743	0.4593	3300
3400	20.786	64.476	217.828	198.864	217.555	43.403	0.4803	3400
3500	20.786	66.555	218.430	199.415	219.633	40.063	0.4986	3500
3600	20.786	68.633	219.016	199.951	221.712	36.723	0.5145	3600
3700	20.786	70.712	219.585	200.474	223.791	33.383	0.5283	3700
3800	20.786	72.790	220.140	200.984	225.869	30.043	0.5401	3800
3900	20.786	74.869	220.680	201.482	227.948	26.703	0.5501	3900
4000	20.786	76.948	221.206	201.969	230.026	23.363	0.5584	4000
4100	20.786	79.026	221.719	202.444	232.105	20.023	0.5654	4100
4200	20.786	81.105	222.220	202.909	234.184	16.683	0.5709	4200
4300	20.786	83.184	222.709	203.364	236.262	13.343	0.5753	4300
4400	20.786	85.262	223.187	203.809	238.341	10.003	0.5785	4400
4500	20.786	87.341	223.654	204.245	240.420	6.663	0.5807	4500
4600	20.786	89.419	224.111	204.672	242.498	3.323	0.5820	4600
4700	20.786	91.498	224.558	205.090	244.577	–0.017	0.5824	4700
4800	20.786	93.577	224.996	205.501	246.655	–3.357	0.5820	4800
4900	20.786	95.655	225.424	205.903	248.734	–6.697	0.5809	4900
5000	20.786	97.734	225.844	206.297	250.813	–10.037	0.5791	5000

TABLE A3.—THERMODYNAMIC PROPERTIES FOR Ag^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	226.256	206.685	252.891	–13.377	0.5767	5100
5200	20.786	101.891	226.659	207.065	254.970	–16.717	0.5737	5200
5300	20.786	103.970	227.055	207.438	257.049	–20.057	0.5702	5300
5400	20.786	106.048	227.444	207.805	259.127	–23.397	0.5663	5400
5500	20.786	108.127	227.825	208.166	261.206	–26.737	0.5619	5500
5600	20.786	110.206	228.200	208.520	263.284	–30.077	0.5571	5600
5700	20.786	112.284	228.568	208.869	265.363	–33.417	0.5519	5700
5800	20.786	114.363	228.929	209.212	267.442	–36.757	0.5463	5800
5900	20.786	116.442	229.285	209.549	269.520	–40.097	0.5405	5900
6000	20.786	118.520	229.634	209.881	271.599	–43.437	0.5343	6000
6200	20.786	122.677	230.316	210.529	275.756			6200
6400	20.786	126.835	230.976	211.158	279.913			6400
6600	20.786	130.992	231.615	211.768	284.071			6600
6800	20.786	135.149	232.236	212.361	288.228			6800
7000	20.786	139.306	232.838	212.937	292.385			7000
7200	20.786	143.464	233.424	213.498	296.542			7200
7400	20.786	147.621	233.993	214.045	300.700			7400
7600	20.786	151.778	234.548	214.577	304.857			7600
7800	20.786	155.936	235.088	215.096	309.014			7800
8000	20.786	160.093	235.614	215.602	313.172			8000
8500	20.786	170.486	236.874	216.817	323.565			8500
9000	20.786	180.879	238.062	217.964	333.958			9000
9500	20.786	191.272	239.186	219.052	344.351			9500
10000	20.786	201.665	240.252	220.086	354.744			10000
10500	20.786	212.058	241.266	221.070	365.137			10500
11000	20.786	222.452	242.233	222.010	375.530			11000
11500	20.786	232.845	243.157	222.910	385.923			11500
12000	20.786	243.238	244.042	223.772	396.317			12000
12500	20.786	253.631	244.891	224.600	406.710			12500
13000	20.786	264.024	245.706	225.396	417.103			13000
13500	20.786	274.417	246.490	226.163	427.496			13500
14000	20.786	284.810	247.246	226.903	437.889			14000
14500	20.786	295.204	247.976	227.617	448.282			14500
15000	20.786	305.597	248.680	228.307	458.675			15000
15500	20.786	315.990	249.362	228.975	469.069			15500
16000	20.786	326.383	250.022	229.623	479.462			16000
16500	20.786	336.776	250.661	230.251	489.855			16500
17000	20.786	347.169	251.282	230.860	500.248			17000
17500	20.786	357.562	251.885	231.452	510.641			17500
18000	20.786	367.956	252.470	232.028	521.034			18000
18500	20.786	378.349	253.040	232.588	531.427			18500
19000	20.786	388.742	253.594	233.134	541.821			19000
19500	20.786	399.135	254.134	233.665	552.214			19500
20000	20.786	409.528	254.660	234.184	562.607			20000

*Assigned reference element phase change at 1235.08 K

TABLE A4.—THERMODYNAMIC PROPERTIES FOR AL

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.919	----------	----------	323.081	327.621	----------	0
100	25.192	–4.458	139.621	184.199	325.542	329.597	–165.2314	100
200	22.133	–2.129	155.885	166.530	327.871	330.127	–79.0755	200
298.15	21.391	0.000	164.555	164.555	330.000	330.000	–50.6961	298.15
300	21.383	0.040	164.688	164.556	330.040	329.995	–50.3396	300
400	21.117	2.163	170.797	165.391	332.163	329.615	–35.9824	400
500	20.995	4.268	175.495	166.960	334.268	329.087	–27.3802	500
600	20.930	6.364	179.316	168.710	336.364	328.436	–21.6556	600
700	20.891	8.454	182.539	170.462	338.454	327.658	–17.5754	700
800	20.866	10.542	185.327	172.150	340.542	326.733	–14.5232	800
900	20.849	12.628	187.784	173.753	342.628	325.613	–12.1566	900
*1000	20.837	14.712	189.980	175.268	344.712	313.758	–10.3100	1000
1100	20.828	16.795	191.965	176.697	346.795	312.666	–8.8226	1100
1200	20.821	18.878	193.777	178.046	348.878	311.574	–7.5875	1200
1300	20.816	20.960	195.444	179.321	350.960	310.481	–6.5460	1300
1400	20.812	23.041	196.986	180.528	353.041	309.387	–5.6565	1400
1500	20.808	25.122	198.422	181.674	355.122	308.293	–4.8883	1500
1600	20.806	27.203	199.765	182.763	357.203	307.199	–4.2185	1600
1700	20.803	29.283	201.026	183.801	359.283	306.104	–3.6296	1700
1800	20.802	31.363	202.215	184.791	361.363	305.009	–3.1080	1800
1900	20.800	33.443	203.340	185.738	363.443	303.914	–2.6430	1900
2000	20.799	35.523	204.407	186.645	365.523	302.819	–2.2260	2000
2100	20.797	37.603	205.421	187.515	367.603	301.724	–1.8500	2100
2200	20.797	39.683	206.389	188.351	369.683	300.629	–1.5095	2200
2300	20.796	41.762	207.313	189.156	371.762	299.533	–1.1997	2300
2400	20.795	43.842	208.198	189.931	373.842	298.438	–0.9168	2400
2500	20.795	45.921	209.047	190.679	375.921	297.343	–0.6575	2500
2600	20.795	48.001	209.863	191.401	378.001	296.247	–0.4190	2600
2700	20.795	50.080	210.648	192.099	380.080	295.151	–0.1989	2700
2800	20.795	52.160	211.404	192.775	382.160	294.056	0.0046	2800
2900	20.796	54.239	212.134	193.430	384.239	292.960	0.1934	2900
3000	20.798	56.319	212.839	194.066	386.319	291.865	0.3690	3000
3100	20.800	58.399	213.521	194.682	388.399	290.770	0.5326	3100
3200	20.804	60.479	214.181	195.281	390.479	289.675	0.6854	3200
3300	20.808	62.560	214.821	195.864	392.560	288.581	0.8284	3300
3400	20.815	64.641	215.443	196.430	394.641	287.487	0.9625	3400
3500	20.823	66.723	216.046	196.982	396.723	286.394	1.0885	3500
3600	20.833	68.806	216.633	197.520	398.806	285.302	1.2070	3600
3700	20.845	70.889	217.204	198.044	400.889	284.211	1.3187	3700
3800	20.861	72.975	217.760	198.556	402.975	283.121	1.4240	3800
3900	20.880	75.062	218.302	199.055	405.062	282.033	1.5236	3900
4000	20.902	77.151	218.831	199.543	407.151	280.947	1.6179	4000
4100	20.929	79.242	219.347	200.020	409.242	279.863	1.7072	4100
4200	20.961	81.337	219.852	200.486	411.337	278.783	1.7919	4200
4300	20.997	83.434	220.346	200.942	413.434	277.705	1.8724	4300
4400	21.039	85.536	220.829	201.389	415.536	276.632	1.9489	4400
4500	21.085	87.642	221.302	201.826	417.642	275.563	2.0218	4500

TABLE A4.—THERMODYNAMIC PROPERTIES FOR AL (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	21.139	89.753	221.766	202.254	419.753	274.499	2.0912	4600
4700	21.200	91.870	222.221	202.674	421.870	273.441	2.1573	4700
4800	21.269	93.993	222.668	203.086	423.993	272.389	2.2205	4800
4900	21.343	96.123	223.107	203.490	426.123	271.344	2.2809	4900
5000	21.428	98.261	223.539	203.887	428.261	270.307	2.3387	5000
5100	21.504	100.407	223.964	204.277	430.407	269.278	2.3939	5100
5200	21.589	102.562	224.383	204.659	432.562	268.258	2.4469	5200
5300	21.684	104.725	224.795	205.035	434.725	267.246	2.4976	5300
5400	21.790	106.899	225.201	205.405	436.899	266.245	2.5463	5400
5500	21.909	109.084	225.602	205.769	439.084	265.255	2.5930	5500
5600	22.041	111.281	225.998	206.126	441.281	264.277	2.6379	5600
5700	22.186	113.492	226.389	206.478	443.492	263.314	2.6811	5700
5800	22.345	115.719	226.777	206.825	445.719	262.365	2.7226	5800
5900	22.516	117.962	227.160	207.166	447.962	261.433	2.7626	5900
6000	22.700	120.222	227.540	207.503	450.222	260.519	2.8011	6000
6200	23.102	124.802	228.291	208.161	454.802			6200
6400	23.548	129.466	229.031	208.802	459.466			6400
6600	24.031	134.223	229.763	209.426	464.223			6600
6800	24.543	139.081	230.488	210.035	469.081			6800
7000	25.079	144.042	231.207	210.630	474.042			7000
7200	25.633	149.113	231.921	211.211	479.113			7200
7400	26.197	154.296	232.631	211.780	484.296			7400
7600	26.766	159.593	233.337	212.338	489.593			7600
7800	27.334	165.003	234.040	212.886	495.003			7800
8000	27.897	170.526	234.739	213.424	500.526			8000
8500	29.253	184.817	236.472	214.728	514.817			8500
9000	30.492	199.759	238.179	215.984	529.759			9000
9500	31.577	215.284	239.858	217.196	545.284			9500
10000	32.485	231.307	241.501	218.371	561.307			10000
10500	33.206	247.738	243.105	219.511	577.738			10500
11000	33.739	264.481	244.662	220.619	594.481			11000
11500	34.093	281.446	246.171	221.697	611.446			11500
12000	34.281	298.547	247.626	222.747	628.547			12000
12500	34.322	315.703	249.027	223.771	645.703			12500
13000	34.237	332.848	250.372	224.768	662.848			13000
13500	34.046	349.922	251.661	225.740	679.922			13500
14000	33.774	366.881	252.894	226.688	696.881			14000
14500	33.441	383.686	254.073	227.612	713.686			14500
15000	33.068	400.314	255.201	228.513	730.314			15000
15500	32.676	416.751	256.279	229.392	746.751			15500
16000	32.279	432.989	257.310	230.248	762.989			16000
16500	31.893	449.032	258.297	231.083	779.032			16500
17000	31.528	464.885	259.244	231.898	794.885			17000
17500	31.190	480.565	260.153	232.692	810.565			17500
18000	30.885	496.082	261.027	233.467	826.082			18000
18500	30.610	511.454	261.870	234.223	841.454			18500
19000	30.362	526.696	262.683	234.962	856.696			19000
19500	30.130	541.819	263.468	235.683	871.819			19500
20000	29.902	556.827	264.228	236.387	886.827			20000

***Assigned reference element phase change at 933.61 K**

TABLE A5.—THERMODYNAMIC PROPERTIES FOR AL^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–616.197	----------	----------	906.818	905.160	----------	0
298.15	20.786	0.000	149.952	149.952	913.015	913.015	–152.5023	298.15
300	20.786	0.038	150.081	149.953	913.054	913.047	–151.5159	300
400	20.786	2.117	156.061	150.768	915.132	914.701	–111.7398	400
500	20.786	4.196	160.699	152.307	917.211	916.226	–87.8323	500
600	20.786	6.274	164.489	154.031	919.289	917.636	–71.8681	600
700	20.786	8.353	167.693	155.760	921.368	918.925	–60.4481	700
800	20.786	10.432	170.469	157.429	923.447	920.069	–51.8718	800
900	20.786	12.510	172.917	159.017	925.525	921.021	–45.1936	900
*1000	20.786	14.589	175.107	160.518	927.604	911.239	–39.8855	1000
1100	20.786	16.667	177.088	161.936	929.683	912.221	–35.5563	1100
1200	20.786	18.746	178.897	163.275	931.761	913.203	–31.9447	1200
1300	20.786	20.825	180.560	164.541	933.840	914.186	–28.8854	1300
1400	20.786	22.903	182.101	165.741	935.918	915.168	–26.2603	1400
1500	20.786	24.982	183.535	166.880	937.997	916.150	–23.9829	1500
1600	20.786	27.061	184.876	167.964	940.076	917.132	–21.9879	1600
1700	20.786	29.139	186.137	168.996	942.154	918.115	–20.2258	1700
1800	20.786	31.218	187.325	169.981	944.233	919.097	–18.6578	1800
1900	20.786	33.296	188.449	170.924	946.312	920.079	–17.2533	1900
2000	20.786	35.375	189.515	171.827	948.390	921.061	–15.9879	2000
2100	20.786	37.454	190.529	172.694	950.469	922.044	–14.8418	2100
2200	20.786	39.532	191.496	173.527	952.548	923.026	–13.7988	2200
2300	20.786	41.611	192.420	174.328	954.626	924.008	–12.8455	2300
2400	20.786	43.690	193.305	175.101	956.705	924.991	–11.9707	2400
2500	20.786	45.768	194.153	175.846	958.783	925.973	–11.1650	2500
2600	20.786	47.847	194.968	176.566	960.862	926.955	–10.4206	2600
2700	20.786	49.926	195.753	177.262	962.941	927.937	–9.7305	2700
2800	20.786	52.004	196.509	177.936	965.019	928.920	–9.0890	2800
2900	20.786	54.083	197.238	178.589	967.098	929.902	–8.4912	2900
3000	20.787	56.161	197.943	179.222	969.177	930.884	–7.9326	3000
3100	20.787	58.240	198.625	179.837	971.255	931.866	–7.4095	3100
3200	20.787	60.319	199.284	180.435	973.334	932.849	–6.9185	3200
3300	20.788	62.398	199.924	181.016	975.413	933.831	–6.4569	3300
3400	20.789	64.476	200.545	181.581	977.492	934.814	–6.0219	3400
3500	20.790	66.555	201.147	182.132	979.570	935.796	–5.6114	3500
3600	20.791	68.634	201.733	182.668	981.650	936.779	–5.2232	3600
3700	20.794	70.714	202.303	183.191	983.729	937.762	–4.8557	3700
3800	20.797	72.793	202.857	183.701	985.808	938.745	–4.5071	3800
3900	20.800	74.873	203.398	184.199	987.888	939.728	–4.1761	3900
4000	20.805	76.953	203.924	184.686	989.968	940.712	–3.8613	4000
4100	20.811	79.034	204.438	185.161	992.049	941.697	–3.5615	4100
4200	20.819	81.116	204.940	185.626	994.131	942.682	–3.2757	4200
4300	20.828	83.198	205.430	186.081	996.213	943.668	–3.0030	4300
4400	20.839	85.281	205.909	186.526	998.296	944.655	–2.7423	4400
4500	20.853	87.366	206.377	186.962	1000.381	945.643	–2.4930	4500
4600	20.869	89.452	206.836	187.389	1002.467	946.633	–2.2542	4600
4700	20.888	91.540	207.285	187.808	1004.555	947.624	–2.0254	4700
4800	20.910	93.630	207.725	188.218	1006.645	948.617	–1.8059	4800
4900	20.936	95.722	208.156	188.621	1008.737	949.613	–1.5951	4900
5000	20.965	97.817	208.579	189.016	1010.832	950.612	–1.3925	5000

TABLE A5.—THERMODYNAMIC PROPERTIES FOR AL^+ (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.999	99.915	208.995	189.404	1012.930	951.614	–1.1977	5100
5200	21.037	102.017	209.403	189.784	1015.032	952.619	–1.0102	5200
5300	21.080	104.123	209.804	190.158	1017.138	953.629	–0.8295	5300
5400	21.128	106.233	210.198	190.526	1019.248	954.643	–0.6554	5400
5500	21.181	108.348	210.587	190.887	1021.363	955.662	–0.4874	5500
5600	21.240	110.469	210.969	191.242	1023.484	956.686	–0.3253	5600
5700	21.305	112.596	211.345	191.591	1025.612	957.717	–0.1686	5700
5800	21.376	114.730	211.716	191.935	1027.746	958.755	–0.0172	5800
5900	21.454	116.872	212.082	192.274	1029.887	959.800	0.1292	5900
6000	21.538	119.021	212.444	192.607	1032.037	960.853	0.2709	6000
6200	21.727	123.347	213.153	193.258	1036.363			6200
6400	21.945	127.714	213.846	193.891	1040.729			6400
6600	22.193	132.128	214.525	194.506	1045.143			6600
6800	22.472	136.594	215.192	195.104	1049.609			6800
7000	22.781	141.118	215.847	195.688	1054.134			7000
7200	23.120	145.708	216.494	196.257	1058.723			7200
7400	23.490	150.369	217.132	196.812	1063.384			7400
7600	23.888	155.106	217.764	197.355	1068.121			7600
7800	24.315	159.926	218.390	197.887	1072.941			7800
8000	24.768	164.834	219.011	198.407	1077.849			8000
8500	26.004	177.521	220.549	199.664	1090.536			8500
9000	27.362	190.858	222.073	200.867	1103.873			9000
9500	28.803	204.896	223.591	202.023	1117.911			9500
10000	30.289	219.668	225.106	203.139	1132.683			10000
10500	31.784	235.187	226.620	204.222	1148.202			10500
11000	33.254	251.448	228.133	205.274	1164.463			11000
11500	34.674	268.432	229.643	206.301	1181.447			11500
12000	36.024	286.110	231.147	207.305	1199.125			12000
12500	37.292	304.440	232.644	208.288	1217.456			12500
13000	38.466	323.377	234.129	209.254	1236.392			13000
13500	39.557	342.882	235.601	210.202	1255.897			13500
14000	40.562	362.906	237.057	211.135	1275.921			14000
14500	41.527	383.443	238.501	212.056	1296.458			14500
15000	42.421	404.433	239.924	212.961	1317.448			15000
15500	43.256	425.854	241.328	213.854	1338.870			15500
16000	44.035	447.679	242.714	214.734	1360.694			16000
16500	44.764	469.881	244.081	215.603	1382.897			16500
17000	45.446	492.435	245.427	216.460	1405.451			17000
17500	46.083	515.319	246.754	217.307	1428.334			17500
18000	46.675	538.511	248.060	218.143	1451.526			18000
18500	47.219	561.986	249.347	218.969	1475.001			18500
19000	47.710	585.722	250.613	219.785	1498.737			19000
19500	48.142	609.687	251.858	220.592	1522.702			19500
20000	48.504	633.852	253.081	221.389	1546.867			20000

*Assigned reference element phase change at 933.61 K

TABLE A6.—THERMODYNAMIC PROPERTIES FOR AL^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.756	----------	----------	274.334	285.071	----------	0
298.15	20.960	0.000	168.137	168.137	281.090	281.090	–43.0362	298.15
300	20.958	0.039	168.267	168.138	281.129	281.045	–42.7325	300
400	20.913	2.131	174.287	168.959	283.221	278.556	–30.5476	400
500	20.984	4.225	178.959	170.509	285.315	275.939	–23.3042	500
600	21.163	6.332	182.799	172.246	287.422	273.220	–18.5219	600
700	21.422	8.461	186.080	173.994	289.551	270.402	–15.1404	700
800	21.715	10.617	188.960	175.688	291.707	267.467	–12.6313	800
900	22.006	12.803	191.534	177.308	293.894	264.368	–10.7016	900
*1000	22.270	15.018	193.867	178.849	296.108	250.565	–9.2159	1000
1100	22.493	17.256	196.000	180.313	298.346	247.550	–8.0330	1100
1200	22.671	19.515	197.965	181.703	300.605	244.555	–7.0592	1200
1300	22.804	21.789	199.786	183.025	302.879	241.575	–6.2452	1300
1400	22.897	24.074	201.479	184.283	305.164	238.607	–5.5561	1400
1500	22.956	26.367	203.061	185.483	307.457	235.646	–4.9662	1500
1600	22.985	28.664	204.544	186.629	309.754	232.690	–4.4565	1600
1700	22.991	30.963	205.937	187.724	312.053	229.735	–4.0124	1700
1800	22.978	33.262	207.251	188.772	314.352	226.780	–3.6227	1800
1900	22.950	35.558	208.493	189.778	316.648	223.823	–3.2786	1900
2000	22.912	37.852	209.669	190.743	318.942	220.863	–2.9729	2000
2100	22.865	40.140	210.786	191.671	321.231	217.898	–2.7001	2100
2200	22.812	42.424	211.848	192.565	323.514	214.928	–2.4554	2200
2300	22.756	44.703	212.861	193.425	325.793	211.953	–2.2350	2300
2400	22.697	46.975	213.829	194.255	328.066	208.972	–2.0358	2400
2500	22.637	49.242	214.754	195.057	330.332	205.985	–1.8552	2500
2600	22.576	51.503	215.640	195.832	332.593	202.992	–1.6909	2600
2700	22.515	53.757	216.491	196.581	334.847	199.993	–1.5409	2700
2800	22.456	56.006	217.309	197.307	337.096	196.988	–1.4038	2800
2900	22.397	58.248	218.096	198.010	339.339	193.977	–1.2780	2900
3000	22.340	60.485	218.854	198.693	341.575	190.960	–1.1624	3000
3100	22.285	62.717	219.586	199.355	343.807	187.938	–1.0560	3100
3200	22.232	64.942	220.293	199.998	346.033	184.910	–0.9579	3200
3300	22.180	67.163	220.976	200.624	348.253	181.877	–0.8671	3300
3400	22.130	69.378	221.637	201.232	350.469	178.839	–0.7832	3400
3500	22.082	71.589	222.278	201.824	352.679	175.796	–0.7053	3500
3600	22.037	73.795	222.900	202.401	354.885	172.748	–0.6331	3600
3700	21.993	75.996	223.503	202.963	357.087	169.696	–0.5659	3700
3800	21.951	78.194	224.089	203.512	359.284	166.639	–0.5034	3800
3900	21.910	80.387	224.658	204.046	361.477	163.579	–0.4452	3900
4000	21.872	82.576	225.213	204.569	363.666	160.514	–0.3910	4000
4100	21.835	84.761	225.752	205.079	365.851	157.446	–0.3403	4100
4200	21.799	86.943	226.278	205.577	368.033	154.374	–0.2931	4200
4300	21.766	89.121	226.791	206.065	370.211	151.299	–0.2488	4300
4400	21.733	91.296	227.291	206.541	372.386	148.220	–0.2075	4400
4500	21.702	93.468	227.779	207.008	374.558	145.138	–0.1688	4500
4600	21.673	95.636	228.255	207.465	376.726	142.053	–0.1326	4600
4700	21.644	97.802	228.721	207.912	378.892	138.965	–0.0986	4700
4800	21.617	99.965	229.176	208.350	381.055	135.875	–0.0668	4800
4900	21.591	102.126	229.622	208.780	383.216	132.782	–0.0370	4900
5000	21.567	104.284	230.058	209.201	385.374	129.686	–0.0090	5000

TABLE A6.—THERMODYNAMIC PROPERTIES FOR AL^- (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.543	106.439	230.485	209.614	387.529	126.588	0.0173	5100
5200	21.520	108.592	230.903	210.020	389.682	123.487	0.0419	5200
5300	21.498	110.743	231.313	210.418	391.833	120.384	0.0650	5300
5400	21.477	112.892	231.714	210.808	393.982	117.280	0.0867	5400
5500	21.457	115.038	232.108	211.192	396.129	114.173	0.1071	5500
5600	21.438	117.183	232.495	211.569	398.273	111.064	0.1262	5600
5700	21.419	119.326	232.874	211.939	400.416	107.953	0.1441	5700
5800	21.402	121.467	233.246	212.304	402.557	104.840	0.1609	5800
5900	21.384	123.606	233.612	212.662	404.697	101.726	0.1767	5900
6000	21.368	125.744	233.971	213.014	406.834	98.610	0.1914	6000
6200	21.337	130.015	234.671	213.701	411.105			6200
6400	21.309	134.279	235.348	214.367	415.369			6400
6600	21.282	138.538	236.004	215.013	419.628			6600
6800	21.257	142.792	236.638	215.640	423.882			6800
7000	21.234	147.041	237.254	216.248	428.131			7000
7200	21.213	151.286	237.852	216.840	432.376			7200
7400	21.193	155.526	238.433	217.416	436.617			7400
7600	21.175	159.763	238.998	217.977	440.853			7600
7800	21.157	163.996	239.548	218.523	445.087			7800
8000	21.141	168.226	240.083	219.055	449.316			8000
8500	21.105	178.788	241.364	220.330	459.878			8500
9000	21.074	189.332	242.569	221.532	470.422			9000
9500	21.047	199.862	243.708	222.670	480.952			9500
10000	21.024	210.379	244.787	223.749	491.470			10000
10500	21.003	220.886	245.812	224.775	501.976			10500
11000	20.985	231.383	246.789	225.754	512.473			11000
11500	20.970	241.872	247.721	226.689	522.962			11500
12000	20.956	252.353	248.614	227.584	533.443			12000
12500	20.943	262.828	249.469	228.442	543.918			12500
13000	20.932	273.297	250.290	229.267	554.387			13000
13500	20.922	283.760	251.080	230.060	564.850			13500
14000	20.913	294.219	251.840	230.825	575.309			14000
14500	20.905	304.673	252.574	231.562	585.763			14500
15000	20.898	315.124	253.283	232.274	596.214			15000
15500	20.891	325.571	253.968	232.963	606.661			15500
16000	20.885	336.015	254.631	233.630	617.105			16000
16500	20.879	346.456	255.274	234.276	627.546			16500
17000	20.874	356.894	255.897	234.903	637.984			17000
17500	20.869	367.330	256.502	235.512	648.420			17500
18000	20.865	377.763	257.090	236.103	658.853			18000
18500	20.861	388.195	257.661	236.678	669.285			18500
19000	20.857	398.624	258.218	237.237	679.714			19000
19500	20.854	409.052	258.759	237.782	690.142			19500
20000	20.850	419.478	259.287	238.313	700.568			20000

*Assigned reference element phase change at 933.61 K

TABLE A7.—THERMODYNAMIC PROPERTIES FOR Ar

T	C_p°	$H^\circ - H^\circ(298.15)$	S°	$-[G^\circ - H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10} K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–6.197	0	----------	0
100	20.786	–4.119	132.139	173.327	–4.119	0	0	100
200	20.786	–2.040	146.547	156.748	–2.040	0	0	200
298.15	20.786	0.000	154.847	154.847	0.000	0	0	298.15
300	20.786	0.038	154.975	154.847	0.038	0	0	300
400	20.786	2.117	160.955	155.662	2.117	0	0	400
500	20.786	4.196	165.593	157.202	4.196	0	0	500
600	20.786	6.274	169.383	158.926	6.274	0	0	600
700	20.786	8.353	172.587	160.655	8.353	0	0	700
800	20.786	10.432	175.363	162.324	10.432	0	0	800
900	20.786	12.510	177.811	163.911	12.510	0	0	900
1000	20.786	14.589	180.001	165.413	14.589	0	0	1000
1100	20.786	16.667	181.982	166.830	16.667	0	0	1100
1200	20.786	18.746	183.791	168.169	18.746	0	0	1200
1300	20.786	20.825	185.455	169.436	20.825	0	0	1300
1400	20.786	22.903	186.995	170.636	22.903	0	0	1400
1500	20.786	24.982	188.429	171.775	24.982	0	0	1500
1600	20.786	27.061	189.771	172.858	27.061	0	0	1600
1700	20.786	29.139	191.031	173.890	29.139	0	0	1700
1800	20.786	31.218	192.219	174.876	31.218	0	0	1800
1900	20.786	33.296	193.343	175.819	33.296	0	0	1900
2000	20.786	35.375	194.409	176.722	35.375	0	0	2000
2100	20.786	37.454	195.423	177.588	37.454	0	0	2100
2200	20.786	39.532	196.390	178.421	39.532	0	0	2200
2300	20.786	41.611	197.314	179.223	41.611	0	0	2300
2400	20.786	43.690	198.199	179.995	43.690	0	0	2400
2500	20.786	45.768	199.048	180.740	45.768	0	0	2500
2600	20.786	47.847	199.863	181.460	47.847	0	0	2600
2700	20.786	49.926	200.647	182.156	49.926	0	0	2700
2800	20.786	52.004	201.403	182.830	52.004	0	0	2800
2900	20.786	54.083	202.133	183.483	54.083	0	0	2900
3000	20.786	56.161	202.837	184.117	56.161	0	0	3000
3100	20.786	58.240	203.519	184.732	58.240	0	0	3100
3200	20.786	60.319	204.179	185.329	60.319	0	0	3200
3300	20.786	62.397	204.819	185.910	62.397	0	0	3300
3400	20.786	64.476	205.439	186.476	64.476	0	0	3400
3500	20.786	66.555	206.042	187.026	66.555	0	0	3500
3600	20.786	68.633	206.627	187.562	68.633	0	0	3600
3700	20.786	70.712	207.197	188.085	70.712	0	0	3700
3800	20.786	72.790	207.751	188.596	72.790	0	0	3800
3900	20.786	74.869	208.291	189.094	74.869	0	0	3900
4000	20.786	76.948	208.817	189.580	76.948	0	0	4000
4100	20.786	79.026	209.331	190.056	79.026	0	0	4100
4200	20.786	81.105	209.831	190.521	81.105	0	0	4200
4300	20.786	83.184	210.321	190.976	83.184	0	0	4300
4400	20.786	85.262	210.798	191.421	85.262	0	0	4400
4500	20.786	87.341	211.266	191.856	87.341	0	0	4500

TABLE A7.—THERMODYNAMIC PROPERTIES FOR Ar (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.786	89.419	211.722	192.283	89.419	0	0	4600
4700	20.786	91.498	212.169	192.702	91.498	0	0	4700
4800	20.786	93.577	212.607	193.112	93.577	0	0	4800
4900	20.786	95.655	213.036	193.514	95.655	0	0	4900
5000	20.786	97.734	213.456	193.909	97.734	0	0	5000
5100	20.786	99.813	213.867	194.296	99.813	0	0	5100
5200	20.786	101.891	214.271	194.676	101.891	0	0	5200
5300	20.786	103.970	214.667	195.050	103.970	0	0	5300
5400	20.786	106.048	215.055	195.417	106.048	0	0	5400
5500	20.786	108.127	215.437	195.777	108.127	0	0	5500
5600	20.786	110.206	215.811	196.132	110.206	0	0	5600
5700	20.786	112.284	216.179	196.480	112.284	0	0	5700
5800	20.786	114.363	216.541	196.823	114.363	0	0	5800
5900	20.786	116.442	216.896	197.160	116.442	0	0	5900
6000	20.786	118.520	217.245	197.492	118.520	0	0	6000
6200	20.786	122.677	217.927	198.140	122.677	0	0	6200
6400	20.786	126.835	218.587	198.769	126.835	0	0	6400
6600	20.786	130.992	219.227	199.379	130.992	0	0	6600
6800	20.786	135.149	219.847	199.972	135.149	0	0	6800
7000	20.787	139.307	220.450	200.549	139.307	0	0	7000
7200	20.787	143.464	221.035	201.110	143.464	0	0	7200
7400	20.787	147.621	221.605	201.656	147.621	0	0	7400
7600	20.787	151.779	222.159	202.188	151.779	0	0	7600
7800	20.788	155.936	222.699	202.707	155.936	0	0	7800
8000	20.789	160.094	223.225	203.214	160.094	0	0	8000
8500	20.793	170.489	224.486	204.428	170.489	0	0	8500
9000	20.802	180.888	225.674	205.576	180.888	0	0	9000
9500	20.819	191.292	226.800	206.664	191.292	0	0	9500
10000	20.848	201.707	227.868	207.697	201.707	0	0	10000
10500	20.900	212.142	228.886	208.682	212.142	0	0	10500
11000	20.981	222.609	229.860	209.623	222.609	0	0	11000
11500	21.104	233.124	230.795	210.523	233.124	0	0	11500
12000	21.275	243.707	231.696	211.387	243.707	0	0	12000
12500	21.511	254.385	232.567	212.216	254.385	0	0	12500
13000	21.846	265.213	233.417	213.015	265.213	0	0	13000
13500	22.299	276.245	234.249	213.787	276.245	0	0	13500
14000	22.882	287.528	235.070	214.532	287.528	0	0	14000
14500	23.546	299.048	235.878	215.254	299.048	0	0	14500
15000	24.278	311.089	236.697	215.957	311.089	0	0	15000
15500	25.339	323.485	237.510	216.640	323.485	0	0	15500
16000	26.564	336.455	238.333	217.305	336.455	0	0	16000
16500	27.914	350.071	239.171	217.954	350.071	0	0	16500
17000	29.343	364.382	240.025	218.591	364.382	0	0	17000
17500	30.806	379.420	240.897	219.216	379.420	0	0	17500
18000	32.259	395.186	241.785	219.830	395.186	0	0	18000
18500	33.664	411.670	242.688	220.436	411.670	0	0	18500
19000	34.989	428.838	243.604	221.033	428.838	0	0	19000
19500	36.218	446.643	244.529	221.624	446.643	0	0	19500
20000	37.342	465.037	245.460	222.208	465.037	0	0	20000

TABLE A8.—THERMODYNAMIC PROPERTIES FOR Ar^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.206	----------	----------	1520.572	1520.572	----------	0
298.15	20.984	0.000	166.406	166.406	1526.778	1526.778	–265.7789	298.15
300	20.991	0.039	166.536	166.406	1526.817	1526.817	–264.1294	300
400	21.423	2.158	172.629	167.234	1528.937	1528.937	–197.6289	400
500	21.915	4.325	177.463	168.813	1531.104	1531.104	–157.6721	500
600	22.319	6.538	181.496	170.600	1533.316	1533.316	–130.9959	600
700	22.588	8.784	184.959	172.409	1535.563	1535.563	–111.9136	700
800	22.734	11.052	187.986	174.171	1537.830	1537.830	–97.5807	800
900	22.786	13.328	190.667	175.858	1540.107	1540.107	–86.4164	900
1000	22.773	15.607	193.068	177.461	1542.385	1542.385	–77.4717	1000
1100	22.719	17.882	195.236	178.980	1544.660	1544.660	–70.1425	1100
1200	22.639	20.150	197.210	180.418	1546.928	1546.928	–64.0258	1200
1300	22.547	22.409	199.018	181.780	1549.187	1549.187	–58.8425	1300
1400	22.449	24.659	200.685	183.072	1551.437	1551.437	–54.3933	1400
1500	22.350	26.899	202.231	184.298	1553.677	1553.677	–50.5316	1500
1600	22.254	29.129	203.670	185.465	1555.907	1555.907	–47.1479	1600
1700	22.163	31.350	205.017	186.576	1558.128	1558.128	–44.1579	1700
1800	22.076	33.562	206.281	187.636	1560.340	1560.340	–41.4964	1800
1900	21.995	35.765	207.472	188.649	1562.543	1562.543	–39.1116	1900
2000	21.920	37.961	208.599	189.618	1564.739	1564.739	–36.9623	2000
2100	21.850	40.149	209.666	190.548	1566.928	1566.928	–35.0150	2100
2200	21.785	42.331	210.681	191.440	1569.109	1569.109	–33.2422	2200
2300	21.725	44.506	211.648	192.298	1571.285	1571.285	–31.6214	2300
2400	21.670	46.676	212.572	193.123	1573.454	1573.454	–30.1335	2400
2500	21.619	48.840	213.455	193.919	1575.619	1575.619	–28.7628	2500
2600	21.572	51.000	214.302	194.687	1577.778	1577.778	–27.4958	2600
2700	21.528	53.155	215.116	195.429	1579.933	1579.933	–26.3210	2700
2800	21.488	55.306	215.898	196.146	1582.084	1582.084	–25.2287	2800
2900	21.450	57.453	216.651	196.840	1584.231	1584.231	–24.2103	2900
3000	21.416	59.596	217.378	197.512	1586.374	1586.374	–23.2585	3000
3100	21.384	61.736	218.079	198.165	1588.514	1588.514	–22.3669	3100
3200	21.354	63.873	218.758	198.798	1590.651	1590.651	–21.5300	3200
3300	21.326	66.007	219.414	199.412	1592.785	1592.785	–20.7427	3300
3400	21.300	68.138	220.051	200.010	1594.916	1594.916	–20.0007	3400
3500	21.276	70.267	220.668	200.592	1597.045	1597.045	–19.3001	3500
3600	21.253	72.393	221.267	201.158	1599.171	1599.171	–18.6376	3600
3700	21.232	74.517	221.849	201.709	1601.296	1601.296	–18.0101	3700
3800	21.213	76.640	222.415	202.247	1603.418	1603.418	–17.4148	3800
3900	21.194	78.760	222.966	202.771	1605.538	1605.538	–16.8494	3900
4000	21.177	80.878	223.502	203.282	1607.657	1607.657	–16.3114	4000
4100	21.160	82.995	224.025	203.782	1609.774	1609.774	–15.7991	4100
4200	21.145	85.111	224.534	204.270	1611.889	1611.889	–15.3104	4200
4300	21.131	87.224	225.032	204.747	1614.003	1614.003	–14.8439	4300
4400	21.117	89.337	225.517	205.214	1616.115	1616.115	–14.3981	4400
4500	21.104	91.448	225.992	205.670	1618.226	1618.226	–13.9715	4500
4600	21.092	93.558	226.456	206.117	1620.336	1620.336	–13.5629	4600
4700	21.081	95.666	226.909	206.555	1622.445	1622.445	–13.1711	4700
4800	21.070	97.774	227.353	206.983	1624.552	1624.552	–12.7952	4800
4900	21.060	99.880	227.787	207.403	1626.659	1626.659	–12.4342	4900
5000	21.050	101.986	228.212	207.815	1628.764	1628.764	–12.0872	5000

TABLE A8.—THERMODYNAMIC PROPERTIES FOR Ar^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.041	104.090	228.629	208.219	1630.869	1630.869	–11.7534	5100
5200	21.032	106.194	229.038	208.616	1632.972	1632.972	–11.4319	5200
5300	21.024	108.297	229.438	209.005	1635.075	1635.075	–11.1223	5300
5400	21.016	110.399	229.831	209.387	1637.177	1637.177	–10.8237	5400
5500	21.008	112.500	230.217	209.762	1639.278	1639.278	–10.5355	5500
5600	21.001	114.600	230.595	210.131	1641.379	1641.379	–10.2574	5600
5700	20.994	116.700	230.967	210.493	1643.478	1643.478	–9.9886	5700
5800	20.988	118.799	231.332	210.849	1645.577	1645.577	–9.7288	5800
5900	20.982	120.898	231.691	211.199	1647.676	1647.676	–9.4774	5900
6000	20.976	122.995	232.043	211.544	1649.774	1649.774	–9.2342	6000
6200	20.965	127.189	232.731	212.216	1653.968	1653.968	–8.7703	6200
6400	20.954	131.381	233.396	212.868	1658.160	1658.160	–8.3343	6400
6600	20.945	135.571	234.041	213.500	1662.350	1662.350	–7.9237	6600
6800	20.936	139.759	234.666	214.113	1666.538	1666.538	–7.5363	6800
7000	20.929	143.946	235.273	214.709	1670.724	1670.724	–7.1701	7000
7200	20.921	148.131	235.862	215.289	1674.909	1674.909	–6.8233	7200
7400	20.915	152.314	236.435	215.852	1679.093	1679.093	–6.4945	7400
7600	20.908	156.497	236.993	216.401	1683.275	1683.275	–6.1822	7600
7800	20.902	160.678	237.536	216.936	1687.456	1687.455	–5.8852	7800
8000	20.897	164.858	238.065	217.458	1691.636	1691.635	–5.6024	8000
8500	20.885	175.303	239.332	218.708	1702.082	1702.078	–4.9507	8500
9000	20.875	185.743	240.525	219.887	1712.521	1712.513	–4.3679	9000
9500	20.866	196.178	241.654	221.003	1722.957	1722.937	–3.8432	9500
10000	20.859	206.610	242.724	222.063	1733.388	1733.347	–3.3682	10000
10500	20.853	217.038	243.741	223.071	1743.816	1743.732	–2.9358	10500
11000	20.848	227.463	244.711	224.033	1754.241	1754.084	–2.5403	11000
11500	20.844	237.885	245.638	224.952	1764.664	1764.384	–2.1771	11500
12000	20.841	248.307	246.525	225.833	1775.085	1774.616	–1.8423	12000
12500	20.840	258.727	247.376	226.677	1785.505	1784.751	–1.5324	12500
13000	20.841	269.147	248.193	227.489	1795.925	1794.736	–1.2448	13000
13500	20.844	279.568	248.980	228.271	1806.346	1804.519	–0.9770	13500
14000	20.851	289.992	249.738	229.024	1816.770	1814.053	–0.7269	14000
14500	20.862	300.420	250.470	229.751	1827.198	1823.354	–0.4929	14500
15000	20.879	310.854	251.177	230.453	1837.633	1832.416	–0.2734	15000
15500	20.903	321.300	251.862	231.133	1848.078	1840.951	–0.0671	15500
16000	20.936	331.759	252.526	231.791	1858.537	1848.887	0.1272	16000
16500	20.979	342.237	253.171	232.429	1869.015	1856.190	0.3105	16500
17000	21.036	352.740	253.798	233.049	1879.519	1862.993	0.4837	17000
17500	21.109	363.276	254.409	233.650	1890.054	1869.120	0.6476	17500
18000	21.200	373.852	255.005	234.235	1900.630	1876.577	0.8036	18000
18500	21.312	384.478	255.587	234.805	1911.257	1881.245	0.9509	18500
19000	21.449	395.166	256.157	235.359	1921.945	1885.645	1.0911	19000
19500	21.613	405.929	256.716	235.899	1932.708	1891.402	1.2251	19500
20000	21.807	416.781	257.266	236.427	1943.560	1897.441	1.3530	20000

TABLE A9.—THERMODYNAMIC PROPERTIES FOR B

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.316	----------	----------	569.283	570.497	----------	0
100	20.881	–4.125	130.690	171.939	571.474	572.664	–292.3111	100
200	20.809	–2.042	145.133	155.341	573.557	574.414	–142.5634	200
298.15	20.797	0.000	153.438	153.438	575.599	575.599	–93.1301	298.15
300	20.796	0.038	153.567	153.439	575.637	575.616	–92.5082	300
400	20.792	2.118	159.549	154.254	577.717	576.333	–67.4372	400
500	20.790	4.197	164.188	155.795	579.796	576.681	–52.3805	500
600	20.789	6.276	167.979	157.519	581.875	576.779	–42.3388	600
700	20.788	8.355	171.183	159.248	583.953	576.702	–35.1659	700
800	20.788	10.433	173.959	160.917	586.032	576.498	–29.7877	800
900	20.787	12.512	176.408	162.505	588.111	576.196	–25.6064	900
1000	20.787	14.591	178.598	164.007	590.190	575.812	–22.2633	1000
1100	20.787	16.670	180.579	165.425	592.268	575.360	–19.5301	1100
1200	20.787	18.748	182.388	166.764	594.347	574.851	–17.2543	1200
1300	20.787	20.827	184.051	168.031	596.426	574.288	–15.3305	1300
1400	20.787	22.906	185.592	169.231	598.504	573.676	–13.6831	1400
1500	20.787	24.984	187.026	170.370	600.583	573.021	–12.2570	1500
1600	20.787	27.063	188.368	171.453	602.662	572.324	–11.0107	1600
1700	20.787	29.142	189.628	172.486	604.740	571.586	–9.9123	1700
1800	20.787	31.220	190.816	173.471	606.819	570.810	–8.9372	1800
1900	20.787	33.299	191.940	174.414	608.898	569.997	–8.0661	1900
2000	20.787	35.378	193.006	175.317	610.976	569.148	–7.2831	2000
2100	20.786	37.456	194.020	176.184	613.055	568.264	–6.5758	2100
2200	20.786	39.535	194.987	177.017	615.134	567.346	–5.9339	2200
2300	20.787	41.614	195.911	177.818	617.212	566.393	–5.3487	2300
*2400	20.787	43.692	196.796	178.591	619.291	515.150	–4.8365	2400
2500	20.787	45.771	197.644	179.336	621.370	514.053	–4.3885	2500
2600	20.787	47.850	198.460	180.056	623.448	512.957	–3.9758	2600
2700	20.787	49.928	199.244	180.752	625.527	511.861	–3.5945	2700
2800	20.788	52.007	200.000	181.426	627.606	510.764	–3.2413	2800
2900	20.788	54.086	200.730	182.079	629.685	509.668	–2.9131	2900
3000	20.789	56.165	201.434	182.713	631.764	508.572	–2.6074	3000
3100	20.791	58.244	202.116	183.328	633.843	507.476	–2.3220	3100
3200	20.793	60.323	202.776	183.925	635.922	506.380	–2.0551	3200
3300	20.795	62.402	203.416	184.506	638.001	505.285	–1.8049	3300
3400	20.799	64.482	204.037	185.072	640.081	504.189	–1.5699	3400
3500	20.803	66.562	204.640	185.622	642.161	503.094	–1.3489	3500
3600	20.808	68.643	205.226	186.159	644.241	502.000	–1.1405	3600
3700	20.814	70.724	205.796	186.682	646.323	500.906	–0.9439	3700
3800	20.822	72.806	206.351	187.192	648.404	499.813	–0.7580	3800
3900	20.831	74.888	206.892	187.690	650.487	498.721	–0.5820	3900
4000	20.842	76.972	207.420	188.177	652.571	497.629	–0.4152	4000
4100	20.855	79.057	207.935	188.653	654.656	496.539	–0.2569	4100
4200	20.870	81.143	208.437	189.118	656.742	495.450	–0.1065	4200
4300	20.887	83.231	208.929	189.573	658.830	494.363	0.0367	4300
4400	20.906	85.321	209.409	190.018	660.919	493.278	0.1730	4400
4500	20.928	87.412	209.879	190.454	663.011	492.194	0.3030	4500

TABLE A9.—THERMODYNAMIC PROPERTIES FOR B (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.952	89.506	210.339	190.882	665.105	491.113	0.4271	4600
4700	20.979	91.603	210.790	191.300	667.201	490.035	0.5456	4700
4800	21.009	93.702	211.232	191.711	669.301	488.959	0.6589	4800
4900	21.042	95.805	211.666	192.114	671.403	487.887	0.7674	4900
5000	21.078	97.911	212.091	192.509	673.509	486.818	0.8713	5000
5100	21.118	100.020	212.509	192.897	675.619	485.753	0.9709	5100
5200	21.160	102.134	212.920	193.278	677.733	484.692	1.0665	5200
5300	21.206	104.253	213.323	193.653	679.851	483.635	1.1582	5300
5400	21.256	106.376	213.720	194.021	681.974	482.583	1.2464	5400
5500	21.309	108.504	214.110	194.382	684.103	481.536	1.3312	5500
5600	21.365	110.638	214.495	194.738	686.236	480.495	1.4128	5600
5700	21.425	112.777	214.874	195.088	688.376	479.459	1.4913	5700
5800	21.489	114.923	215.247	195.432	690.521	478.430	1.5670	5800
5900	21.557	117.075	215.615	195.771	692.674	477.407	1.6399	5900
6000	21.628	119.234	215.978	196.105	694.833	476.391	1.7103	6000
6200	21.782	123.575	216.689	196.758	699.174			6200
6400	21.946	127.946	217.383	197.391	703.544			6400
6600	22.129	132.353	218.061	198.008	707.952			6600
6800	22.326	136.798	218.725	198.607	712.397			6800
7000	22.537	141.284	219.375	199.191	716.883			7000
7200	22.763	145.814	220.013	199.761	721.413			7200
7400	22.978	150.453	220.650	200.318	726.052			7400
7600	23.205	155.071	221.265	200.861	730.670			7600
7800	23.448	159.737	221.871	201.392	735.335			7800
8000	23.708	164.452	222.468	201.912	740.051			8000
8500	24.420	176.481	223.926	203.164	752.079			8500
9000	25.205	188.884	225.344	204.357	764.483			9000
9500	26.034	201.693	226.729	205.498	777.292			9500
10000	26.880	214.921	228.086	206.594	790.520			10000
10500	27.718	228.572	229.418	207.649	804.171			10500
11000	28.525	242.634	230.726	208.668	818.233			11000
11500	29.282	257.088	232.011	209.655	832.687			11500
12000	29.976	271.905	233.272	210.613	847.504			12000
12500	30.595	287.051	234.509	211.544	862.650			12500
13000	31.134	302.487	235.719	212.451	878.085			13000
13500	31.586	318.171	236.903	213.335	893.770			13500
14000	31.952	334.060	238.059	214.197	909.658			14000
14500	32.232	350.109	239.185	215.039	925.707			14500
15000	32.427	366.277	240.281	215.863	941.875			15000
15500	32.543	382.523	241.347	216.668	958.121			15500
16000	32.585	398.807	242.381	217.455	974.406			16000
16500	32.560	415.097	243.383	218.226	990.696			16500
17000	32.475	431.357	244.354	218.980	1006.956			17000
17500	32.339	447.563	245.294	219.718	1023.162			17500
18000	32.160	463.689	246.202	220.442	1039.288			18000
18500	31.947	479.716	247.080	221.150	1055.315			18500
19000	31.710	495.633	247.929	221.843	1071.231			19000
19500	31.459	511.425	248.750	222.523	1087.023			19500
20000	31.203	527.090	249.543	223.188	1102.688			20000

***Assigned reference element phase change at 2350 K**

TABLE A10.—THERMODYNAMIC PROPERTIES FOR B^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1376.118	1371.135	----------	0
298.15	20.786	0.000	138.545	138.545	1382.316	1382.316	–234.1421	298.15
300	20.786	0.038	138.674	138.546	1382.354	1382.371	–232.6486	300
400	20.786	2.117	144.654	139.361	1384.433	1385.166	–172.4205	400
500	20.786	4.196	149.292	140.901	1386.511	1387.592	–136.2146	500
600	20.786	6.274	153.082	142.625	1388.590	1389.768	–112.0370	600
700	20.786	8.353	156.286	144.353	1390.668	1391.770	–94.7412	700
800	20.786	10.432	159.062	146.022	1392.747	1393.645	–81.7512	800
900	20.786	12.510	161.510	147.610	1394.826	1395.421	–71.6346	900
1000	20.786	14.589	163.700	149.111	1396.904	1397.115	–63.5312	1000
1100	20.786	16.667	165.681	150.529	1398.983	1398.742	–56.8932	1100
1200	20.786	18.746	167.490	151.868	1401.062	1400.312	–51.3553	1200
1300	20.786	20.825	169.154	153.134	1403.140	1401.827	–46.6642	1300
1400	20.786	22.903	170.694	154.334	1405.219	1403.294	–42.6389	1400
1500	20.786	24.982	172.128	155.473	1407.298	1404.717	–39.1468	1500
1600	20.786	27.061	173.470	156.557	1409.376	1406.099	–36.0881	1600
1700	20.786	29.139	174.730	157.589	1411.455	1407.439	–33.3866	1700
1800	20.786	31.218	175.918	158.575	1413.533	1408.742	–30.9830	1800
1900	20.786	33.296	177.042	159.517	1415.612	1410.008	–28.8306	1900
2000	20.786	35.375	178.108	160.420	1417.691	1411.238	–26.8916	2000
2100	20.786	37.454	179.122	161.287	1419.769	1412.432	–25.1358	2100
2200	20.786	39.532	180.089	162.120	1421.848	1413.592	–23.5382	2200
2300	20.786	41.611	181.013	162.921	1423.927	1414.719	–22.0784	2300
*2400	20.786	43.690	181.898	163.694	1426.005	1365.553	–20.7625	2400
2500	20.786	45.768	182.746	164.439	1428.084	1366.536	–19.5733	2500
2600	20.786	47.847	183.561	165.159	1430.162	1367.518	–18.4747	2600
2700	20.786	49.926	184.346	165.855	1432.241	1368.500	–17.4569	2700
2800	20.786	52.004	185.102	166.529	1434.320	1369.482	–16.5110	2800
2900	20.787	54.083	185.831	167.182	1436.398	1370.465	–15.6298	2900
3000	20.787	56.161	186.536	167.816	1438.477	1371.447	–14.8067	3000
3100	20.787	58.240	187.218	168.430	1440.556	1372.429	–14.0361	3100
3200	20.787	60.319	187.878	169.028	1442.634	1373.412	–13.3132	3200
3300	20.788	62.398	188.517	169.609	1444.713	1374.394	–12.6336	3300
3400	20.789	64.476	189.138	170.174	1446.792	1375.376	–11.9936	3400
3500	20.790	66.555	189.740	170.725	1448.871	1376.359	–11.3897	3500
3600	20.792	68.634	190.326	171.261	1450.950	1377.342	–10.8189	3600
3700	20.794	70.714	190.896	171.784	1453.029	1378.325	–10.2786	3700
3800	20.797	72.793	191.450	172.294	1455.109	1379.308	–9.7664	3800
3900	20.801	74.873	191.991	172.792	1457.189	1380.291	–9.2800	3900
4000	20.806	76.954	192.517	173.279	1459.269	1381.275	–8.8177	4000
4100	20.812	79.034	193.031	173.755	1461.350	1382.260	–8.3776	4100
4200	20.820	81.116	193.533	174.220	1463.432	1383.245	–7.9582	4200
4300	20.830	83.199	194.023	174.674	1465.514	1384.231	–7.5580	4300
4400	20.842	85.282	194.502	175.120	1467.598	1385.218	–7.1757	4400
4500	20.856	87.367	194.970	175.556	1469.683	1386.207	–6.8102	4500
4600	20.873	89.453	195.429	175.983	1471.769	1387.197	–6.4602	4600
4700	20.892	91.542	195.878	176.401	1473.857	1388.189	–6.1250	4700
4800	20.915	93.632	196.318	176.812	1475.947	1389.183	–5.8035	4800
4900	20.942	95.725	196.750	177.214	1478.040	1390.179	–5.4948	4900
5000	20.972	97.820	197.173	177.609	1480.136	1391.178	–5.1984	5000

TABLE A10.—THERMODYNAMIC PROPERTIES FOR B^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.007	99.919	197.589	177.997	1482.235	1392.181	–4.9133	5100
5200	21.046	102.022	197.997	178.377	1484.337	1393.187	–4.6390	5200
5300	21.090	104.129	198.398	178.751	1486.444	1394.198	–4.3748	5300
5400	21.139	106.240	198.793	179.119	1488.556	1395.213	–4.1203	5400
5500	21.194	108.357	199.181	179.480	1490.672	1396.233	–3.8748	5500
5600	21.254	110.479	199.564	179.835	1492.795	1397.259	–3.6380	5600
5700	21.321	112.608	199.941	180.185	1494.923	1398.291	–3.4092	5700
5800	21.394	114.743	200.312	180.529	1497.059	1399.330	–3.1882	5800
5900	21.473	116.887	200.678	180.867	1499.202	1400.377	–2.9746	5900
6000	21.559	119.038	201.040	181.200	1501.354	1401.432	–2.7679	6000
6200	21.751	123.369	201.750	181.852	1505.684			6200
6400	21.973	127.741	202.444	182.484	1510.056			6400
6600	22.224	132.160	203.124	183.100	1514.475			6600
6800	22.504	136.632	203.791	183.698	1518.948			6800
7000	22.815	141.164	204.448	184.282	1523.479			7000
7200	23.156	145.760	205.096	184.851	1528.076			7200
7400	23.525	150.428	205.735	185.407	1532.743			7400
7600	23.922	155.172	206.368	185.950	1537.488			7600
7800	24.345	159.998	206.994	186.482	1542.314			7800
8000	24.793	164.912	207.616	187.002	1547.227			8000
8500	26.006	177.606	209.155	188.260	1559.922			8500
9000	27.323	190.935	210.678	189.463	1573.251			9000
9500	28.701	204.939	212.192	190.620	1587.255			9500
10000	30.098	219.639	213.700	191.736	1601.955			10000
10500	31.474	235.034	215.202	192.818	1617.350			10500
11000	32.791	251.104	216.697	193.869	1633.419			11000
11500	34.020	267.810	218.182	194.894	1650.126			11500
12000	35.136	285.104	219.654	195.895	1667.420			12000
12500	36.126	302.925	221.109	196.875	1685.241			12500
13000	36.979	321.207	222.543	197.835	1703.523			13000
13500	37.695	339.882	223.952	198.776	1722.197			13500
14000	38.275	358.880	225.334	199.700	1741.195			14000
14500	38.728	378.136	226.685	200.607	1760.451			14500
15000	39.064	397.588	228.004	201.498	1779.904			15000
15500	39.294	417.182	229.289	202.374	1799.497			15500
16000	39.433	436.867	230.539	203.235	1819.183			16000
16500	39.495	456.602	231.754	204.081	1838.918			16500
17000	39.493	476.351	232.933	204.912	1858.667			17000
17500	39.440	496.086	234.077	205.729	1878.402			17500
18000	39.348	515.785	235.187	206.532	1898.100			18000
18500	39.229	535.429	236.263	207.321	1917.745			18500
19000	39.091	555.009	237.308	208.097	1937.324			19000
19500	38.943	574.516	238.321	208.859	1956.832			19500
20000	38.790	593.944	239.305	209.608	1976.259			20000

***Assigned reference element phase change at 2350 K**

TABLE A11.—THERMODYNAMIC PROPERTIES FOR B^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.273	----------	----------	536.359	543.770	----------	0
298.15	20.788	0.000	156.814	156.814	542.631	542.631	–88.2740	298.15
300	20.788	0.038	156.943	156.815	542.670	542.611	–87.6878	300
400	20.787	2.117	162.923	157.630	544.749	541.248	–64.0943	400
500	20.787	4.196	167.562	159.170	546.827	539.517	–49.9790	500
600	20.787	6.275	171.352	160.894	548.906	537.536	–40.6014	600
700	20.787	8.353	174.556	162.623	550.985	535.381	–33.9289	700
800	20.787	10.432	177.332	164.292	553.063	533.098	–28.9453	800
900	20.786	12.511	179.780	165.879	555.142	530.717	–25.0861	900
1000	20.786	14.589	181.970	167.381	557.221	528.254	–22.0128	1000
1100	20.786	16.668	183.951	168.798	559.299	525.724	–19.5102	1100
1200	20.786	18.747	185.760	170.138	561.378	523.136	–17.4348	1200
1300	20.786	20.825	187.424	171.404	563.457	520.494	–15.6875	1300
1400	20.786	22.904	188.964	172.604	565.535	517.804	–14.1975	1400
1500	20.786	24.982	190.398	173.743	567.614	515.070	–12.9128	1500
1600	20.786	27.061	191.740	174.826	569.693	512.294	–11.7948	1600
1700	20.786	29.140	193.000	175.859	571.771	509.477	–10.8137	1700
1800	20.786	31.218	194.188	176.844	573.850	506.623	–9.9464	1800
1900	20.786	33.297	195.312	177.787	575.928	503.731	–9.1748	1900
2000	20.786	35.376	196.378	178.690	578.007	500.804	–8.4843	2000
2100	20.786	37.454	197.392	179.557	580.086	497.841	–7.8634	2100
2200	20.786	39.533	198.359	180.390	582.164	494.844	–7.3022	2200
2300	20.786	41.612	199.283	181.191	584.243	491.813	–6.7929	2300
*2400	20.786	43.690	200.168	181.964	586.322	438.491	–6.3522	2400
2500	20.786	45.769	201.016	182.709	588.400	435.316	–5.9718	2500
2600	20.786	47.847	201.832	183.429	590.479	432.141	–5.6233	2600
2700	20.786	49.926	202.616	184.125	592.558	428.966	–5.3029	2700
2800	20.786	52.005	203.372	184.799	594.636	425.791	–5.0076	2800
2900	20.786	54.083	204.101	185.452	596.715	422.616	–4.7347	2900
3000	20.786	56.162	204.806	186.085	598.793	419.441	–4.4819	3000
3100	20.786	58.241	205.488	186.700	600.872	416.266	–4.2472	3100
3200	20.786	60.319	206.148	187.298	602.951	413.091	–4.0289	3200
3300	20.786	62.398	206.787	187.879	605.029	409.916	–3.8253	3300
3400	20.786	64.476	207.408	188.444	607.108	406.741	–3.6352	3400
3500	20.786	66.555	208.010	188.995	609.187	403.566	–3.4574	3500
3600	20.786	68.634	208.596	189.531	611.265	400.391	–3.2907	3600
3700	20.786	70.712	209.165	190.054	613.344	397.216	–3.1343	3700
3800	20.786	72.791	209.720	190.564	615.422	394.041	–2.9873	3800
3900	20.786	74.870	210.260	191.062	617.501	390.866	–2.8490	3900
4000	20.786	76.948	210.786	191.549	619.580	387.691	–2.7187	4000
4100	20.786	79.027	211.299	192.024	621.658	384.516	–2.5957	4100
4200	20.786	81.105	211.800	192.489	623.737	381.341	–2.4795	4200
4300	20.786	83.184	212.289	192.944	625.816	378.166	–2.3697	4300
4400	20.786	85.263	212.767	193.389	627.894	374.991	–2.2657	4400
4500	20.786	87.341	213.234	193.825	629.973	371.816	–2.1672	4500
4600	20.786	89.420	213.691	194.252	632.051	368.641	–2.0738	4600
4700	20.786	91.499	214.138	194.670	634.130	365.466	–1.9851	4700
4800	20.786	93.577	214.576	195.080	636.209	362.291	–1.9009	4800
4900	20.786	95.656	215.004	195.483	638.287	359.116	–1.8208	4900
5000	20.786	97.735	215.424	195.877	640.366	355.941	–1.7445	5000

TABLE A11.—THERMODYNAMIC PROPERTIES FOR B^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	215.836	196.265	642.445	352.766	–1.6719	5100
5200	20.786	101.892	216.240	196.645	644.523	349.591	–1.6028	5200
5300	20.786	103.970	216.635	197.018	646.602	346.416	–1.5368	5300
5400	20.786	106.049	217.024	197.385	648.681	343.241	–1.4739	5400
5500	20.786	108.128	217.405	197.746	650.759	340.066	–1.4138	5500
5600	20.786	110.206	217.780	198.100	652.838	336.891	–1.3564	5600
5700	20.786	112.285	218.148	198.449	654.916	333.716	–1.3015	5700
5800	20.786	114.364	218.509	198.792	656.995	330.541	–1.2490	5800
5900	20.786	116.442	218.865	199.129	659.074	327.366	–1.1988	5900
6000	20.786	118.521	219.214	199.461	661.152	324.191	–1.1508	6000
6200	20.786	122.678	219.896	200.109	665.310			6200
6400	20.786	126.835	220.556	200.738	669.467			6400
6600	20.786	130.993	221.195	201.348	673.624			6600
6800	20.786	135.150	221.816	201.941	677.781			6800
7000	20.786	139.307	222.418	202.517	681.939			7000
7200	20.786	143.464	223.004	203.078	686.096			7200
7400	20.786	147.622	223.573	203.625	690.253			7400
7600	20.786	151.779	224.128	204.157	694.410			7600
7800	20.786	155.936	224.668	204.676	698.568			7800
8000	20.786	160.093	225.194	205.182	702.725			8000
8500	20.786	170.486	226.454	206.397	713.118			8500
9000	20.786	180.880	227.642	207.544	723.511			9000
9500	20.786	191.273	228.766	208.632	733.904			9500
10000	20.786	201.666	229.832	209.666	744.297			10000
10500	20.786	212.059	230.846	210.650	754.691			10500
11000	20.786	222.452	231.813	211.590	765.084			11000
11500	20.786	232.845	232.737	212.490	775.477			11500
12000	20.786	243.238	233.622	213.352	785.870			12000
12500	20.786	253.632	234.471	214.180	796.263			12500
13000	20.786	264.025	235.286	214.976	806.656			13000
13500	20.786	274.418	236.070	215.743	817.049			13500
14000	20.786	284.811	236.826	216.483	827.443			14000
14500	20.786	295.204	237.556	217.197	837.836			14500
15000	20.786	305.597	238.260	217.887	848.229			15000
15500	20.786	315.990	238.942	218.555	858.622			15500
16000	20.786	326.384	239.602	219.203	869.015			16000
16500	20.786	336.777	240.241	219.831	879.408			16500
17000	20.786	347.170	240.862	220.440	889.801			17000
17500	20.786	357.563	241.465	221.032	900.194			17500
18000	20.786	367.956	242.050	221.608	910.588			18000
18500	20.786	378.349	242.620	222.168	920.981			18500
19000	20.786	388.742	243.174	222.714	931.374			19000
19500	20.786	399.136	243.714	223.245	941.767			19500
20000	20.786	409.529	244.240	223.764	952.160			20000

*Assigned reference element phase change at 2350 K

TABLE A12.—THERMODYNAMIC PROPERTIES FOR Ba

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	178.803	185.710	----------	0
100	20.786	–4.119	147.539	188.727	180.881	186.095	–91.2710	100
200	20.786	–2.040	161.947	172.148	182.960	185.629	–42.7119	200
298.15	20.786	0.000	170.247	170.247	185.000	185.000	–26.7747	298.15
300	20.786	0.038	170.375	170.247	185.038	184.986	–26.5749	300
400	20.786	2.117	176.355	171.062	187.117	184.166	–18.5383	400
500	20.786	4.196	180.993	172.602	189.196	183.177	–13.7401	500
600	20.786	6.274	184.783	174.326	191.274	182.018	–10.5601	600
700	20.787	8.353	187.987	176.055	193.353	180.689	–8.3041	700
800	20.788	10.432	190.763	177.724	195.432	179.191	–6.6252	800
900	20.796	12.511	193.212	179.311	197.511	177.525	–5.3310	900
1000	20.821	14.591	195.404	180.813	199.591	175.690	–4.3057	1000
*1100	20.884	16.676	197.391	182.231	201.676	165.925	–3.5132	1100
1200	21.015	18.770	199.213	183.571	203.770	164.019	–2.8603	1200
1300	21.170	20.892	200.918	184.847	205.892	162.141	–2.3138	1300
1400	21.843	23.040	202.509	186.052	208.040	160.289	–1.8511	1400
1500	22.865	25.273	204.049	187.201	210.273	158.521	–1.4546	1500
1600	24.184	27.623	205.565	188.301	212.623	156.871	–1.1113	1600
1700	25.738	30.117	207.077	189.361	215.117	155.366	–0.8115	1700
1800	27.466	32.776	208.596	190.387	217.776	154.025	–0.5475	1800
1900	29.312	35.614	210.131	191.386	220.614	152.863	–0.3131	1900
2000	31.227	38.641	211.683	192.362	223.641	151.889	–0.1037	2000
2100	33.168	41.861	213.253	193.319	226.861	151.109	0.0847	2100
2200	35.099	45.274	214.841	194.261	230.274	150.523	0.2552	2200
2300	36.992	48.879	216.443	195.191	233.879	150.128	0.4104	2300
2400	38.821	52.670	218.056	196.110	237.670	149.919	0.5523	2400
2500	40.570	56.641	219.677	197.020	241.641	149.889	0.6828	2500
2600	42.222	60.781	221.300	197.923	245.781	150.030	0.8033	2600
2700	43.768	65.082	222.923	198.819	250.082	150.330	0.9150	2700
2800	45.199	69.531	224.541	199.709	254.531	150.779	1.0190	2800
2900	46.511	74.117	226.150	200.593	259.117	151.366	1.1162	2900
3000	47.700	78.829	227.748	201.471	263.829	152.077	1.2073	3000
3100	48.765	83.653	229.329	202.344	268.653	152.902	1.2929	3100
3200	49.709	88.578	230.893	203.212	273.578	153.826	1.3737	3200
3300	50.531	93.591	232.435	204.074	278.591	154.839	1.4500	3300
3400	51.237	98.680	233.955	204.931	283.680	155.929	1.5223	3400
3500	51.829	103.834	235.449	205.782	288.834	157.083	1.5910	3500
3600	52.313	109.042	236.916	206.626	294.042	158.291	1.6564	3600
3700	52.694	114.293	238.354	207.464	299.293	159.542	1.7187	3700
3800	52.978	119.578	239.764	208.296	304.578	160.827	1.7782	3800
3900	53.171	124.886	241.142	209.120	309.886	162.135	1.8351	3900
4000	53.281	130.209	242.490	209.938	315.209	163.458	1.8896	4000
4100	53.312	135.540	243.806	210.748	320.540	164.788	1.9419	4100
4200	53.273	140.870	245.091	211.550	325.870	166.118	1.9921	4200
4300	53.170	146.192	246.343	212.345	331.192	167.441	2.0403	4300
4400	53.010	151.502	247.564	213.132	336.502	168.750	2.0867	4400
4500	52.799	156.793	248.753	213.910	341.793	170.041	2.1314	4500

TABLE A12.—THERMODYNAMIC PROPERTIES FOR Ba (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	52.544	162.060	249.911	214.680	347.060	171.308	2.1745	4600
4700	52.251	167.300	251.038	215.442	352.300	172.548	2.2160	4700
4800	51.926	172.509	252.134	216.195	357.509	173.758	2.2561	4800
4900	51.575	177.684	253.201	216.939	362.684	174.933	2.2948	4900
5000	51.203	182.823	254.240	217.675	367.823	176.072	2.3322	5000
5100	50.816	187.925	255.250	218.402	372.925	177.173	2.3684	5100
5200	50.419	192.987	256.233	219.120	377.987	178.235	2.4034	5200
5300	50.016	198.008	257.189	219.829	383.008	179.257	2.4373	5300
5400	49.611	202.989	258.120	220.530	387.989	180.238	2.4701	5400
5500	49.208	207.931	259.027	221.221	392.931	181.179	2.5019	5500
5600	48.810	212.831	259.910	221.904	397.831	182.080	2.5327	5600
5700	48.421	217.693	260.771	222.579	402.693	182.941	2.5626	5700
5800	48.042	222.516	261.609	223.245	407.516	183.764	2.5915	5800
5900	47.676	227.301	262.427	223.902	412.301	184.550	2.6196	5900
6000	47.324	232.051	263.226	224.551	417.051	185.300	2.6469	6000
6200	46.667	241.449	264.767	225.823	426.449			6200
6400	46.075	250.722	266.239	227.063	435.722			6400
6600	45.542	259.883	267.648	228.272	444.883			6600
6800	44.834	268.008	268.309	228.896	453.008			6800
7000	44.085	276.900	269.598	230.040	461.900			7000
7200	43.324	285.641	270.829	231.156	470.641			7200
7400	42.555	294.230	272.005	232.245	479.230			7400
7600	41.782	302.663	273.130	233.306	487.663			7600
7800	41.011	310.942	274.205	234.341	495.942			7800
8000	40.244	319.068	275.234	235.351	504.068			8000
8500	38.372	338.719	277.617	237.768	523.719			8500
9000	36.596	357.456	279.760	240.042	542.456			9000
9500	34.949	375.336	281.694	242.185	560.336			9500
10000	33.449	392.429	283.447	244.204	577.429			10000
10500	32.104	408.811	285.046	246.112	593.811			10500
11000	30.915	424.559	286.512	247.915	609.559			11000
11500	29.873	439.750	287.862	249.623	624.750			11500
12000	28.968	454.455	289.114	251.243	639.455			12000
12500	28.186	468.739	290.280	252.781	653.739			12500
13000	27.508	482.658	291.372	254.245	667.658			13000
13500	26.919	496.262	292.399	255.639	681.262			13500
14000	26.402	509.590	293.369	256.970	694.590			14000
14500	25.942	522.673	294.287	258.241	707.673			14500
15000	25.524	535.539	295.159	259.457	720.539			15000
15500	25.137	548.203	295.990	260.622	733.203			15500
16000	24.774	560.679	296.782	261.740	745.679			16000
16500	24.431	572.981	297.539	262.813	757.981			16500
17000	24.105	585.114	298.264	263.845	770.114			17000
17500	23.801	597.088	298.958	264.839	782.088			17500
18000	23.526	608.919	299.625	265.796	793.919			18000
18500	23.294	620.622	300.266	266.719	805.622			18500
19000	23.120	632.222	300.885	267.610	817.222			19000
19500	23.028	643.756	301.484	268.471	828.756			19500
20000	23.046	655.268	302.067	269.303	840.268			20000

***Assigned reference element phase change at 1000 K**

TABLE A13.—THERMODYNAMIC PROPERTIES FOR Ba^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	687.852	688.562	----------	0
298.15	20.786	0.000	176.010	176.010	694.050	694.050	–114.5590	298.15
300	20.786	0.038	176.138	176.010	694.088	694.074	–113.8092	300
400	20.786	2.117	182.118	176.825	696.167	695.333	–83.5723	400
500	20.789	4.196	186.757	178.365	698.245	696.422	–65.3990	500
600	20.811	6.276	190.549	180.089	700.325	697.343	–53.2657	600
700	20.890	8.360	193.761	181.819	702.409	698.099	–44.5886	700
800	21.081	10.457	196.562	183.490	704.507	698.698	–38.0744	800
900	21.438	12.582	199.064	185.084	706.631	699.155	–33.0039	900
1000	21.989	14.751	201.349	186.598	708.801	699.488	–28.9452	1000
*1100	22.739	16.986	203.478	188.036	711.036	691.952	–25.6603	1100
1200	23.661	19.305	205.495	189.408	713.354	692.349	–22.9215	1200
1300	24.711	21.723	207.430	190.720	715.772	692.845	–20.6025	1300
1400	25.835	24.250	209.302	191.981	718.299	693.451	–18.6132	1400
1500	26.976	26.890	211.124	193.197	720.940	694.170	–16.8876	1500
1600	28.082	29.644	212.900	194.373	723.693	695.002	–15.3759	1600
1700	29.110	32.504	214.634	195.514	726.553	695.941	–14.0404	1700
1800	30.027	35.462	216.324	196.623	729.511	696.978	–12.8516	1800
1900	30.811	38.505	217.970	197.704	732.554	698.099	–11.7863	1900
2000	31.453	41.619	219.567	198.757	735.669	699.292	–10.8259	2000
2100	31.891	44.811	221.097	199.758	738.861	700.563	–9.9569	2100
2200	32.172	48.015	222.588	200.762	742.065	701.846	–9.1641	2200
2300	32.347	51.242	224.022	201.743	745.292	703.151	–8.4390	2300
2400	32.429	54.482	225.401	202.700	748.531	704.469	–7.7730	2400
2500	32.432	57.725	226.725	203.635	751.775	705.791	–7.1591	2500
2600	32.367	60.966	227.996	204.547	755.015	707.111	–6.5914	2600
2700	32.245	64.197	229.215	205.439	758.246	708.420	–6.0648	2700
2800	32.077	67.413	230.385	206.309	761.463	709.716	–5.5749	2800
2900	31.869	70.611	231.507	207.158	764.660	710.992	–5.1180	2900
3000	31.631	73.786	232.583	207.988	767.836	712.245	–4.6907	3000
3100	31.368	76.936	233.616	208.798	770.986	713.474	–4.2904	3100
3200	31.087	80.059	234.608	209.590	774.109	714.676	–3.9144	3200
3300	30.793	83.153	235.560	210.362	777.203	715.849	–3.5606	3300
3400	30.490	86.217	236.475	211.117	780.267	716.991	–3.2271	3400
3500	30.183	89.251	237.354	211.854	783.301	718.104	–2.9121	3500
3600	29.874	92.254	238.200	212.574	786.303	719.185	–2.6142	3600
3700	29.567	95.226	239.014	213.278	789.275	720.236	–2.3320	3700
3800	29.264	98.167	239.799	213.965	792.217	721.256	–2.0642	3800
3900	28.967	101.079	240.555	214.638	795.128	722.246	–1.8098	3900
4000	28.678	103.961	241.285	215.295	798.010	723.207	–1.5678	4000
4100	28.398	106.815	241.990	215.937	800.864	724.139	–1.3373	4100
4200	28.129	109.641	242.671	216.566	803.690	725.044	–1.1176	4200
4300	27.871	112.441	243.330	217.181	806.490	725.922	–0.9077	4300
4400	27.625	115.216	243.967	217.782	809.265	726.776	–0.7072	4400
4500	27.392	117.966	244.586	218.371	812.016	727.605	–0.5154	4500
4600	27.171	120.694	245.185	218.947	814.744	728.412	–0.3317	4600
4700	26.964	123.401	245.767	219.512	817.451	729.197	–0.1556	4700
4800	26.770	126.087	246.333	220.065	820.137	729.962	0.0133	4800
4900	26.589	128.755	246.883	220.606	822.805	730.709	0.1755	4900
5000	26.421	131.406	247.419	221.137	825.456	731.438	0.3314	5000

TABLE A13.—THERMODYNAMIC PROPERTIES FOR Ba^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	26.265	134.040	247.940	221.658	828.090	732.151	0.4813	5100
5200	26.122	136.659	248.449	222.168	830.709	732.849	0.6256	5200
5300	25.990	139.265	248.945	222.669	833.314	733.533	0.7645	5300
5400	25.870	141.858	249.430	223.160	835.907	734.204	0.8984	5400
5500	25.761	144.439	249.903	223.642	838.489	734.864	1.0276	5500
5600	25.662	147.010	250.367	224.115	841.060	735.514	1.1523	5600
5700	25.573	149.572	250.820	224.579	843.622	736.154	1.2727	5700
5800	25.492	152.125	251.264	225.036	846.174	736.786	1.3891	5800
5900	25.420	154.671	251.699	225.484	848.720	737.410	1.5016	5900
6000	25.356	157.209	252.126	225.924	851.259	738.027	1.6104	6000
6200	25.238	162.281	253.000	226.825	856.330			6200
6400	25.131	167.317	253.799	227.656	861.367			6400
6600	25.050	172.335	254.571	228.460	866.384			6600
6800	24.993	177.339	255.318	229.239	871.388			6800
7000	24.960	182.334	256.042	229.994	876.383			7000
7200	24.950	187.324	256.745	230.728	881.374			7200
7400	24.963	192.315	257.429	231.440	886.365			7400
7600	24.999	197.311	258.095	232.133	891.361			7600
7800	25.056	202.316	258.745	232.807	896.365			7800
8000	25.134	207.334	259.380	233.463	901.384			8000
8500	25.414	219.966	260.912	235.033	914.016			8500
9000	25.805	232.767	262.375	236.512	926.817			9000
9500	26.292	245.788	263.783	237.910	939.838			9500
10000	26.860	259.073	265.145	239.238	953.122			10000
10500	27.492	272.659	266.471	240.504	966.708			10500
11000	28.173	286.573	267.766	241.713	980.623			11000
11500	28.888	300.838	269.034	242.874	994.887			11500
12000	29.620	315.464	270.278	243.990	1009.514			12000
12500	30.355	330.458	271.503	245.066	1024.508			12500
13000	31.081	345.818	272.707	246.106	1039.868			13000
13500	31.784	361.535	273.894	247.113	1055.584			13500
14000	32.453	377.595	275.062	248.091	1071.645			14000
14500	33.077	393.980	276.212	249.040	1088.029			14500
15000	33.649	410.664	277.343	249.965	1104.713			15000
15500	34.160	427.619	278.455	250.866	1121.668			15500
16000	34.603	444.812	279.546	251.745	1138.862			16000
16500	34.975	462.210	280.617	252.604	1156.259			16500
17000	35.272	479.775	281.666	253.444	1173.825			17000
17500	35.492	497.470	282.691	254.265	1191.520			17500
18000	35.635	515.255	283.693	255.068	1209.305			18000
18500	35.702	533.092	284.671	255.855	1227.141			18500
19000	35.696	550.943	285.623	256.626	1244.993			19000
19500	35.622	568.776	286.549	257.381	1262.826			19500
20000	35.485	586.556	287.450	258.122	1280.605			20000

*Assigned reference element phase change at 1000 K

TABLE A14.—THERMODYNAMIC PROPERTIES FOR Be

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	317.803	319.745	----------	0
100	20.786	–4.119	113.569	154.757	319.881	321.783	–162.1733	100
200	20.786	–2.040	127.977	138.178	321.960	323.282	–77.9657	200
298.15	20.786	0.000	136.276	136.276	324.000	324.000	–50.1402	298.15
300	20.786	0.038	136.405	136.277	324.038	324.008	–49.7902	300
400	20.786	2.117	142.385	137.092	326.117	324.245	–35.6809	400
500	20.786	4.196	147.023	138.632	328.196	324.221	–27.2126	500
600	20.786	6.274	150.813	140.355	330.274	324.032	–21.5689	600
700	20.786	8.353	154.017	142.084	332.353	323.719	–17.5408	700
800	20.786	10.432	156.793	143.753	334.432	323.301	–14.5231	800
900	20.786	12.510	159.241	145.341	336.510	322.787	–12.1795	900
1000	20.786	14.589	161.431	146.842	338.589	322.183	–10.3077	1000
1100	20.786	16.667	163.412	148.260	340.667	321.490	–8.7794	1100
1200	20.786	18.746	165.221	149.599	342.746	320.711	–7.5087	1200
1300	20.786	20.825	166.884	150.865	344.825	319.844	–6.4363	1300
1400	20.786	22.903	168.425	152.065	346.903	318.891	–5.5197	1400
1500	20.786	24.982	169.859	153.204	348.982	317.849	–4.7277	1500
*1600	20.786	27.061	171.201	154.288	351.061	302.168	–4.0513	1600
1700	20.786	29.139	172.461	155.320	353.139	301.298	–3.4719	1700
1800	20.787	31.218	173.649	156.306	355.218	300.429	–2.9583	1800
1900	20.787	33.297	174.773	157.248	357.297	299.560	–2.5001	1900
2000	20.789	35.375	175.839	158.151	359.375	298.690	–2.0889	2000
2100	20.791	37.454	176.853	159.018	361.454	297.821	–1.7180	2100
2200	20.795	39.534	177.821	159.851	363.534	296.953	–1.3818	2200
2300	20.801	41.614	178.745	160.652	365.614	296.084	–1.0757	2300
2400	20.811	43.694	179.631	161.425	367.694	295.217	–0.7959	2400
2500	20.825	45.776	180.480	162.170	369.776	294.351	–0.5393	2500
2600	20.844	47.859	181.298	162.890	371.859	293.486	–0.3031	2600
2700	20.870	49.945	182.085	163.587	373.945	292.624	–0.0850	2700
2800	20.905	52.034	182.844	164.261	376.034	291.765	0.1169	2800
2900	20.950	54.126	183.579	164.914	378.126	290.909	0.3043	2900
3000	21.006	56.224	184.290	165.548	380.224	290.059	0.4787	3000
3100	21.075	58.328	184.980	166.164	382.328	289.215	0.6413	3100
3200	21.159	60.439	185.650	166.763	384.439	288.378	0.7934	3200
3300	21.259	62.560	186.303	167.345	386.560	287.551	0.9359	3300
3400	21.377	64.692	186.939	167.912	388.692	286.735	1.0695	3400
3500	21.513	66.836	187.561	168.464	390.836	285.931	1.1952	3500
3600	21.668	68.995	188.169	169.003	392.995	285.142	1.3136	3600
3700	21.844	71.170	188.765	169.529	395.170	284.369	1.4252	3700
3800	22.041	73.365	189.350	170.043	397.365	283.615	1.5308	3800
3900	22.260	75.579	189.925	170.546	399.579	282.882	1.6306	3900
4000	22.500	77.817	190.492	171.037	401.817	282.172	1.7252	4000
4100	22.762	80.080	191.050	171.519	404.080	281.487	1.8149	4100
4200	23.045	82.370	191.602	171.990	406.370	280.829	1.9002	4200
4300	23.350	84.690	192.148	172.453	408.690	280.201	1.9814	4300
4400	23.675	87.041	192.689	172.907	411.041	279.604	2.0586	4400
4500	24.020	89.425	193.224	173.352	413.425	279.040	2.1323	4500

TABLE A14.—THERMODYNAMIC PROPERTIES FOR Be (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	24.383	91.845	193.756	173.790	415.845	278.512	2.2027	4600
4700	24.765	94.303	194.285	174.220	418.303	278.022	2.2699	4700
4800	25.163	96.799	194.810	174.644	420.799	277.570	2.3342	4800
4900	25.576	99.336	195.333	175.061	423.336	277.159	2.3958	4900
5000	26.003	101.915	195.854	175.471	425.915	276.790	2.4549	5000
5100	26.443	104.537	196.374	175.876	428.537	276.464	2.5115	5100
5200	26.894	107.204	196.891	176.275	431.204	276.183	2.5659	5200
5300	27.354	109.916	197.408	176.669	433.916	275.947	2.6183	5300
5400	27.822	112.675	197.924	177.058	436.675	275.758	2.6686	5400
5500	28.296	115.480	198.439	177.442	439.480	275.615	2.7171	5500
5600	28.775	118.334	198.953	177.822	442.334	275.521	2.7638	5600
5700	29.257	121.236	199.466	178.197	445.236	275.474	2.8089	5700
5800	29.741	124.185	199.979	178.568	448.185	275.476	2.8524	5800
5900	30.225	127.184	200.492	178.935	451.184	275.527	2.8945	5900
6000	30.708	130.230	201.004	179.299	454.230	275.625	2.9351	6000
6200	31.666	136.468	202.026	180.015	460.468			6200
6400	32.599	142.893	203.046	180.719	466.893			6400
6600	33.510	149.504	204.063	181.411	473.504			6600
6800	34.380	156.291	205.076	182.092	480.291			6800
7000	35.218	163.251	206.085	182.763	487.251			7000
7200	36.015	170.375	207.088	183.425	494.375			7200
7400	36.751	177.644	208.084	184.078	501.644			7400
7600	37.457	185.065	209.074	184.723	509.065			600
7800	38.120	192.624	210.055	185.360	516.624			7800
8000	38.742	200.311	211.028	185.989	524.311			8000
8500	40.079	220.072	213.424	187.534	544.072			8500
9000	41.139	240.387	215.746	189.037	564.387			9000
9500	41.960	261.171	217.994	190.502	585.171			9500
10000	42.571	282.312	220.162	191.931	606.312			10000
10500	43.000	303.712	222.251	193.326	627.712			10500
11000	43.269	325.285	224.258	194.686	649.285			11000
11500	43.403	346.959	226.184	196.014	670.959			11500
12000	43.420	368.669	228.032	197.310	692.669			12000
12500	43.337	390.362	229.804	198.575	714.362			12500
13000	43.168	411.992	231.500	199.809	735.992			13000
13500	42.925	433.518	233.125	201.013	757.518			13500
14000	42.619	454.907	234.681	202.187	778.907			14000
14500	42.257	476.127	236.170	203.334	800.127			14500
15000	41.845	497.154	237.596	204.452	821.154			15000
15500	41.389	517.965	238.961	205.544	841.965			15500
16000	40.893	538.537	240.267	206.608	862.537			16000
16500	40.358	558.851	241.517	207.647	882.851			16500
17000	39.789	578.889	242.714	208.661	902.889			17000
17500	39.184	598.633	243.858	209.651	922.633			17500
18000	38.544	618.068	244.953	210.616	942.068			18000
18500	37.870	637.173	246.000	211.559	961.173			18500
19000	37.160	655.931	247.001	212.478	979.931			19000
19500	36.413	674.326	247.957	213.376	998.326			19500
20000	35.628	692.338	248.869	214.252	1016.338			20000

***Assigned reference element phase change at 1563 K**

TABLE A15.—THERMODYNAMIC PROPERTIES FOR Be^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1223.504	1219.249	----------	0
298.15	20.786	0.000	142.039	142.039	1229.701	1229.701	–207.4145	298.15
300	20.786	0.038	142.167	142.039	1229.740	1229.748	–206.0860	300
400	20.786	2.117	148.147	142.854	1231.818	1232.063	–152.5110	400
500	20.786	4.196	152.785	144.394	1233.897	1234.118	–120.3084	500
600	20.786	6.274	156.575	146.118	1235.976	1236.008	–98.8054	600
700	20.786	8.353	159.779	147.847	1238.054	1237.774	–83.4232	700
800	20.786	10.432	162.555	149.515	1240.133	1239.434	–71.8705	800
900	20.786	12.510	165.003	151.103	1242.212	1240.999	–62.8734	900
1000	20.786	14.589	167.193	152.604	1244.290	1242.473	–55.6668	1000
1100	20.786	16.667	169.174	154.022	1246.369	1243.859	–49.7638	1100
1200	20.786	18.746	170.983	155.361	1248.447	1245.158	–44.8392	1200
1300	20.786	20.825	172.647	156.628	1250.526	1246.371	–40.6681	1300
1400	20.786	22.903	174.187	157.828	1252.605	1247.495	–37.0894	1400
1500	20.786	24.982	175.621	158.967	1254.683	1248.532	–33.9852	1500
*1600	20.786	27.061	176.963	160.050	1256.762	1234.929	–31.2811	1600
1700	20.786	29.139	178.223	161.082	1258.841	1236.139	–28.9085	1700
1800	20.786	31.218	179.411	162.068	1260.919	1237.348	–26.7974	1800
1900	20.786	33.296	180.535	163.011	1262.998	1238.557	–24.9067	1900
2000	20.786	35.375	181.601	163.914	1265.076	1239.767	–23.2034	2000
2100	20.786	37.454	182.615	164.780	1267.155	1240.976	–21.6609	2100
2200	20.786	39.532	183.582	165.613	1269.234	1242.185	–20.2571	2200
2300	20.786	41.611	184.506	166.415	1271.312	1243.394	–18.9743	2300
2400	20.786	43.690	185.391	167.187	1273.391	1244.604	–17.7971	2400
2500	20.786	45.768	186.240	167.932	1275.470	1245.813	–16.7131	2500
2600	20.786	47.847	187.055	168.652	1277.548	1247.022	–15.7115	2600
2700	20.787	49.926	187.839	169.348	1279.627	1248.231	–14.7832	2700
2800	20.787	52.004	188.595	170.022	1281.706	1249.441	–13.9204	2800
2900	20.787	54.083	189.325	170.675	1283.784	1250.650	–13.1162	2900
3000	20.788	56.162	190.029	171.309	1285.863	1251.859	–12.3650	3000
3100	20.788	58.240	190.711	171.924	1287.942	1253.069	–11.6616	3100
3200	20.789	60.319	191.371	172.521	1290.021	1254.278	–11.0015	3200
3300	20.791	62.398	192.011	173.102	1292.100	1255.488	–10.3808	3300
3400	20.792	64.477	192.632	173.668	1294.179	1256.698	–9.7960	3400
3500	20.795	66.557	193.234	174.218	1296.258	1257.908	–9.2441	3500
3600	20.798	68.636	193.820	174.754	1298.338	1259.118	–8.7224	3600
3700	20.802	70.716	194.390	175.277	1300.418	1260.328	–8.2284	3700
3800	20.807	72.797	194.945	175.788	1302.498	1261.540	–7.7600	3800
3900	20.813	74.878	195.485	176.286	1304.579	1262.751	–7.3151	3900
4000	20.820	76.959	196.012	176.773	1306.661	1263.963	–6.8921	4000
4100	20.829	79.042	196.527	177.248	1308.743	1265.176	–6.4894	4100
4200	20.839	81.125	197.029	177.713	1310.827	1266.390	–6.1054	4200
4300	20.851	83.210	197.519	178.168	1312.911	1267.606	–5.7390	4300
4400	20.866	85.296	197.999	178.613	1314.997	1268.822	–5.3889	4400
4500	20.882	87.383	198.468	179.049	1317.084	1270.040	–5.0540	4500
4600	20.901	89.472	198.927	179.476	1319.173	1271.260	–4.7334	4600
4700	20.922	91.563	199.377	179.895	1321.265	1272.481	–4.4261	4700
4800	20.945	93.657	199.817	180.306	1323.358	1273.705	–4.1313	4800
4900	20.972	95.752	200.249	180.708	1325.454	1274.932	–3.8483	4900
5000	21.001	97.851	200.673	181.103	1327.552	1276.161	–3.5764	5000

TABLE A15.—THERMODYNAMIC PROPERTIES FOR Be^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.034	99.953	201.090	181.491	1329.654	1277.394	–3.3149	5100
5200	21.069	102.058	201.498	181.872	1331.759	1278.629	–3.0631	5200
5300	21.108	104.167	201.900	182.246	1333.868	1279.869	–2.8207	5300
5400	21.150	106.280	202.295	182.614	1335.981	1281.112	–2.5870	5400
5500	21.196	108.397	202.684	182.975	1338.098	1282.360	–2.3616	5500
5600	21.245	110.519	203.066	183.330	1340.220	1283.613	–2.1440	5600
5700	21.297	112.646	203.442	183.680	1342.347	1284.871	–1.9338	5700
5800	21.353	114.778	203.813	184.024	1344.480	1286.134	–1.7307	5800
5900	21.412	116.917	204.179	184.362	1346.618	1287.402	–1.5343	5900
6000	21.475	119.061	204.539	184.696	1348.762	1288.677	–1.3443	6000
6200	21.612	123.369	205.246	185.347	1353.071			6200
6400	21.762	127.707	205.934	185.980	1357.408			6400
6600	21.926	132.075	206.606	186.595	1361.777			6600
6800	22.102	136.478	207.263	187.193	1366.179			6800
7000	22.290	140.917	207.907	187.776	1370.618			7000
7200	22.489	145.394	208.537	188.344	1375.096			7200
7400	22.698	149.913	209.156	188.898	1379.614			7400
7600	22.916	154.474	209.765	189.439	1384.175			7600
7800	23.141	159.080	210.363	189.968	1388.781			7800
8000	23.374	163.731	210.951	190.485	1393.432			8000
8500	23.976	175.568	212.386	191.731	1405.269			8500
9000	24.594	187.710	213.774	192.918	1417.411			9000
9500	25.212	200.162	215.121	194.051	1429.863			9500
10000	25.816	212.920	216.429	195.137	1442.621			10000
10500	26.389	225.981	217.704	196.182	1455.683			10500
11000	26.928	239.312	218.944	197.189	1469.014			11000
11500	27.431	252.903	220.153	198.161	1482.605			11500
12000	27.897	266.738	221.330	199.102	1496.439			12000
12500	28.326	280.795	222.478	200.014	1510.496			12500
13000	28.719	295.057	223.597	200.900	1524.759			13000
13500	29.081	309.509	224.687	201.761	1539.210			13500
14000	29.414	324.134	225.751	202.599	1553.835			14000
14500	29.723	338.919	226.789	203.415	1568.620			14500
15000	30.013	353.854	227.801	204.211	1583.555			15000
15500	30.289	368.930	228.790	204.988	1598.632			15500
16000	30.554	384.142	229.756	205.747	1613.843			16000
16500	30.815	399.484	230.700	206.489	1629.185			16500
17000	31.074	414.955	231.624	207.215	1644.656			17000
17500	31.335	430.557	232.528	207.925	1660.259			17500
18000	31.603	446.291	233.415	208.621	1675.993			18000
18500	31.878	462.161	234.284	209.303	1691.863			18500
19000	32.164	478.172	235.138	209.971	1707.873			19000
19500	32.461	494.328	235.978	210.627	1724.029			19500
20000	32.769	510.634	236.803	211.272	1740.336			20000

*Assigned reference element phase change at 1563 K

TABLE A16.—THERMODYNAMIC PROPERTIES FOR Br

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	105.673	117.933	----------	0
100	20.786	–4.119	152.312	193.500	107.751	118.615	–55.4066	100
200	20.786	–2.040	166.720	176.920	109.830	118.243	–24.4562	200
*298.15	20.786	0.000	175.019	175.019	111.870	111.870	–14.4321	298.15
300	20.786	0.038	175.148	175.019	111.908	111.838	–14.3112	300
400	20.788	2.117	181.128	175.835	113.987	110.151	–9.4763	400
500	20.798	4.196	185.767	177.374	116.066	108.465	–6.6199	500
600	20.839	6.278	189.562	179.099	118.148	106.781	–4.7452	600
700	20.934	8.366	192.781	180.829	120.236	105.104	–3.4271	700
800	21.109	10.467	195.586	182.502	122.337	103.441	–2.4542	800
900	21.382	12.591	198.087	184.097	124.461	101.799	–1.7095	900
1000	21.765	14.747	200.359	185.612	126.617	100.190	–1.1232	1000
1100	22.258	16.948	202.456	187.049	128.818	98.626	–0.6511	1100
1200	22.858	19.203	204.417	188.415	131.073	97.115	–0.2637	1200
1300	23.553	21.522	206.274	189.718	133.392	95.670	0.0591	1300
1400	24.327	23.916	208.047	190.964	135.786	94.298	0.3317	1400
1500	25.163	26.390	209.754	192.161	138.260	93.007	0.5647	1500
1600	26.041	28.950	211.406	193.312	140.820	91.802	0.7658	1600
1700	26.941	31.599	213.011	194.424	143.469	90.686	0.9410	1700
1800	27.845	34.338	214.577	195.500	146.208	89.660	1.0949	1800
1900	28.736	37.167	216.106	196.545	149.037	88.724	1.2312	1900
2000	29.599	40.084	217.602	197.560	151.954	87.876	1.3525	2000
2100	30.423	43.086	219.067	198.550	154.956	87.113	1.4613	2100
2200	31.198	46.167	220.500	199.515	158.037	86.429	1.5595	2200
2300	31.917	49.324	221.903	200.458	161.194	85.820	1.6484	2300
2400	32.575	52.549	223.275	201.380	164.419	85.280	1.7293	2400
2500	33.169	55.836	224.617	202.283	167.706	84.803	1.8033	2500
2600	33.698	59.180	225.929	203.167	171.050	84.382	1.8713	2600
2700	34.164	62.574	227.209	204.034	174.444	84.010	1.9340	2700
2800	34.567	66.011	228.459	204.884	177.881	83.682	1.9919	2800
2900	34.911	69.485	229.679	205.718	181.355	83.391	2.0456	2900
3000	35.199	72.991	230.867	206.537	184.861	83.132	2.0956	3000
3100	35.434	76.523	232.025	207.340	188.393	82.899	2.1422	3100
3200	35.622	80.076	233.153	208.129	191.946	82.687	2.1858	3200
3300	35.765	83.646	234.252	208.904	195.516	82.492	2.2267	3300
3400	35.869	87.228	235.321	209.666	199.098	82.309	2.2650	3400
3500	35.938	90.819	236.362	210.414	202.689	82.134	2.3011	3500
3600	35.974	94.415	237.375	211.149	206.285	81.965	2.3351	3600
3700	35.983	98.013	238.361	211.871	209.883	81.798	2.3673	3700
3800	35.968	101.610	239.320	212.581	213.480	81.631	2.3976	3800
3900	35.931	105.206	240.254	213.278	217.076	81.461	2.4264	3900
4000	35.876	108.796	241.163	213.964	220.666	81.286	2.4536	4000
4100	35.806	112.380	242.048	214.638	224.250	81.105	2.4795	4100
4200	35.722	115.957	242.910	215.301	227.827	80.917	2.5040	4200
4300	35.628	119.524	243.749	215.953	231.394	80.719	2.5274	4300
4400	35.524	123.082	244.567	216.594	234.952	80.512	2.5497	4400
4500	35.414	126.629	245.364	217.225	238.499	80.294	2.5709	4500

TABLE A16.—THERMODYNAMIC PROPERTIES FOR Br (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	35.297	130.165	246.142	217.845	242.035	80.064	2.5911	4600
4700	35.176	133.688	246.899	218.455	245.558	79.823	2.6104	4700
4800	35.052	137.200	247.639	219.055	249.070	79.569	2.6289	4800
4900	34.926	140.699	248.360	219.646	252.569	79.303	2.6465	4900
5000	34.798	144.185	249.064	220.227	256.055	79.024	2.6634	5000
5100	34.669	147.658	249.752	220.800	259.528	78.732	2.6796	5100
5200	34.541	151.119	250.424	221.363	262.989	78.427	2.6950	5200
5300	34.412	154.566	251.081	221.917	266.436	78.110	2.7099	5300
5400	34.285	158.001	251.723	222.463	269.871	77.780	2.7241	5400
5500	34.160	161.423	252.351	223.001	273.293	77.437	2.7377	5500
5600	34.036	164.833	252.965	223.531	276.703	77.082	2.7508	5600
5700	33.914	168.231	253.567	224.052	280.101	76.714	2.7634	5700
5800	33.794	171.616	254.155	224.566	283.486	76.334	2.7755	5800
5900	33.676	174.989	254.732	225.073	286.859	75.943	2.7871	5900
6000	33.561	178.351	255.297	225.572	290.221	75.539	2.7983	6000
6200	33.339	185.041	256.394	226.549	296.911			6200
6400	33.128	191.688	257.449	227.498	303.558			6400
6600	32.927	198.293	258.465	228.421	310.163			6600
6800	32.738	204.859	259.445	229.319	316.729			6800
7000	32.560	211.389	260.392	230.193	323.259			7000
7200	32.392	217.884	261.307	231.045	329.754			7200
7400	32.234	224.346	262.192	231.875	336.216			7400
7600	32.087	230.778	263.050	232.684	342.648			7600
7800	31.948	237.181	263.881	233.473	349.051			7800
8000	31.817	243.554	264.687	234.243	355.424			8000
8500	31.525	259.387	266.607	236.091	371.257			8500
9000	31.283	275.088	268.402	237.837	386.958			9000
9500	31.085	290.678	270.088	239.490	402.548			9500
10000	30.922	306.178	271.678	241.060	418.048			10000
10500	30.790	321.605	273.184	242.555	433.475			10500
11000	30.682	336.972	274.613	243.979	448.842			11000
11500	30.595	352.290	275.975	245.341	464.160			11500
12000	30.522	367.569	277.276	246.645	479.439			12000
12500	30.462	382.815	278.520	247.895	494.685			12500
13000	30.411	398.032	279.714	249.096	509.902			13000
13500	30.366	413.226	280.861	250.252	525.096			13500
14000	30.326	428.400	281.965	251.365	540.270			14000
14500	30.288	443.553	283.028	252.438	555.423			14500
15000	30.252	458.688	284.054	253.475	570.558			15000
15500	30.216	473.805	285.046	254.478	585.675			15500
16000	30.179	488.903	286.004	255.448	600.773			16000
16500	30.140	503.984	286.932	256.388	615.854			16500
17000	30.099	519.044	287.832	257.300	630.914			17000
17500	30.054	534.082	288.703	258.185	645.952			17500
18000	30.005	549.098	289.549	259.044	660.968			18000
18500	29.951	564.086	290.371	259.880	675.956			18500
19000	29.891	579.047	291.169	260.693	690.917			19000
19500	29.824	593.977	291.944	261.484	705.847			19500
20000	29.750	608.870	292.699	262.255	720.740			20000

***Assigned reference element phase change at 265.9 K**

TABLE A17.—THERMODYNAMIC PROPERTIES FOR Br^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	-6.197	----------	----------	1251.730	1257.792	----------	0
*298.15	20.787	0.000	176.874	176.874	1257.927	1257.927	–214.0187	298.15
300	20.787	0.038	177.003	176.875	1257.965	1257.933	–212.6597	300
400	20.795	2.117	182.983	177.690	1260.044	1258.325	–157.8969	400
500	20.838	4.199	187.627	179.230	1262.126	1258.720	–125.0289	500
600	20.953	6.287	191.436	180.956	1264.214	1259.122	–103.1099	600
700	21.153	8.392	194.679	182.691	1266.319	1259.540	–87.4484	700
800	21.427	10.521	197.521	184.371	1268.448	1259.982	–75.6982	800
900	21.747	12.679	200.063	185.975	1270.606	1260.454	–66.5559	900
1000	22.084	14.870	202.372	187.501	1272.797	1260.959	–59.2392	1000
1100	22.415	17.096	204.492	188.951	1275.023	1261.498	–53.2503	1100
1200	22.720	19.353	206.456	190.329	1277.280	1262.069	–48.2574	1200
1300	22.990	21.638	208.285	191.640	1279.565	1262.668	–44.0306	1300
1400	23.220	23.949	209.998	192.891	1281.876	1263.292	–40.4060	1400
1500	23.409	26.281	211.607	194.086	1284.208	1263.938	–37.2630	1500
1600	23.560	28.630	213.122	195.229	1286.557	1264.600	–34.5115	1600
1700	23.677	30.992	214.554	196.324	1288.919	1265.276	–32.0824	1700
1800	23.765	33.364	215.910	197.375	1291.291	1265.961	–29.9220	1800
1900	23.829	35.744	217.197	198.384	1293.671	1266.655	–27.9880	1900
2000	23.874	38.129	218.421	199.356	1296.057	1267.354	–26.2464	2000
2100	23.904	40.519	219.586	200.292	1298.446	1268.056	–24.6699	2100
2200	23.924	42.910	220.699	201.194	1300.837	1268.761	–23.2358	2200
2300	23.936	45.303	221.762	202.065	1303.230	1269.468	–21.9257	2300
2400	23.942	47.697	222.781	202.908	1305.624	1270.175	–20.7242	2400
2500	23.946	50.091	223.759	203.722	1308.018	1270.883	–19.6181	2500
2600	23.948	52.486	224.698	204.511	1310.413	1271.592	–18.5966	2600
2700	23.950	54.881	225.602	205.275	1312.808	1272.300	–17.6502	2700
2800	23.952	57.276	226.473	206.017	1315.203	1273.009	–16.7709	2800
2900	23.955	59.671	227.313	206.737	1317.598	1273.717	–15.9518	2900
3000	23.959	62.067	228.126	207.436	1319.994	1274.427	–15.1868	3000
3100	23.965	64.463	228.911	208.117	1322.390	1275.136	–14.4708	3100
3200	23.971	66.860	229.672	208.778	1324.787	1275.847	–13.7992	3200
3300	23.979	69.258	230.410	209.423	1327.185	1276.558	–13.1680	3300
3400	23.988	71.656	231.126	210.051	1329.583	1277.270	–12.5735	3400
3500	23.998	74.055	231.821	210.663	1331.982	1277.982	–12.0127	3500
3600	24.008	76.456	232.498	211.260	1334.383	1278.696	–11.4828	3600
3700	24.019	78.857	233.156	211.843	1336.784	1279.411	–10.9812	3700
3800	24.030	81.259	233.796	212.412	1339.186	1280.127	–10.5058	3800
3900	24.041	83.663	234.421	212.969	1341.590	1280.844	–10.0545	3900
4000	24.051	86.067	235.029	213.512	1343.994	1281.562	–9.6255	4000
4100	24.061	88.473	235.623	214.045	1346.400	1282.281	–9.2172	4100
4200	24.071	90.880	236.203	214.565	1348.807	1283.001	–8.8282	4200
4300	24.080	93.287	236.770	215.075	1351.214	1283.723	–8.4570	4300
4400	24.088	95.696	237.323	215.574	1353.623	1284.445	–8.1025	4400
4500	24.096	98.105	237.865	216.064	1356.032	1285.167	–7.7636	4500
4600	24.102	100.515	238.395	216.544	1358.442	1285.891	–7.4392	4600
4700	24.107	102.925	238.913	217.014	1360.852	1286.615	–7.1284	4700
4800	24.111	105.336	239.421	217.476	1363.263	1287.339	–6.8304	4800
4900	24.114	107.747	239.918	217.928	1365.674	1288.064	–6.5445	4900
5000	24.116	110.159	240.405	218.373	1368.086	1288.789	–6.2698	5000

TABLE A17.—THERMODYNAMIC PROPERTIES FOR Br^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	24.117	112.570	240.882	218.810	1370.497	1289.514	–6.0057	5100
5200	24.116	114.982	241.351	219.239	1372.909	1290.239	–5.7517	5200
5300	24.114	117.394	241.810	219.660	1375.321	1290.964	–5.5071	5300
5400	24.112	119.805	242.261	220.075	1377.732	1291.689	–5.2714	5400
5500	24.108	122.216	242.703	220.482	1380.143	1292.414	–5.0442	5500
5600	24.103	124.626	243.138	220.883	1382.553	1293.138	–4.8249	5600
5700	24.097	127.036	243.564	221.277	1384.963	1293.861	–4.6133	5700
5800	24.089	129.446	243.983	221.665	1387.373	1294.584	–4.4088	5800
5900	24.081	131.854	244.395	222.047	1389.781	1295.306	–4.2111	5900
6000	24.072	134.262	244.800	222.423	1392.189	1296.027	–4.0199	6000
6200	24.052	139.074	245.589	223.157	1397.001			6200
6400	24.028	143.882	246.352	223.870	1401.809			6400
6600	24.001	148.685	247.091	224.563	1406.612			6600
6800	23.972	153.483	247.807	225.236	1411.410			6800
7000	23.940	158.274	248.501	225.891	1416.201			7000
7200	23.907	163.059	249.175	226.528	1420.986			7200
7400	23.872	167.836	249.830	227.149	1425.764			7400
7600	23.835	172.607	250.466	227.754	1430.534			7600
7800	23.797	177.370	251.085	228.345	1435.297			7800
8000	23.759	182.126	251.687	228.921	1440.053			8000
8500	23.660	193.981	253.124	230.303	1451.908			8500
9000	23.559	205.786	254.473	231.608	1463.713			9000
9500	23.459	217.540	255.745	232.846	1475.467			9500
10000	23.362	229.246	256.945	234.021	1487.173			10000
10500	23.269	240.903	258.083	235.140	1498.830			10500
11000	23.182	252.515	259.163	236.207	1510.442			11000
11500	23.103	264.086	260.192	237.228	1522.013			11500
12000	23.035	275.620	261.174	238.206	1533.547			12000
12500	22.979	287.123	262.113	239.143	1545.050			12500
13000	22.940	298.602	263.013	240.044	1556.529			13000
13500	22.919	310.066	263.879	240.911	1567.993			13500
14000	22.922	321.525	264.712	241.746	1579.452			14000
14500	22.953	332.992	265.517	242.552	1590.919			14500
15000	23.016	344.482	266.296	243.331	1602.409			15000
15500	23.117	356.012	267.052	244.084	1613.939			15500
16000	23.260	367.602	267.788	244.813	1625.529			16000
16500	23.448	379.271	268.506	245.520	1637.198			16500
17000	23.690	391.047	269.209	246.206	1648.974			17000
17500	23.988	402.954	269.899	246.874	1660.881			17500
18000	24.344	415.017	270.579	247.523	1672.944			18000
18500	24.765	427.271	271.250	248.155	1685.198			18500
19000	25.266	439.765	271.917	248.771	1697.692			19000
19500	25.813	452.476	272.577	249.373	1710.403			19500
20000	26.426	465.463	273.234	249.961	1723.390			20000

*Assigned reference element phase change at 265.9 K

TABLE A18.—THERMODYNAMIC PROPERTIES FOR Br^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–225.198	–206.740	----------	0
*298.15	20.786	0.000	163.493	163.493	–219.000	–219.000	41.8358	298.15
300	20.786	0.038	163.621	163.493	–218.962	–219.071	41.5992	300
400	20.786	2.117	169.601	164.308	–216.883	–222.837	31.9894	400
500	20.786	4.196	174.240	165.848	–214.805	–226.602	26.1241	500
600	20.786	6.274	178.029	167.572	–212.726	–230.367	22.1480	600
700	20.786	8.353	181.234	169.301	–210.648	–234.132	19.2608	700
800	20.786	10.432	184.009	170.970	–208.569	–237.897	17.0602	800
900	20.786	12.510	186.457	172.557	–206.490	–241.662	15.3212	900
1000	20.786	14.589	188.647	174.059	–204.412	–245.427	13.9081	1000
1100	20.786	16.667	190.629	175.476	–202.333	–249.193	12.7340	1100
1200	20.786	18.746	192.437	176.815	–200.254	–252.958	11.7407	1200
1300	20.786	20.825	194.101	178.082	–198.176	–256.723	10.8876	1300
1400	20.786	22.903	195.641	179.282	–196.097	–260.488	10.1456	1400
1500	20.786	24.982	197.076	180.421	–194.018	–264.253	9.4931	1500
1600	20.786	27.061	198.417	181.504	–191.940	–268.018	8.9140	1600
1700	20.786	29.139	199.677	182.537	–189.861	–271.783	8.3957	1700
1800	20.786	31.218	200.865	183.522	–187.783	–275.548	7.9287	1800
1900	20.786	33.296	201.989	184.465	–185.704	–279.313	7.5050	1900
2000	20.786	35.375	203.055	185.368	–183.625	–283.078	7.1185	2000
2100	20.786	37.454	204.070	186.234	–181.547	–286.843	6.7642	2100
2200	20.786	39.532	205.037	187.067	–179.468	–290.609	6.4378	2200
2300	20.786	41.611	205.961	187.869	–177.389	–294.374	6.1359	2300
2400	20.786	43.690	206.845	188.641	–175.311	–298.139	5.8556	2400
2500	20.786	45.768	207.694	189.386	–173.232	–301.904	5.5944	2500
2600	20.786	47.847	208.509	190.106	–171.154	–305.669	5.3503	2600
2700	20.786	49.926	209.293	190.803	–169.075	–309.434	5.1215	2700
2800	20.786	52.004	210.049	191.476	–166.996	–313.199	4.9064	2800
2900	20.786	54.083	210.779	192.130	–164.918	–316.964	4.7037	2900
3000	20.786	56.161	211.484	192.763	–162.839	–320.729	4.5123	3000
3100	20.786	58.240	212.165	193.378	–160.760	–324.495	4.3311	3100
3200	20.786	60.319	212.825	193.975	–158.682	–328.260	4.1593	3200
3300	20.786	62.397	213.465	194.556	–156.603	–332.025	3.9960	3300
3400	20.786	64.476	214.085	195.122	–154.525	–335.790	3.8406	3400
3500	20.786	66.555	214.688	195.672	–152.446	–339.555	3.6923	3500
3600	20.786	68.633	215.273	196.209	–150.367	–343.320	3.5508	3600
3700	20.786	70.712	215.843	196.732	–148.289	–347.085	3.4154	3700
3800	20.786	72.790	216.397	197.242	–146.210	–350.850	3.2858	3800
3900	20.786	74.869	216.937	197.740	–144.131	–354.615	3.1615	3900
4000	20.786	76.948	217.463	198.226	–142.053	–358.380	3.0421	4000
4100	20.786	79.026	217.977	198.702	–139.974	–362.145	2.9274	4100
4200	20.786	81.105	218.478	199.167	–137.896	–365.911	2.8170	4200
4300	20.786	83.184	218.967	199.622	–135.817	–369.676	2.7106	4300
4400	20.786	85.262	219.444	200.067	–133.738	–373.441	2.6080	4400
4500	20.786	87.341	219.912	200.503	–131.660	–377.206	2.5090	4500
4600	20.786	89.419	220.368	200.929	–129.581	–380.971	2.4134	4600
4700	20.786	91.498	220.816	201.348	–127.502	–384.736	2.3209	4700
4800	20.786	93.577	221.253	201.758	–125.424	–388.501	2.2314	4800
4900	20.786	95.655	221.682	202.160	–123.345	–392.266	2.1447	4900
5000	20.786	97.734	222.102	202.555	–121.267	–396.031	2.0606	5000

TABLE A18.—THERMODYNAMIC PROPERTIES FOR Br^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	222.513	202.942	–119.188	–399.796	1.9791	5100
5200	20.786	101.891	222.917	203.322	–117.109	–403.562	1.9000	5200
5300	20.786	103.970	223.313	203.696	–115.031	–407.327	1.8232	5300
5400	20.786	106.048	223.701	204.063	–112.952	–411.092	1.7485	5400
5500	20.786	108.127	224.083	204.423	–110.873	–414.857	1.6759	5500
5600	20.786	110.206	224.457	204.778	–108.795	–418.622	1.6052	5600
5700	20.786	112.284	224.825	205.126	–106.716	–422.387	1.5364	5700
5800	20.786	114.363	225.187	205.469	–104.638	–426.152	1.4694	5800
5900	20.786	116.442	225.542	205.806	–102.559	–429.917	1.4040	5900
6000	20.786	118.520	225.891	206.138	–100.480	–433.682	1.3403	6000
6200	20.786	122.677	226.573	206.786	–96.323			6200
6400	20.786	126.835	227.233	207.415	–92.166			6400
6600	20.786	130.992	227.873	208.025	–88.008			6600
6800	20.786	135.149	228.493	208.618	–83.851			6800
7000	20.786	139.306	229.096	209.195	–79.694			7000
7200	20.786	143.464	229.681	209.756	–75.537			7200
7400	20.786	147.621	230.251	210.302	–71.379			7400
7600	20.786	151.778	230.805	210.834	–67.222			7600
7800	20.786	155.936	231.345	211.353	–63.065			7800
8000	20.786	160.093	231.871	211.860	–58.908			8000
8500	20.786	170.486	233.131	213.074	–48.515			8500
9000	20.786	180.879	234.320	214.222	–38.121			9000
9500	20.786	191.272	235.443	215.310	–27.728			9500
10000	20.786	201.665	236.510	216.343	–17.335			10000
10500	20.786	212.058	237.524	217.328	–6.942			10500
11000	20.786	222.452	238.491	218.268	3.451			11000
11500	20.786	232.845	239.415	219.167	13.844			11500
12000	20.786	243.238	240.299	220.030	24.237			12000
12500	20.786	253.631	241.148	220.857	34.631			12500
13000	20.786	264.024	241.963	221.654	45.024			13000
13500	20.786	274.417	242.748	222.420	55.417			13500
14000	20.786	284.810	243.504	223.160	65.810			14000
14500	20.786	295.204	244.233	223.874	76.203			14500
15000	20.786	305.597	244.938	224.565	86.596			15000
15500	20.786	315.990	245.619	225.233	96.989			15500
16000	20.786	326.383	246.279	225.880	107.383			16000
16500	20.786	336.776	246.919	226.508	117.776			16500
17000	20.786	347.169	247.539	227.118	128.169			17000
17500	20.786	357.562	248.142	227.710	138.562			17500
18000	20.786	367.956	248.728	228.286	148.955			18000
18500	20.786	378.349	249.297	228.846	159.348			18500
19000	20.786	388.742	249.851	229.391	169.741			19000
19500	20.786	399.135	250.391	229.923	180.134			19500
20000	20.786	409.528	250.918	230.441	190.528			20000

*Assigned reference element phase change at 265.9 K

TABLE A19.—THERMODYNAMIC PROPERTIES FOR C

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.536	----------	----------	710.144	711.198	----------	0
100	21.271	–4.150	135.182	176.687	712.530	713.522	–365.6841	100
200	20.904	–2.048	149.770	160.009	714.632	715.297	–179.1494	200
298.15	20.839	0.000	158.102	158.102	716.680	716.680	–117.5975	298.15
300	20.838	0.039	158.230	158.102	716.719	716.703	–116.8233	300
400	20.815	2.121	164.222	158.919	718.801	717.762	–85.6047	400
500	20.805	4.202	168.865	160.461	720.882	718.516	–66.8495	500
600	20.799	6.282	172.658	162.187	722.962	719.019	–54.3348	600
700	20.796	8.362	175.864	163.918	725.042	719.326	–45.3908	700
800	20.793	10.441	178.640	165.589	727.121	719.484	–38.6806	800
900	20.792	12.521	181.089	167.178	729.201	719.529	–33.4607	900
1000	20.791	14.600	183.280	168.680	731.280	719.484	–29.2849	1000
1100	20.791	16.679	185.262	170.099	733.359	719.369	–25.8687	1100
1200	20.793	18.758	187.071	171.439	735.438	719.198	–23.0224	1200
1300	20.797	20.837	188.735	172.706	737.517	718.979	–20.6147	1300
1400	20.803	22.917	190.277	173.907	739.597	718.719	–18.5516	1400
1500	20.814	24.998	191.712	175.047	741.678	718.427	–16.7643	1500
1600	20.829	27.080	193.056	176.131	743.760	718.105	–15.2011	1600
1700	20.851	29.164	194.319	177.164	745.844	717.757	–13.8224	1700
1800	20.878	31.251	195.512	178.150	747.931	717.387	–12.5975	1800
1900	20.912	33.340	196.642	179.094	750.020	716.998	–11.5021	1900
2000	20.952	35.433	197.715	179.999	752.113	716.592	–10.5168	2000
2100	20.999	37.531	198.739	180.867	754.211	716.171	–9.6259	2100
2200	21.052	39.633	199.717	181.701	756.313	715.737	–8.8164	2200
2300	21.110	41.741	200.654	182.505	758.421	715.292	–8.0778	2300
2400	21.174	43.856	201.553	183.280	760.536	714.837	–7.4012	2400
2500	21.242	45.976	202.419	184.029	762.656	714.372	–6.7791	2500
2600	21.313	48.104	203.254	184.752	764.784	713.901	–6.2052	2600
2700	21.388	50.239	204.059	185.452	766.919	713.422	–5.6742	2700
2800	21.464	52.382	204.839	186.131	769.062	712.936	–5.1815	2800
2900	21.542	54.532	205.593	186.789	771.212	712.445	–4.7230	2900
3000	21.622	56.690	206.325	187.428	773.370	711.948	–4.2954	3000
3100	21.701	58.856	207.035	188.049	775.536	711.448	–3.8957	3100
3200	21.780	61.030	207.725	188.653	777.710	710.942	–3.5212	3200
3300	21.859	63.212	208.397	189.242	779.892	710.432	–3.1697	3300
3400	21.937	65.402	209.050	189.815	782.082	709.918	–2.8390	3400
3500	22.013	67.600	209.687	190.373	784.280	709.398	–2.5276	3500
3600	22.087	69.805	210.309	190.918	786.485	708.876	–2.2336	3600
3700	22.160	72.017	210.915	191.451	788.697	708.348	–1.9557	3700
3800	22.230	74.236	211.507	191.971	790.916	707.817	–1.6926	3800
3900	22.298	76.463	212.085	192.479	793.143	707.281	–1.4433	3900
4000	22.363	78.696	212.650	192.976	795.376	706.739	–1.2065	4000
4100	22.426	80.935	213.203	193.463	797.615	706.195	–0.9815	4100
4200	22.487	83.181	213.745	193.940	799.861	705.645	–0.7674	4200
4300	22.545	85.433	214.274	194.406	802.113	705.088	–0.5634	4300
4400	22.600	87.690	214.793	194.864	804.370	704.524	–0.3688	4400
4500	22.653	89.953	215.302	195.312	806.633	703.956	–0.1830	4500

TABLE A19.—THERMODYNAMIC PROPERTIES FOR C (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	22.703	92.220	215.800	195.752	808.900	703.384	–0.0054	4600
4700	22.750	94.493	216.289	196.184	811.173	702.807	0.1645	4700
4800	22.795	96.770	216.768	196.608	813.450	702.224	0.3271	4800
4900	22.838	99.052	217.239	197.024	815.732	701.636	0.4829	4900
5000	22.879	101.338	217.701	197.433	818.018	701.031	0.6325	5000
5100	22.917	103.628	218.154	197.835	820.308			5100
5200	22.953	105.921	218.599	198.230	822.601			5200
5300	22.988	108.218	219.037	198.618	824.898			5300
5400	23.020	110.519	219.467	199.001	827.199			5400
5500	23.051	112.822	219.890	199.377	829.502			5500
5600	23.080	115.129	220.305	199.747	831.809			5600
5700	23.108	117.438	220.714	200.111	834.118			5700
5800	23.134	119.750	221.116	200.470	836.430			5800
5900	23.158	122.065	221.512	200.823	838.745			5900
6000	23.182	124.382	221.901	201.171	841.062			6000
6200	23.225	129.023	222.662	201.852	845.703			6200
6400	23.265	133.672	223.400	202.514	850.352			6400
6600	23.301	138.328	224.117	203.158	855.008			6600
6800	23.335	142.992	224.813	203.784	859.672			6800
7000	23.368	147.662	225.490	204.395	864.342			7000
7200	23.399	152.339	226.148	204.990	869.019			7200
7400	23.431	157.022	226.790	205.571	873.702			7400
7600	23.462	161.711	227.415	206.137	878.391			7600
7800	23.488	166.428	228.028	206.692	883.108			7800
8000	23.508	171.127	228.623	207.232	887.807			8000
8500	23.566	182.895	230.050	208.533	899.575			8500
9000	23.656	194.699	231.399	209.766	911.379			9000
9500	23.792	206.558	232.682	210.939	923.238			9500
10000	23.984	218.500	233.907	212.057	935.180			10000
10500	24.235	230.552	235.083	213.126	947.232			10500
11000	24.547	242.746	236.217	214.150	959.426			11000
11500	24.915	255.109	237.316	215.133	971.789			11500
12000	25.331	267.668	238.385	216.080	984.348			12000
12500	25.787	280.447	239.429	216.993	997.127			12500
13000	26.272	293.460	240.449	217.875	1010.140			13000
13500	26.774	306.721	241.450	218.730	1023.401			13500
14000	27.283	320.236	242.433	219.559	1036.916			14000
14500	27.786	334.004	243.399	220.365	1050.684			14500
15000	28.273	348.019	244.350	221.148	1064.699			15000
15500	28.734	362.272	245.284	221.912	1078.952			15500
16000	29.160	376.747	246.203	222.657	1093.427			16000
16500	29.544	391.425	247.107	223.384	1108.105			16500
17000	29.881	406.283	247.994	224.095	1122.963			17000
17500	30.166	421.297	248.864	224.790	1137.977			17500
18000	30.399	436.440	249.717	225.471	1153.120			18000
18500	30.580	451.688	250.553	226.137	1168.368			18500
19000	30.712	467.012	251.370	226.791	1183.692			19000
19500	30.801	482.392	252.169	227.431	1199.072			19500
20000	30.853	497.807	252.950	228.059	1214.487			20000

TABLE A20.—THERMODYNAMIC PROPERTIES FOR C^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.649	----------	----------	1802.795	1797.651	----------	0
298.15	20.974	0.000	154.664	154.664	1809.444	1809.444	–308.1242	298.15
300	20.971	0.039	154.794	154.664	1809.483	1809.506	–306.1694	300
400	20.889	2.131	160.814	155.486	1811.576	1812.653	–227.3424	400
500	20.851	4.218	165.470	157.035	1813.662	1815.492	–179.9671	500
600	20.831	6.302	169.270	158.767	1815.746	1818.078	–148.3358	600
700	20.819	8.384	172.480	160.502	1817.829	1820.466	–125.7110	700
800	20.811	10.466	175.260	162.177	1819.910	1822.705	–108.7208	800
900	20.806	12.547	177.711	163.770	1821.991	1824.830	–95.4903	900
1000	20.802	14.627	179.903	165.275	1824.072	1826.865	–84.8938	1000
1100	20.799	16.707	181.885	166.697	1826.152	1828.830	–76.2144	1100
1200	20.797	18.787	183.695	168.039	1828.232	1830.737	–68.9739	1200
1300	20.796	20.867	185.359	169.308	1830.311	1832.597	–62.8411	1300
1400	20.794	22.946	186.900	170.510	1832.391	1834.416	–57.5790	1400
1500	20.793	25.026	188.335	171.651	1834.470	1836.201	–53.0141	1500
1600	20.792	27.105	189.677	172.736	1836.549	1837.954	–49.0160	1600
1700	20.792	29.184	190.937	173.770	1838.629	1839.680	–45.4848	1700
1800	20.791	31.263	192.126	174.757	1840.708	1841.382	–42.3431	1800
1900	20.791	33.342	193.250	175.701	1842.787	1843.061	–39.5295	1900
2000	20.790	35.421	194.316	176.606	1844.866	1844.719	–36.9950	2000
2100	20.790	37.500	195.331	177.473	1846.945	1846.359	–34.6998	2100
2200	20.789	39.579	196.298	178.307	1849.024	1847.980	–32.6114	2200
2300	20.789	41.658	197.222	179.110	1851.103	1849.584	–30.7030	2300
2400	20.789	43.737	198.107	179.883	1853.182	1851.173	–28.9521	2400
2500	20.789	45.816	198.955	180.629	1855.260	1852.744	–27.3398	2500
2600	20.789	47.895	199.771	181.350	1857.339	1854.303	–25.8503	2600
2700	20.788	49.974	200.555	182.047	1859.418	1855.846	–24.4701	2700
2800	20.788	52.053	201.311	182.721	1861.497	1857.376	–23.1873	2800
2900	20.788	54.131	202.041	183.375	1863.576	1858.892	–21.9920	2900
3000	20.788	56.210	202.746	184.009	1865.655	1860.394	–20.8755	3000
3100	20.788	58.289	203.427	184.624	1867.733	1861.885	–19.8303	3100
3200	20.788	60.368	204.087	185.222	1869.812	1863.362	–18.8495	3200
3300	20.788	62.447	204.727	185.804	1871.891	1864.828	–17.9274	3300
3400	20.788	64.525	205.347	186.369	1873.970	1866.281	–17.0590	3400
3500	20.788	66.604	205.950	186.920	1876.049	1867.722	–16.2395	3500
3600	20.788	68.683	206.536	187.457	1878.127	1869.152	–15.4649	3600
3700	20.788	70.762	207.105	187.980	1880.206	1870.569	–14.7317	3700
3800	20.788	72.840	207.660	188.491	1882.285	1871.976	–14.0365	3800
3900	20.788	74.919	208.200	188.989	1884.364	1873.371	–13.3765	3900
4000	20.788	76.998	208.726	189.476	1886.442	1874.754	–12.7490	4000
4100	20.788	79.077	209.239	189.952	1888.521	1876.127	–12.1517	4100
4200	20.789	81.156	209.740	190.417	1890.600	1877.489	–11.5824	4200
4300	20.789	83.234	210.229	190.872	1892.679	1878.838	–11.0391	4300
4400	20.790	85.313	210.707	191.318	1894.758	1880.174	–10.5202	4400
4500	20.790	87.392	211.174	191.754	1896.837	1881.501	–10.0241	4500
4600	20.791	89.471	211.631	192.181	1898.916	1882.819	–9.5491	4600
4700	20.793	91.551	212.079	192.600	1900.995	1884.127	–9.0941	4700
4800	20.794	93.630	212.516	193.010	1903.074	1885.425	–8.6577	4800
4900	20.796	95.709	212.945	193.413	1905.154	1886.713	–8.2389	4900
5000	20.798	97.789	213.365	193.807	1907.234	1887.981	–7.8365	5000

TABLE A20.—THERMODYNAMIC PROPERTIES FOR C^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.800	99.869	213.777	194.195	1909.314			5100
5200	20.803	101.949	214.181	194.575	1911.394			5200
5300	20.806	104.030	214.577	194.949	1913.474			5300
5400	20.810	106.110	214.966	195.316	1915.555			5400
5500	20.814	108.192	215.348	195.677	1917.636			5500
5600	20.819	110.273	215.723	196.032	1919.718			5600
5700	20.825	112.355	216.092	196.380	1921.800			5700
5800	20.831	114.438	216.454	196.723	1923.883			5800
5900	20.838	116.522	216.810	197.061	1925.966			5900
6000	20.846	118.606	217.160	197.393	1928.050			6000
6200	20.864	122.777	217.844	198.042	1932.221			6200
6400	20.885	126.952	218.507	198.671	1936.396			6400
6600	20.911	131.131	219.150	199.282	1940.576			6600
6800	20.941	135.316	219.775	199.875	1944.761			6800
7000	20.976	139.508	220.382	200.453	1948.952			7000
7200	21.015	143.707	220.974	201.014	1953.151			7200
7400	21.060	147.914	221.550	201.562	1957.359			7400
7600	21.110	152.131	222.112	202.095	1961.576			7600
7800	21.165	156.359	222.661	202.615	1965.803			7800
8000	21.225	160.598	223.198	203.123	1970.042			8000
8500	21.400	171.253	224.490	204.342	1980.697			8500
9000	21.609	182.003	225.719	205.496	1991.448			9000
9500	21.850	192.867	226.893	206.592	2002.311			9500
10000	22.120	203.858	228.021	207.635	2013.303			10000
10500	22.416	214.991	229.107	208.632	2024.435			10500
11000	22.734	226.278	230.157	209.587	2035.722			11000
11500	23.071	237.728	231.175	210.503	2047.173			11500
12000	23.423	249.351	232.165	211.385	2058.796			12000
12500	23.785	261.153	233.128	212.236	2070.597			12500
13000	24.154	273.137	234.068	213.057	2082.581			13000
13500	24.527	285.307	234.987	213.853	2094.752			13500
14000	24.901	297.664	235.885	214.624	2107.109			14000
14500	25.273	310.208	236.766	215.372	2119.652			14500
15000	25.641	322.936	237.629	216.100	2132.381			15000
15500	26.003	335.848	238.475	216.808	2145.292			15500
16000	26.358	348.938	239.306	217.498	2158.383			16000
16500	26.704	362.204	240.123	218.171	2171.648			16500
17000	27.041	375.640	240.925	218.829	2185.085			17000
17500	27.368	389.243	241.714	219.471	2198.687			17500
18000	27.680	402.999	242.489	220.100	2212.444			18000
18500	27.984	416.914	243.251	220.715	2226.359			18500
19000	28.280	430.981	244.001	221.318	2240.425			19000
19500	28.566	445.193	244.740	221.909	2254.637			19500
20000	28.840	459.541	245.466	222.489	2268.986			20000

TABLE A21.—THERMODYNAMIC PROPERTIES FOR C^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.219	----------	----------	582.095	589.346	----------	0
298.15	20.787	0.000	159.004	159.004	588.314	588.314	–96.1576	298.15
300	20.787	0.038	159.132	159.004	588.353	588.298	–95.5220	300
400	20.787	2.117	165.112	159.820	590.431	587.275	–69.9337	400
500	20.786	4.196	169.751	161.359	592.510	585.948	–54.6114	500
600	20.786	6.274	173.541	163.083	594.589	584.371	–44.4220	600
700	20.786	8.353	176.745	164.812	596.667	582.599	–37.1647	700
800	20.786	10.432	179.520	166.481	598.746	580.677	–31.7391	800
900	20.786	12.510	181.969	168.068	600.825	578.643	–27.5335	900
1000	20.786	14.589	184.159	169.570	602.903	576.519	–24.1811	1000
1100	20.786	16.668	186.140	170.988	604.982	574.325	–21.4486	1100
1200	20.786	18.746	187.949	172.327	607.060	572.074	–19.1802	1200
1300	20.786	20.825	189.612	173.593	609.139	569.776	–17.2685	1300
1400	20.786	22.903	191.153	174.793	611.218	567.436	–15.6365	1400
1500	20.786	24.982	192.587	175.932	613.296	565.063	–14.2281	1500
1600	20.786	27.061	193.928	177.015	615.375	562.659	–13.0009	1600
1700	20.786	29.139	195.189	178.048	617.454	560.227	–11.9226	1700
1800	20.786	31.218	196.377	179.033	619.532	557.771	–10.9684	1800
1900	20.786	33.297	197.501	179.976	621.611	555.292	–10.1184	1900
2000	20.786	35.375	198.567	180.879	623.689	552.793	–9.3567	2000
2100	20.786	37.454	199.581	181.746	625.768	550.275	–8.6708	2100
2200	20.786	39.532	200.548	182.579	627.847	547.738	–8.0501	2200
2300	20.786	41.611	201.472	183.380	629.925	545.185	–7.4860	2300
2400	20.786	43.690	202.357	184.152	632.004	542.616	–6.9713	2400
2500	20.786	45.768	203.205	184.898	634.083	540.030	–6.5000	2500
2600	20.786	47.847	204.020	185.618	636.161	537.431	–6.0671	2600
2700	20.786	49.926	204.805	186.314	638.240	534.817	–5.6682	2700
2800	20.786	52.004	205.561	186.988	640.318	532.189	–5.2996	2800
2900	20.786	54.083	206.290	187.641	642.397	529.548	–4.9580	2900
3000	20.786	56.162	206.995	188.274	644.476	526.892	–4.6409	3000
3100	20.786	58.240	207.676	188.889	646.554	524.226	–4.3457	3100
3200	20.786	60.319	208.336	189.487	648.633	521.546	–4.0704	3200
3300	20.786	62.397	208.976	190.068	650.712	518.854	–3.8131	3300
3400	20.786	64.476	209.597	190.633	652.790	516.150	–3.5721	3400
3500	20.786	66.555	210.199	191.183	654.869	513.433	–3.3462	3500
3600	20.786	68.633	210.785	191.720	656.948	510.706	–3.1339	3600
3700	20.786	70.712	211.354	192.243	659.026	507.966	–2.9342	3700
3800	20.786	72.791	211.908	192.753	661.105	505.215	–2.7459	3800
3900	20.786	74.869	212.448	193.251	663.183	502.453	–2.5684	3900
4000	20.786	76.948	212.975	193.738	665.262	499.678	–2.4006	4000
4100	20.786	79.026	213.488	194.213	667.341	496.894	–2.2419	4100
4200	20.786	81.105	213.989	194.678	669.419	494.098	–2.0916	4200
4300	20.786	83.184	214.478	195.133	671.498	491.290	–1.9491	4300
4400	20.786	85.262	214.956	195.578	673.577	488.468	–1.8138	4400
4500	20.786	87.341	215.423	196.014	675.655	485.638	–1.6853	4500
4600	20.786	89.420	215.880	196.441	677.734	482.798	–1.5631	4600
4700	20.786	91.498	216.327	196.859	679.812	479.948	–1.4468	4700
4800	20.786	93.577	216.764	197.269	681.891	477.088	–1.3360	4800
4900	20.786	95.655	217.193	197.672	683.970	474.218	–1.2304	4900
5000	20.786	97.734	217.613	198.066	686.048	471.328	–1.1296	5000

TABLE A21.—THERMODYNAMIC PROPERTIES FOR C^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	218.025	198.453	688.127			5100
5200	20.786	101.891	218.428	198.834	690.206			5200
5300	20.786	103.970	218.824	199.207	692.284			5300
5400	20.786	106.049	219.213	199.574	694.363			5400
5500	20.786	108.127	219.594	199.935	696.441			5500
5600	20.786	110.206	219.969	200.289	698.520			5600
5700	20.786	112.284	220.337	200.638	700.599			5700
5800	20.786	114.363	220.698	200.980	702.677			5800
5900	20.786	116.442	221.053	201.318	704.756			5900
6000	20.786	118.520	221.403	201.649	706.835			6000
6200	20.786	122.678	222.084	202.298	710.992			6200
6400	20.786	126.835	222.744	202.926	715.149			6400
6600	20.786	130.992	223.384	203.537	719.306			6600
6800	20.786	135.149	224.004	204.130	723.464			6800
7000	20.786	139.307	224.607	204.706	727.621			7000
7200	20.786	143.464	225.193	205.267	731.778			7200
7400	20.786	147.621	225.762	205.813	735.935			7400
7600	20.786	151.778	226.316	206.346	740.093			7600
7800	20.786	155.936	226.856	206.865	744.250			7800
8000	20.786	160.093	227.383	207.371	748.407			8000
8500	20.786	170.486	228.643	208.586	758.800			8500
9000	20.786	180.879	229.831	209.733	769.193			9000
9500	20.786	191.272	230.955	210.821	779.587			9500
10000	20.786	201.665	232.021	211.854	789.980			10000
10500	20.786	212.059	233.035	212.839	800.373			10500
11000	20.786	222.452	234.002	213.779	810.766			11000
11500	20.786	232.845	234.926	214.679	821.159			11500
12000	20.786	243.238	235.811	215.541	831.552			12000
12500	20.786	253.631	236.659	216.369	841.945			12500
13000	20.786	264.024	237.475	217.165	852.339			13000
13500	20.786	274.417	238.259	217.932	862.732			13500
14000	20.786	284.811	239.015	218.671	873.125			14000
14500	20.786	295.204	239.744	219.385	883.518			14500
15000	20.786	305.597	240.449	220.076	893.911			15000
15500	20.786	315.990	241.131	220.744	904.304			15500
16000	20.786	326.383	241.791	221.392	914.697			16000
16500	20.786	336.776	242.430	222.020	925.090			16500
17000	20.786	347.169	243.051	222.629	935.484			17000
17500	20.786	357.563	243.653	223.221	945.877			17500
18000	20.786	367.956	244.239	223.797	956.270			18000
18500	20.786	378.349	244.808	224.357	966.663			18500
19000	20.786	388.742	245.363	224.903	977.056			19000
19500	20.786	399.135	245.903	225.434	987.449			19500
20000	20.786	409.528	246.429	225.952	997.842			20000

TABLE A22.—THERMODYNAMIC PROPERTIES FOR Ca

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	171.603	177.386	----------	0
100	20.786	–4.119	132.180	173.368	173.681	178.436	–87.1773	100
200	20.786	–2.040	146.588	156.789	175.760	178.226	–40.5886	200
298.15	20.786	0.000	154.887	154.887	177.800	177.800	–25.2806	298.15
300	20.786	0.038	155.016	154.888	177.838	177.791	–25.0885	300
400	20.786	2.117	160.996	155.703	179.917	177.228	–17.3603	400
500	20.786	4.196	165.634	157.243	181.996	176.516	–12.7399	500
600	20.786	6.274	169.424	158.966	184.074	175.633	–9.6736	600
700	20.786	8.353	172.628	160.695	186.153	174.567	–7.4954	700
*800	20.786	10.432	175.404	162.364	188.232	172.673	–5.8787	800
900	20.786	12.510	177.852	163.952	190.310	171.699	–4.6294	900
1000	20.786	14.589	180.042	165.453	192.389	170.606	–3.6359	1000
1100	20.786	16.667	182.023	166.871	194.467	169.328	–2.8286	1100
*1200	20.787	18.746	183.832	168.210	196.546	159.113	–2.1900	1200
1300	20.787	20.825	185.496	169.476	198.625	157.391	–1.6601	1300
1400	20.789	22.904	187.036	170.676	200.704	155.670	–1.2108	1400
1500	20.793	24.983	188.471	171.815	202.783	153.949	–0.8257	1500
1600	20.802	27.062	189.813	172.899	204.862	152.229	–0.4925	1600
1700	20.818	29.143	191.074	173.931	206.943	150.510	–0.2017	1700
1800	20.846	31.226	192.265	174.917	209.026	148.793	0.0537	1800
1900	20.889	33.313	193.393	175.860	211.113	147.080	0.2797	1900
2000	20.954	35.405	194.466	176.764	213.205	145.372	0.4807	2000
2100	21.046	37.505	195.491	177.631	215.305	143.671	0.6605	2100
2200	21.174	39.615	196.472	178.465	217.415	141.982	0.8220	2200
2300	21.343	41.741	197.417	179.269	219.541	140.308	0.9677	2300
2400	21.562	43.886	198.330	180.044	221.686	138.652	1.0997	2400
2500	21.836	46.055	199.216	180.793	223.855	137.022	1.2197	2500
2600	22.173	48.255	200.078	181.519	226.055	135.422	1.3291	2600
2700	22.579	50.492	200.923	182.222	228.292	133.859	1.4293	2700
2800	23.058	52.773	201.752	182.905	230.573	132.340	1.5213	2800
2900	23.614	55.106	202.571	183.569	232.906	130.873	1.6060	2900
3000	24.251	57.499	203.382	184.215	235.299	129.465	1.6841	3000
3100	24.970	59.959	204.188	184.847	237.759	128.126	1.7564	3100
3200	25.772	62.496	204.994	185.464	240.296	126.862	1.8236	3200
3300	26.655	65.116	205.800	186.068	242.916	125.683	1.8860	3300
3400	27.618	67.829	206.610	186.660	245.629	124.596	1.9443	3400
3500	28.657	70.642	207.425	187.242	248.442	123.609	1.9988	3500
3600	29.767	73.563	208.248	187.814	251.363	122.730	2.0498	3600
3700	30.944	76.598	209.079	188.377	254.398	121.965	2.0978	3700
3800	32.179	79.754	209.921	188.933	257.554	121.320	2.1430	3800
3900	33.466	83.035	210.773	189.482	260.835	120.802	2.1856	3900
4000	34.797	86.448	211.637	190.025	264.248	120.415	2.2260	4000
4100	36.162	89.996	212.513	190.563	267.796	120.162	2.2643	4100
4200	37.553	93.681	213.401	191.096	271.481	120.048	2.3008	4200
4300	38.962	97.507	214.301	191.625	275.307	120.073	2.3355	4300
4400	40.368	101.470	215.212	192.151	279.270	120.237	2.3686	4400
4500	41.773	105.575	216.135	192.674	283.375	120.542	2.4004	4500

TABLE A22.—THERMODYNAMIC PROPERTIES FOR Ca (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	43.158	109.817	217.067	193.194	287.617	120.984	2.4309	4600
4700	44.536	114.202	218.010	193.712	292.002	121.569	2.4602	4700
4800	45.887	118.724	218.962	194.228	296.524	122.290	2.4884	4800
4900	47.204	123.378	219.922	194.742	301.178	123.145	2.5156	4900
5000	48.478	128.162	220.888	195.256	305.962	124.129	2.5420	5000
5100	49.709	133.072	221.860	195.768	310.872	125.239	2.5675	5100
5200	50.913	138.053	222.812	196.263	315.853	126.420	2.5915	5200
5300	52.071	143.203	223.793	196.773	321.003	127.769	2.6156	5300
5400	53.163	148.465	224.776	197.283	326.265	129.232	2.6390	5400
5500	54.181	153.833	225.761	197.792	331.633	130.799	2.6619	5500
5600	55.116	159.298	226.746	198.300	337.098	132.465	2.6842	5600
5700	55.960	164.853	227.729	198.808	342.653	134.219	2.7060	5700
5800	56.705	170.487	228.709	199.315	348.287	136.053	2.7274	5800
5900	57.342	176.190	229.684	199.821	353.990	137.957	2.7483	5900
6000	57.862	181.951	230.652	200.327	359.751	139.918	2.7688	6000
6200	58.742	193.616	232.564	201.336	371.416			6200
6400	59.385	205.432	234.440	202.341	383.232			6400
6600	59.795	217.354	236.274	203.342	395.154			6600
6800	59.983	229.335	238.063	204.337	407.135			6800
7000	59.962	241.333	239.802	205.326	419.133			7000
7200	59.751	253.308	241.488	206.307	431.108			7200
7400	59.370	265.223	243.121	207.280	443.023			7400
7600	58.838	277.045	244.697	208.244	454.845			7600
7800	58.174	288.749	246.217	209.198	466.549			7800
8000	57.399	300.308	247.681	210.142	478.108			8000
8500	55.089	328.449	251.093	212.452	506.249			8500
9000	52.447	355.342	254.168	214.686	533.142			9000
9500	49.677	380.875	256.930	216.838	558.675			9500
10000	46.933	405.023	259.408	218.906	582.823			10000
10500	44.324	427.830	261.634	220.888	605.630			10500
11000	41.921	449.382	263.640	222.787	627.182			11000
11500	39.760	469.791	265.454	224.603	647.591			11500
12000	37.856	489.185	267.105	226.340	666.985			12000
12500	36.202	507.689	268.616	228.001	685.489			12500
13000	34.776	525.425	270.008	229.591	703.225			13000
13500	33.549	542.499	271.297	231.112	720.299			13500
14000	32.485	559.002	272.497	232.568	736.802			14000
14500	31.545	575.004	273.620	233.965	752.804			14500
15000	30.692	590.560	274.675	235.305	768.360			15000
15500	29.892	605.704	275.668	236.591	783.504			15500
16000	29.116	620.457	276.605	237.827	798.257			16000
16500	28.341	634.821	277.489	239.015	812.621			16500
17000	27.555	648.796	278.324	240.159	826.596			17000
17500	26.753	662.374	279.111	241.261	840.174			17500
18000	25.944	675.548	279.853	242.323	853.348			18000
18500	25.146	688.319	280.553	243.347	866.119			18500
19000	24.393	700.701	281.214	244.335	878.501			19000
19500	23.731	712.728	281.839	245.288	890.528			19500
20000	23.221	724.458	282.433	246.210	902.258			20000

***Assigned reference element phase change at 716 K and 1115 K**

TABLE A23.—THERMODYNAMIC PROPERTIES FOR Ca^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	767.630	767.216	----------	0
298.15	20.786	0.000	160.650	160.650	773.828	773.828	–128.3027	298.15
300	20.786	0.038	160.779	160.651	773.866	773.857	–127.4667	300
400	20.786	2.117	166.759	161.466	775.945	775.372	–93.7521	400
500	20.786	4.196	171.397	163.006	778.023	776.739	–73.4851	500
600	20.786	6.274	175.187	164.729	780.102	777.935	–59.9512	600
700	20.786	8.353	178.391	166.458	782.181	778.948	–50.2702	700
*800	20.786	10.432	181.167	168.127	784.259	779.133	–43.0070	800
900	20.786	12.510	183.615	169.715	786.338	780.237	–37.3508	900
1000	20.786	14.589	185.805	171.216	788.417	781.223	–32.8197	1000
1100	20.786	16.667	187.786	172.634	790.495	782.023	–29.1081	1100
*1200	20.787	18.746	189.595	173.973	792.574	773.887	–26.0411	1200
1300	20.789	20.825	191.259	175.239	794.653	774.244	–23.4493	1300
1400	20.793	22.904	192.799	176.439	796.732	774.602	–21.2267	1400
1500	20.801	24.984	194.234	177.578	798.811	774.960	–19.2996	1500
1600	20.815	27.064	195.577	178.662	800.892	775.319	–17.6126	1600
1700	20.838	29.147	196.840	179.694	802.975	775.681	–16.1234	1700
1800	20.875	31.232	198.032	180.680	805.060	776.045	–14.7991	1800
1900	20.927	33.322	199.162	181.623	807.150	776.413	–13.6135	1900
2000	21.000	35.418	200.237	182.527	809.246	776.788	–12.5461	2000
2100	21.096	37.523	201.264	183.395	811.351	777.171	–11.5798	2100
2200	21.218	39.639	202.248	184.230	813.466	777.565	–10.7009	2200
2300	21.369	41.768	203.194	185.034	815.595	777.973	–9.8980	2300
2400	21.551	43.913	204.107	185.810	817.741	778.397	–9.1617	2400
2500	21.764	46.079	204.991	186.560	819.907	778.841	–8.4838	2500
2600	22.009	48.267	205.849	187.285	822.095	779.308	–7.8578	2600
2700	22.286	50.482	206.685	187.988	824.309	779.802	–7.2777	2700
2800	22.594	52.725	207.501	188.671	826.553	780.324	–6.7388	2800
2900	22.932	55.001	208.300	189.334	828.829	780.879	–6.2367	2900
3000	23.296	57.313	209.083	189.979	831.140	781.468	–5.7677	3000
3100	23.686	59.662	209.853	190.608	833.489	782.096	–5.3286	3100
3200	24.098	62.051	210.612	191.221	835.878	782.764	–4.9166	3200
3300	24.530	64.482	211.360	191.820	838.310	783.474	–4.5292	3300
3400	24.977	66.957	212.099	192.406	840.785	784.227	–4.1643	3400
3500	25.438	69.478	212.830	192.979	843.306	785.027	–3.8199	3500
3600	25.908	72.045	213.553	193.540	845.873	785.873	–3.4943	3600
3700	26.385	74.660	214.269	194.091	848.487	786.766	–3.1860	3700
3800	26.865	77.322	214.979	194.631	851.150	787.707	–2.8935	3800
3900	27.345	80.033	215.683	195.162	853.860	788.696	–2.6157	3900
4000	27.822	82.791	216.381	195.684	856.619	789.733	–2.3515	4000
4100	28.294	85.597	217.074	196.197	859.425	790.818	–2.0998	4100
4200	28.758	88.450	217.762	196.702	862.277	791.949	–1.8597	4200
4300	29.211	91.348	218.444	197.200	865.176	793.126	–1.6305	4300
4400	29.652	94.291	219.120	197.690	868.119	794.348	–1.4114	4400
4500	30.078	97.278	219.791	198.174	871.106	795.613	–1.2017	4500
4600	30.488	100.306	220.457	198.651	874.134	796.920	–1.0008	4600
4700	30.880	103.375	221.117	199.122	877.203	798.268	–0.8081	4700
4800	31.254	106.482	221.771	199.587	880.310	799.653	–0.6231	4800
4900	31.608	109.625	222.419	200.047	883.453	801.075	–0.4453	4900
5000	31.942	112.803	223.061	200.501	886.631	802.531	–0.2744	5000

TABLE A23.—THERMODYNAMIC PROPERTIES FOR Ca^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	32.255	116.013	223.697	200.949	889.841	804.020	–0.1099	5100
5200	32.547	119.253	224.326	201.393	893.081	805.539	0.0487	5200
5300	32.817	122.522	224.949	201.831	896.349	807.086	0.2015	5300
5400	33.066	125.816	225.564	202.265	899.644	808.659	0.3489	5400
5500	33.294	129.134	226.173	202.694	902.962	810.256	0.4913	5500
5600	33.500	132.474	226.775	203.119	906.302	811.874	0.6288	5600
5700	33.686	135.833	227.370	203.539	909.661	813.512	0.7618	5700
5800	33.852	139.210	227.957	203.955	913.038	815.168	0.8905	5800
5900	33.998	142.603	228.537	204.367	916.431	816.839	1.0150	5900
6000	34.125	146.009	229.109	204.774	919.837	818.524	1.1357	6000
6200	34.324	152.855	230.232	205.578	926.683			6200
6400	34.457	159.735	231.324	206.365	933.562			6400
6600	34.530	166.634	232.385	207.138	940.462			6600
6800	34.550	173.543	233.417	207.896	947.371			6800
7000	34.523	180.451	234.418	208.639	954.279			7000
7200	34.456	187.349	235.389	209.369	961.177			7200
7400	34.356	194.231	236.332	210.085	968.059			7400
7600	34.228	201.090	237.247	210.788	974.917			7600
7800	34.080	207.921	238.134	211.477	981.749			7800
8000	33.914	214.720	238.995	212.155	988.547			8000
8500	33.461	231.565	241.037	213.794	1005.392			8500
9000	33.000	248.178	242.937	215.361	1022.006			9000
9500	32.572	264.564	244.708	216.860	1038.392			9500
10000	32.171	280.714	246.365	218.294	1054.542			10000
10500	31.820	296.756	247.926	219.664	1070.583			10500
11000	31.609	312.609	249.401	220.982	1086.437			11000
11500	31.509	328.383	250.804	222.249	1102.211			11500
12000	31.514	344.134	252.145	223.467	1117.962			12000
12500	31.614	359.913	253.433	224.640	1133.741			12500
13000	31.790	375.762	254.676	225.771	1149.590			13000
13500	32.024	391.713	255.880	226.864	1165.541			13500
14000	32.295	407.792	257.049	227.921	1181.619			14000
14500	32.582	424.010	258.188	228.946	1197.838			14500
15000	32.867	440.374	259.297	229.939	1214.202			15000
15500	33.133	456.875	260.379	230.903	1230.702			15500
16000	33.367	473.502	261.435	231.841	1247.330			16000
16500	33.559	490.235	262.465	232.754	1264.063			16500
17000	33.706	507.052	263.469	233.642	1280.880			17000
17500	33.807	523.933	264.447	234.508	1297.761			17500
18000	33.871	540.853	265.401	235.353	1314.681			18000
18500	33.911	557.799	266.329	236.178	1331.627			18500
19000	33.945	574.763	267.234	236.984	1348.591			19000
19500	34.001	591.749	268.117	237.770	1365.577			19500
20000	34.113	608.774	268.979	238.540	1382.601			20000

*Assigned reference element phase change at 716 K and 1115 K

TABLE A24.—THERMODYNAMIC PROPERTIES FOR Cd

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	105.603	111.850	----------	0
100	20.786	–4.119	145.042	186.230	107.681	112.568	–52.5384	100
200	20.786	–2.040	159.450	169.651	109.760	112.262	–23.1652	200
298.15	20.786	0.000	167.750	167.750	111.800	111.800	–13.5300	298.15
300	20.786	0.038	167.878	167.750	111.838	111.790	–13.4092	300
400	20.786	2.117	173.858	168.565	113.917	111.216	–8.5541	400
500	20.786	4.196	178.496	170.105	115.996	110.525	–5.6576	500
*600	20.786	6.274	182.286	171.829	118.074	103.642	–3.7449	600
700	20.786	8.353	185.490	173.558	120.153	102.730	–2.4613	700
800	20.786	10.432	188.266	175.227	122.232	101.819	–1.5072	800
900	20.786	12.510	190.714	176.814	124.310	100.908	–0.7717	900
1000	20.786	14.589	192.904	178.316	126.389	99.996	–0.1886	1000
1100	20.786	16.667	194.886	179.733	128.467	99.085	0.2841	1100
1200	20.786	18.746	196.694	181.072	130.546	98.173	0.6745	1200
1300	20.786	20.825	198.358	182.339	132.625	97.262	1.0017	1300
1400	20.786	22.903	199.898	183.539	134.703	96.351	1.2795	1400
1500	20.786	24.982	201.333	184.678	136.782	95.439	1.5181	1500
1600	20.786	27.061	202.674	185.761	138.861	94.528	1.7248	1600
1700	20.786	29.139	203.934	186.793	140.939	93.617	1.9055	1700
1800	20.786	31.218	205.122	187.779	143.018	92.705	2.0645	1800
1900	20.786	33.296	206.246	188.722	145.096	91.794	2.2054	1900
2000	20.786	35.375	207.312	189.625	147.175	90.882	2.3310	2000
2100	20.786	37.454	208.327	190.491	149.254	89.971	2.4435	2100
2200	20.786	39.532	209.294	191.324	151.332	89.060	2.5447	2200
2300	20.786	41.611	210.218	192.126	153.411	88.148	2.6362	2300
2400	20.786	43.690	211.102	192.898	155.490	87.237	2.7191	2400
2500	20.787	45.768	211.951	193.643	157.568	86.326	2.7947	2500
2600	20.787	47.847	212.766	194.363	159.647	85.414	2.8637	2600
2700	20.788	49.926	213.551	195.060	161.726	84.503	2.9269	2700
2800	20.788	52.005	214.307	195.733	163.805	83.592	2.9850	2800
2900	20.790	54.083	215.036	196.387	165.883	82.681	3.0385	2900
3000	20.792	56.162	215.741	197.020	167.962	81.770	3.0879	3000
3100	20.795	58.242	216.423	197.635	170.042	80.859	3.1335	3100
3200	20.798	60.321	217.083	198.232	172.121	79.949	3.1759	3200
3300	20.804	62.402	217.723	198.813	174.202	79.039	3.2152	3300
3400	20.811	64.482	218.344	199.379	176.282	78.130	3.2518	3400
3500	20.820	66.564	218.948	199.929	178.364	77.221	3.2859	3500
3600	20.832	68.646	219.534	200.466	180.446	76.314	3.3177	3600
3700	20.846	70.730	220.105	200.989	182.530	75.407	3.3474	3700
3800	20.865	72.816	220.661	201.499	184.616	74.503	3.3753	3800
3900	20.887	74.903	221.204	201.998	186.703	73.601	3.4014	3900
4000	20.914	76.993	221.733	202.484	188.793	72.701	3.4259	4000
4100	20.946	79.086	222.250	202.960	190.886	71.804	3.4489	4100
4200	20.984	81.183	222.755	203.426	192.983	70.910	3.4705	4200
4300	21.029	83.283	223.249	203.881	195.083	70.021	3.4909	4300
4400	21.080	85.389	223.733	204.327	197.189	69.136	3.5101	4400
4500	21.139	87.500	224.207	204.763	199.300	68.257	3.5283	4500

TABLE A24.—THERMODYNAMIC PROPERTIES FOR Cd (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	21.206	89.617	224.673	205.191	201.417	67.384	3.5454	4600
4700	21.282	91.741	225.130	205.610	203.541	66.518	3.5616	4700
4800	21.367	93.874	225.579	206.022	205.674	65.661	3.5769	4800
4900	21.462	96.015	226.020	206.425	207.815	64.812	3.5913	4900
5000	21.568	98.166	226.455	206.821	209.966	63.974	3.6051	5000
5100	21.684	100.329	226.883	207.211	212.129	63.146	3.6181	5100
5200	21.812	102.504	227.305	207.593	214.304	62.331	3.6304	5200
5300	21.952	104.692	227.722	207.969	216.492	61.529	3.6422	5300
5400	22.104	106.894	228.134	208.339	218.694	60.742	3.6533	5400
5500	22.268	109.113	228.541	208.702	220.913	59.970	3.6640	5500
5600	22.446	111.348	228.944	209.060	223.148	59.216	3.6741	5600
5700	22.636	113.602	229.343	209.412	225.402	58.479	3.6837	5700
5800	22.841	115.876	229.738	209.759	227.676	57.763	3.6929	5800
5900	23.060	118.170	230.130	210.101	229.970	57.068	3.7016	5900
6000	23.293	120.488	230.520	210.438	232.288	56.395	3.7100	6000
6200	23.802	125.196	231.291	211.099	236.996			6200
6400	24.363	130.007	232.055	211.742	241.807			6400
6600	24.979	134.935	232.813	212.369	246.735			6600
6800	25.651	139.991	233.568	212.981	251.791			6800
7000	26.393	145.193	234.322	213.580	256.993			7000
7200	27.194	150.549	235.076	214.167	262.349			7200
7400	28.150	155.960	235.816	214.740	267.760			7400
7600	29.144	161.689	236.580	215.305	273.489			7600
7800	30.175	167.621	237.350	215.860	279.421			7800
8000	31.234	173.761	238.127	216.407	285.561			8000
8500	33.934	190.051	240.102	217.743	301.851			8500
9000	36.609	207.690	242.118	219.041	319.490			9000
9500	39.160	226.640	244.166	220.309	338.440			9500
10000	41.518	246.818	246.236	221.554	358.618			10000
10500	43.634	268.117	248.314	222.779	379.917			10500
11000	45.481	290.407	250.387	223.986	402.207			11000
11500	47.047	313.551	252.444	225.179	425.351			11500
12000	48.329	337.408	254.475	226.358	449.208			12000
12500	49.334	361.834	256.469	227.522	473.634			12500
13000	50.072	386.697	258.419	228.673	498.497			13000
13500	50.558	411.865	260.319	229.810	523.665			13500
14000	50.807	437.216	262.163	230.933	549.016			14000
14500	50.833	462.635	263.947	232.041	574.435			14500
15000	50.648	488.014	265.667	233.133	599.814			15000
15500	50.260	513.248	267.322	234.210	625.048			15500
16000	49.674	538.241	268.909	235.269	650.041			16000
16500	48.889	562.889	270.426	236.312	674.689			16500
17000	47.898	587.094	271.872	237.337	698.894			17000
17500	46.688	610.751	273.243	238.343	722.551			17500
18000	45.238	633.742	274.539	239.331	745.542			18000
18500	43.521	655.943	275.755	240.299	767.743			18500
19000	41.500	677.212	276.890	241.247	789.012			19000
19500	39.132	697.387	277.938	242.175	809.187			19500
20000	36.364	716.279	278.895	243.081	828.079			20000

***Assigned reference element phase change at 594.258 K**

TABLE A25.—THERMODYNAMIC PROPERTIES FOR Cd^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	979.557	979.606	----------	0
298.15	20.786	0.000	173.513	173.513	985.754	985.754	–165.2424	298.15
300	20.786	0.038	173.641	173.513	985.793	985.783	–164.1775	300
400	20.786	2.117	179.621	174.329	987.871	987.287	–121.2386	400
500	20.786	4.196	184.260	175.868	989.950	988.675	–95.4368	500
*600	20.786	6.274	188.049	177.592	992.029	983.870	–78.2175	600
700	20.786	8.353	191.254	179.321	994.107	985.038	–65.9747	700
800	20.786	10.432	194.029	180.990	996.186	986.205	–56.7817	800
900	20.786	12.510	196.477	182.577	998.265	987.372	–49.6231	900
1000	20.786	14.589	198.668	184.079	1000.343	988.539	–43.8894	1000
1100	20.786	16.667	200.649	185.496	1002.422	989.707	–39.1927	1100
1200	20.786	18.746	202.457	186.836	1004.500	990.874	–35.2741	1200
1300	20.786	20.825	204.121	188.102	1006.579	992.041	–31.9545	1300
1400	20.786	22.903	205.662	189.302	1008.658	993.208	–29.1057	1400
1500	20.786	24.982	207.096	190.441	1010.736	994.376	–26.6339	1500
1600	20.786	27.061	208.437	191.524	1012.815	995.543	–24.4685	1600
1700	20.786	29.139	209.697	192.557	1014.894	996.710	–22.5556	1700
1800	20.786	31.218	210.885	193.542	1016.972	997.877	–20.8533	1800
1900	20.786	33.296	212.009	194.485	1019.051	999.045	–19.3284	1900
2000	20.786	35.375	213.075	195.388	1021.129	1000.212	–17.9543	2000
2100	20.786	37.454	214.090	196.255	1023.208	1001.379	–16.7097	2100
2200	20.786	39.532	215.057	197.087	1025.287	1002.546	–15.5769	2200
2300	20.786	41.611	215.981	197.889	1027.365	1003.714	–14.5414	2300
2400	20.786	43.690	216.865	198.661	1029.444	1004.881	–13.5911	2400
2500	20.786	45.768	217.714	199.407	1031.523	1006.048	–12.7158	2500
2600	20.786	47.847	218.529	200.126	1033.601	1007.215	–11.9069	2600
2700	20.786	49.926	219.314	200.823	1035.680	1008.383	–11.1570	2700
2800	20.786	52.004	220.070	201.497	1037.758	1009.550	–10.4599	2800
2900	20.786	54.083	220.799	202.150	1039.837	1010.717	–9.8101	2900
3000	20.786	56.161	221.504	202.783	1041.916	1011.884	–9.2029	3000
3100	20.786	58.240	222.185	203.398	1043.994	1013.052	–8.6343	3100
3200	20.786	60.319	222.845	203.996	1046.073	1014.219	–8.1006	3200
3300	20.786	62.397	223.485	204.576	1048.152	1015.386	–7.5986	3300
3400	20.786	64.476	224.105	205.142	1050.230	1016.553	–7.1257	3400
3500	20.786	66.555	224.708	205.692	1052.309	1017.721	–6.6792	3500
3600	20.786	68.633	225.293	206.229	1054.388	1018.888	–6.2571	3600
3700	20.786	70.712	225.863	206.752	1056.466	1020.055	–5.8573	3700
3800	20.787	72.790	226.417	207.262	1058.545	1021.223	–5.4781	3800
3900	20.787	74.869	226.957	207.760	1060.623	1022.390	–5.1180	3900
4000	20.787	76.948	227.483	208.247	1062.702	1023.557	–4.7755	4000
4100	20.787	79.026	227.997	208.722	1064.781	1024.724	–4.4493	4100
4200	20.787	81.105	228.498	209.187	1066.860	1025.892	–4.1383	4200
4300	20.788	83.184	228.987	209.642	1068.938	1027.059	–3.8414	4300
4400	20.788	85.263	229.465	210.087	1071.017	1028.227	–3.5577	4400
4500	20.789	87.342	229.932	210.523	1073.096	1029.394	–3.2863	4500
4600	20.790	89.420	230.389	210.950	1075.175	1030.562	–3.0264	4600
4700	20.790	91.499	230.836	211.368	1077.254	1031.729	–2.7773	4700
4800	20.792	93.579	231.274	211.778	1079.333	1032.897	–2.5383	4800
4900	20.793	95.658	231.702	212.180	1081.412	1034.065	–2.3087	4900
5000	20.795	97.737	232.122	212.575	1083.492	1035.233	–2.0882	5000

TABLE A25.—THERMODYNAMIC PROPERTIES FOR Cd^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.797	99.817	232.534	212.962	1085.571	1036.401	–1.8760	5100
5200	20.799	101.897	232.938	213.343	1087.651	1037.569	–1.6717	5200
5300	20.802	103.977	233.334	213.716	1089.731	1038.738	–1.4750	5300
5400	20.806	106.057	233.723	214.083	1091.811	1039.907	–1.2853	5400
5500	20.810	108.138	234.105	214.444	1093.892	1041.077	–1.1023	5500
5600	20.814	110.219	234.480	214.798	1095.973	1042.246	–0.9257	5600
5700	20.819	112.301	234.848	215.147	1098.055	1043.417	–0.7550	5700
5800	20.825	114.383	235.211	215.489	1100.137	1044.588	–0.5901	5800
5900	20.832	116.466	235.567	215.827	1102.220	1045.759	–0.4305	5900
6000	20.839	118.549	235.917	216.159	1104.304	1046.931	–0.2761	6000
6200	20.857	122.719	236.600	216.807	1108.473			6200
6400	20.879	126.893	237.263	217.436	1112.647			6400
6600	20.906	131.071	237.906	218.047	1116.825			6600
6800	20.937	135.255	238.530	218.640	1121.009			6800
7000	20.975	139.446	239.138	219.217	1125.200			7000
7200	21.018	143.645	239.729	219.779	1129.400			7200
7400	21.068	147.854	240.306	220.326	1133.608			7400
7600	21.125	152.073	240.868	220.859	1137.827			7600
7800	21.189	156.304	241.418	221.379	1142.059			7800
8000	21.261	160.549	241.955	221.887	1146.303			8000
8500	21.478	171.232	243.251	223.106	1156.986			8500
9000	21.750	182.036	244.486	224.259	1167.791			9000
9500	22.082	192.992	245.670	225.355	1178.746			9500
10000	22.476	204.128	246.813	226.400	1189.883			10000
10500	22.937	215.479	247.920	227.398	1201.233			10500
11000	23.467	227.076	248.999	228.356	1212.831			11000
11500	24.071	238.957	250.055	229.276	1224.712			11500
12000	24.753	251.160	251.094	230.164	1236.914			12000
12500	25.513	263.719	252.119	231.021	1249.473			12500
13000	26.352	276.672	253.135	231.852	1262.427			13000
13500	27.277	290.065	254.146	232.659	1275.819			13500
14000	28.305	303.956	255.156	233.445	1289.710			14000
14500	29.431	318.384	256.168	234.211	1304.138			14500
15000	30.659	333.401	257.186	234.960	1319.155			15000
15500	31.988	349.056	258.213	235.693	1334.810			15500
16000	33.368	365.405	259.256	236.418	1351.160			16000
16500	34.801	382.445	260.305	237.126	1368.199			16500
17000	36.294	400.217	261.366	237.824	1385.971			17000
17500	37.838	418.747	262.440	238.512	1404.501			17500
18000	39.424	438.061	263.528	239.191	1423.816			18000
18500	41.042	458.177	264.630	239.864	1443.932			18500
19000	42.681	479.107	265.747	240.530	1464.861			19000
19500	44.329	500.859	266.876	241.191	1486.613			19500
20000	45.973	523.435	268.020	241.848	1509.190			20000

*Assigned reference element phase change at 594.258 K

TABLE A26.—THERMODYNAMIC PROPERTIES FOR CL

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.272	----------	----------	115.029	119.620	----------	0
100	20.788	–4.193	142.177	184.106	117.108	120.243	–60.3166	100
200	21.079	–2.105	156.638	167.164	119.196	120.811	–28.8538	200
298.15	21.838	0.000	165.192	165.192	121.301	121.301	–18.4485	298.15
300	21.852	0.040	165.327	165.192	121.341	121.310	–18.3175	300
400	22.467	2.259	171.706	166.057	123.560	121.794	–13.0276	400
500	22.744	4.522	176.754	167.710	125.823	122.271	–9.8410	500
600	22.782	6.800	180.907	169.574	128.101	122.733	–7.7083	600
700	22.692	9.075	184.413	171.450	130.376	123.171	–6.1793	700
800	22.549	11.337	187.434	173.263	132.638	123.584	–5.0286	800
900	22.390	13.584	190.081	174.988	134.885	123.971	–4.1307	900
1000	22.234	15.815	192.432	176.617	137.116	124.333	–3.4102	1000
1100	22.089	18.031	194.544	178.152	139.332	124.674	–2.8190	1100
1200	21.959	20.233	196.461	179.600	141.534	124.995	–2.3250	1200
1300	21.844	22.423	198.214	180.965	143.724	125.299	–1.9060	1300
1400	21.742	24.602	199.829	182.255	145.903	125.586	–1.5460	1400
1500	21.652	26.772	201.325	183.477	148.073	125.860	–1.2333	1500
1600	21.574	28.933	202.720	184.637	150.234	126.121	–0.9591	1600
1700	21.504	31.087	204.026	185.740	152.388	126.370	–0.7166	1700
1800	21.443	33.234	205.253	186.790	154.535	126.607	–0.5007	1800
1900	21.389	35.376	206.411	187.792	156.677	126.834	–0.3072	1900
2000	21.341	37.512	207.507	188.751	158.813	127.050	–0.1327	2000
2100	21.298	39.644	208.547	189.669	160.945	127.255	0.0254	2100
2200	21.260	41.772	209.537	190.550	163.073	127.449	0.1694	2200
2300	21.226	43.896	210.482	191.396	165.197	127.631	0.3011	2300
2400	21.195	46.018	211.384	192.210	167.319	127.800	0.4219	2400
2500	21.167	48.136	212.249	192.995	169.437	127.955	0.5333	2500
2600	21.142	50.251	213.079	193.751	171.552	128.095	0.6361	2600
2700	21.120	52.364	213.876	194.482	173.665	128.219	0.7315	2700
2800	21.099	54.475	214.644	195.188	175.776	128.326	0.8201	2800
2900	21.080	56.584	215.384	195.872	177.885	128.415	0.9027	2900
3000	21.063	58.691	216.098	196.535	179.992	128.485	0.9798	3000
3100	21.047	60.797	216.789	197.177	182.098	128.535	1.0520	3100
3200	21.033	62.901	217.457	197.800	184.202	128.566	1.1197	3200
3300	21.019	65.003	218.104	198.406	186.304	128.577	1.1833	3300
3400	21.007	67.105	218.731	198.994	188.406	128.569	1.2431	3400
3500	20.996	69.205	219.340	199.567	190.506	128.541	1.2995	3500
3600	20.985	71.304	219.931	200.124	192.605	128.496	1.3528	3600
3700	20.975	73.402	220.506	200.668	194.703	128.434	1.4032	3700
3800	20.966	75.499	221.065	201.197	196.800	128.356	1.4509	3800
3900	20.958	77.595	221.610	201.713	198.896	128.264	1.4961	3900
4000	20.950	79.690	222.140	202.218	200.991	128.160	1.5391	4000
4100	20.943	81.785	222.657	202.710	203.086	128.046	1.5799	4100
4200	20.936	83.879	223.162	203.191	205.180	127.923	1.6187	4200
4300	20.930	85.972	223.655	203.661	207.273	127.793	1.6557	4300
4400	20.924	88.065	224.136	204.121	209.366	127.660	1.6909	4400
4500	20.918	90.157	224.606	204.571	211.458	127.524	1.7246	4500

TABLE A26.—THERMODYNAMIC PROPERTIES FOR CL (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.913	92.249	225.065	205.011	213.550	127.387	1.7567	4600
4700	20.908	94.340	225.515	205.443	215.641	127.253	1.7875	4700
4800	20.903	96.430	225.955	205.866	217.731	127.122	1.8170	4800
4900	20.898	98.520	226.386	206.280	219.821	126.997	1.8452	4900
5000	20.894	100.610	226.808	206.686	221.911	126.879	1.8722	5000
5100	20.890	102.699	227.222	207.085	224.000	126.770	1.8982	5100
5200	20.887	104.788	227.628	207.476	226.089	126.672	1.9232	5200
5300	20.883	106.876	228.026	207.860	228.177	126.585	1.9472	5300
5400	20.880	108.964	228.416	208.237	230.265	126.511	1.9703	5400
5500	20.876	111.052	228.799	208.608	232.353	126.451	1.9925	5500
5600	20.873	113.140	229.175	208.972	234.441	126.407	2.0140	5600
5700	20.871	115.227	229.545	209.329	236.528	126.379	2.0346	5700
5800	20.868	117.314	229.907	209.681	238.615	126.368	2.0546	5800
5900	20.865	119.401	230.264	210.027	240.702	126.373	2.0739	5900
6000	20.863	121.487	230.615	210.367	242.788	126.397	2.0926	6000
6200	20.859	125.659	231.299	211.031	246.960			6200
6400	20.855	129.830	231.961	211.675	251.131			6400
6600	20.851	134.001	232.603	212.300	255.302			6600
6800	20.848	138.171	233.225	212.906	259.472			6800
7000	20.846	142.340	233.829	213.495	263.641			7000
7200	20.845	146.509	234.417	214.068	267.810			7200
7400	20.844	150.678	234.988	214.626	271.979			7400
7600	20.844	154.847	235.544	215.169	276.148			7600
7800	20.845	159.016	236.085	215.698	280.317			7800
8000	20.848	163.185	236.613	216.215	284.486			8000
8500	20.861	173.611	237.877	217.452	294.912			8500
9000	20.888	184.048	239.070	218.620	305.349			9000
9500	20.936	194.503	240.201	219.727	315.804			9500
10000	21.013	204.988	241.276	220.777	326.289			10000
10500	21.122	215.516	242.304	221.778	336.817			10500
11000	21.271	226.106	243.289	222.734	347.407			11000
11500	21.458	236.767	244.236	223.648	358.068			11500
12000	21.663	247.628	245.162	224.527	368.929			12000
12500	21.911	258.520	246.052	225.370	379.821			12500
13000	22.204	269.546	246.916	226.182	390.847			13000
13500	22.542	280.731	247.761	226.966	402.032			13500
14000	22.930	292.096	248.587	227.723	413.397			14000
14500	23.367	303.669	249.399	228.457	424.970			14500
15000	23.856	315.473	250.200	229.168	436.774			15000
15500	24.397	327.534	250.991	229.859	448.835			15500
16000	24.988	339.877	251.774	230.532	461.178			16000
16500	25.629	352.529	252.553	231.188	473.830			16500
17000	26.317	365.514	253.328	231.827	486.815			17000
17500	27.050	378.854	254.101	232.453	500.155			17500
18000	27.824	392.571	254.874	233.065	513.872			18000
18500	28.633	406.683	255.648	233.665	527.984			18500
19000	29.473	421.209	256.422	234.253	542.510			19000
19500	30.336	436.160	257.199	234.832	557.461			19500
20000	31.215	451.547	257.978	235.401	572.848			20000

TABLE A27.—THERMODYNAMIC PROPERTIES FOR CL^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.386	----------	----------	1372.413	1370.806	----------	0
298.15	22.959	0.000	167.558	167.558	1378.800	1378.800	–237.5321	298.15
300	22.978	0.042	167.700	167.558	1378.842	1378.849	–236.0425	300
400	23.621	2.378	174.415	168.469	1381.178	1381.529	–175.9715	400
500	23.706	4.748	179.703	170.207	1383.548	1384.191	–139.8584	500
600	23.519	7.111	184.011	172.160	1385.910	1386.817	–115.7366	600
700	23.239	9.449	187.616	174.117	1388.248	1389.397	–98.4741	700
800	22.949	11.758	190.700	176.002	1390.558	1391.935	–85.5033	800
900	22.681	14.039	193.387	177.788	1392.839	1394.435	–75.3966	900
1000	22.446	16.295	195.764	179.469	1395.095	1396.901	–67.2969	1000
1100	22.245	18.530	197.894	181.049	1397.329	1399.339	–60.6581	1100
1200	22.073	20.745	199.822	182.534	1399.545	1401.752	–55.1162	1200
1300	21.928	22.945	201.583	183.933	1401.745	1404.144	–50.4188	1300
1400	21.806	25.132	203.203	185.252	1403.931	1406.518	–46.3856	1400
1500	21.704	27.307	204.704	186.499	1406.107	1408.876	–42.8843	1500
1600	21.620	29.473	206.102	187.681	1408.273	1411.220	–39.8155	1600
1700	21.552	31.632	207.411	188.804	1410.431	1413.553	–37.1033	1700
1800	21.499	33.784	208.641	189.872	1412.584	1415.873	–34.6885	1800
1900	21.459	35.932	209.802	190.891	1414.732	1418.185	–32.5243	1900
2000	21.431	38.076	210.902	191.864	1416.876	1420.488	–30.5734	2000
2100	21.414	40.219	211.947	192.796	1419.018	1422.782	–28.8054	2100
2200	21.409	42.360	212.943	193.689	1421.159	1425.068	–27.1955	2200
2300	21.413	44.501	213.895	194.547	1423.300	1427.345	–25.7233	2300
2400	21.426	46.643	214.807	195.372	1425.442	1429.613	–24.3716	2400
2500	21.447	48.786	215.682	196.167	1427.586	1431.873	–23.1260	2500
2600	21.476	50.932	216.523	196.934	1429.732	1434.122	–21.9745	2600
2700	21.510	53.081	217.335	197.675	1431.881	1436.361	–20.9066	2700
2800	21.551	55.234	218.118	198.391	1434.034	1438.588	–19.9135	2800
2900	21.596	57.392	218.875	199.084	1436.191	1440.804	–18.9874	2900
3000	21.646	59.554	219.608	199.756	1438.354	1443.008	–18.1217	3000
3100	21.698	61.721	220.318	200.408	1440.521	1445.198	–17.3106	3100
3200	21.753	63.894	221.008	201.041	1442.693	1447.376	–16.5491	3200
3300	21.811	66.072	221.678	201.656	1444.871	1449.542	–15.8326	3300
3400	21.870	68.256	222.330	202.255	1447.055	1451.695	–15.1573	3400
3500	21.929	70.446	222.965	202.838	1449.245	1453.836	–14.5196	3500
3600	21.990	72.642	223.584	203.405	1451.441	1455.966	–13.9165	3600
3700	22.050	74.844	224.187	203.959	1453.643	1458.086	–13.3452	3700
3800	22.110	77.052	224.776	204.499	1455.851	1460.198	–12.8031	3800
3900	22.169	79.266	225.351	205.026	1458.065	1462.302	–12.2880	3900
4000	22.227	81.485	225.913	205.542	1460.285	1464.401	–11.7981	4000
4100	22.284	83.711	226.462	206.045	1462.511	1466.496	–11.3314	4100
4200	22.339	85.942	227.000	206.538	1464.742	1468.589	–10.8862	4200
4300	22.393	88.179	227.526	207.020	1466.978	1470.681	–10.4612	4300
4400	22.446	90.421	228.042	207.492	1469.220	1472.776	–10.0549	4400
4500	22.496	92.668	228.547	207.954	1471.467	1474.874	–9.6661	4500
4600	22.545	94.920	229.042	208.407	1473.719	1476.976	–9.2936	4600
4700	22.591	97.177	229.527	208.851	1475.976	1479.086	–8.9365	4700
4800	22.635	99.438	230.003	209.287	1478.238	1481.205	–8.5938	4800
4900	22.678	101.704	230.470	209.714	1480.503	1483.334	–8.2647	4900
5000	22.718	103.973	230.929	210.134	1482.773	1485.475	–7.9482	5000

TABLE A27.—THERMODYNAMIC PROPERTIES FOR CL^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	22.756	106.247	231.379	210.546	1485.047	1487.630	–7.6437	5100
5200	22.792	108.524	231.821	210.951	1487.324	1489.798	–7.3505	5200
5300	22.826	110.805	232.256	211.349	1489.605	1491.983	–7.0679	5300
5400	22.858	113.090	232.683	211.740	1491.889	1494.183	–6.7954	5400
5500	22.887	115.377	233.102	212.125	1494.176	1496.402	–6.5325	5500
5600	22.915	117.667	233.515	212.503	1496.467	1498.639	–6.2785	5600
5700	22.941	119.960	233.921	212.875	1498.759	1500.895	–6.0331	5700
5800	22.965	122.255	234.320	213.242	1501.055	1503.170	–5.7958	5800
5900	22.988	124.553	234.713	213.602	1503.352	1505.466	–5.5661	5900
6000	23.008	126.853	235.099	213.957	1505.652	1507.782	–5.3438	6000
6200	23.044	131.458	235.855	214.652	1510.258			6200
6400	23.074	136.070	236.587	215.326	1514.870			6400
6600	23.098	140.687	237.297	215.981	1519.487			6600
6800	23.117	145.309	237.987	216.618	1524.109			6800
7000	23.131	149.934	238.657	217.238	1528.733			7000
7200	23.140	154.561	239.309	217.842	1533.361			7200
7400	23.146	159.190	239.943	218.431	1537.989			7400
7600	23.147	163.819	240.560	219.005	1542.619			7600
7800	23.146	168.448	241.162	219.566	1547.248			7800
8000	23.142	173.077	241.748	220.113	1551.877			8000
8500	23.120	184.643	243.150	221.427	1563.443			8500
9000	23.086	196.195	244.471	222.671	1574.995			9000
9500	23.044	207.728	245.718	223.852	1586.528			9500
10000	22.996	219.238	246.898	224.975	1598.038			10000
10500	22.945	230.724	248.019	226.046	1609.523			10500
11000	22.893	242.183	249.085	227.069	1620.983			11000
11500	22.842	253.617	250.102	228.048	1632.416			11500
12000	22.794	265.025	251.073	228.988	1643.825			12000
12500	22.750	276.411	252.003	229.890	1655.211			12500
13000	22.713	287.776	252.894	230.757	1666.576			13000
13500	22.685	299.126	253.751	231.593	1677.925			13500
14000	22.667	310.463	254.575	232.399	1689.263			14000
14500	22.663	321.795	255.371	233.178	1700.595			14500
15000	22.674	333.128	256.139	233.931	1711.928			15000
15500	22.703	344.472	256.883	234.659	1723.272			15500
16000	22.753	355.835	257.605	235.365	1734.635			16000
16500	22.826	367.229	258.306	236.049	1746.028			16500
17000	22.925	378.665	258.989	236.714	1757.465			17000
17500	23.052	390.158	259.655	237.360	1768.958			17500
18000	23.211	401.722	260.306	237.988	1780.522			18000
18500	23.403	413.374	260.945	238.600	1792.174			18500
19000	23.632	425.131	261.572	239.197	1803.931			19000
19500	23.897	437.011	262.189	239.778	1815.810			19500
20000	24.204	449.034	262.798	240.346	1827.834			20000

TABLE A28.—THERMODYNAMIC PROPERTIES FOR CL^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–240.155	–229.367	----------	0
298.15	20.786	0.000	153.358	153.358	–233.958	–233.958	42.0759	298.15
300	20.786	0.038	153.487	153.358	–233.920	–233.989	41.8231	300
400	20.786	2.117	159.466	154.174	–231.841	–235.724	31.6042	400
500	20.786	4.196	164.105	155.713	–229.762	–237.510	25.4263	500
600	20.786	6.274	167.895	157.437	–227.684	–239.326	21.2762	600
700	20.786	8.353	171.099	159.166	–225.605	–241.162	18.2890	700
800	20.786	10.432	173.874	160.835	–223.526	–243.012	16.0313	800
900	20.786	12.510	176.323	162.422	–221.448	–244.872	14.2619	900
1000	20.786	14.589	178.513	163.924	–219.369	–246.741	12.8355	1000
1100	20.786	16.667	180.494	165.342	–217.290	–248.616	11.6596	1100
1200	20.786	18.746	182.302	166.681	–215.212	–250.497	10.6721	1200
1300	20.786	20.825	183.966	167.947	–213.133	–252.384	9.8303	1300
1400	20.786	22.903	185.507	169.147	–211.055	–254.275	9.1034	1400
1500	20.786	24.982	186.941	170.286	–208.976	–256.171	8.4686	1500
1600	20.786	27.061	188.282	171.369	–206.897	–258.071	7.9091	1600
1700	20.786	29.139	189.542	172.402	–204.819	–259.976	7.4117	1700
1800	20.786	31.218	190.731	173.387	–202.740	–261.886	6.9663	1800
1900	20.786	33.296	191.854	174.330	–200.661	–263.801	6.5649	1900
2000	20.786	35.375	192.921	175.233	–198.583	–265.721	6.2010	2000
2100	20.786	37.454	193.935	176.100	–196.504	–267.648	5.8693	2100
2200	20.786	39.532	194.902	176.933	–194.426	–269.582	5.5657	2200
2300	20.786	41.611	195.826	177.734	–192.347	–271.524	5.2864	2300
2400	20.786	43.690	196.710	178.506	–190.268	–273.476	5.0285	2400
2500	20.786	45.768	197.559	179.252	–188.190	–275.439	4.7896	2500
2600	20.786	47.847	198.374	179.972	–186.111	–277.415	4.5675	2600
2700	20.786	49.926	199.159	180.668	–184.032	–279.404	4.3604	2700
2800	20.786	52.004	199.915	181.342	–181.954	–281.408	4.1666	2800
2900	20.786	54.083	200.644	181.995	–179.875	–283.428	3.9850	2900
3000	20.786	56.161	201.349	182.628	–177.797	–285.465	3.8142	3000
3100	20.786	58.240	202.030	183.243	–175.718	–287.521	3.6533	3100
3200	20.786	60.319	202.690	183.841	–173.639	–289.594	3.5014	3200
3300	20.786	62.397	203.330	184.422	–171.561	–291.685	3.3576	3300
3400	20.786	64.476	203.950	184.987	–169.482	–293.795	3.2213	3400
3500	20.786	66.555	204.553	185.537	–167.403	–295.922	3.0919	3500
3600	20.786	68.633	205.139	186.074	–165.325	–298.067	2.9688	3600
3700	20.786	70.712	205.708	186.597	–163.246	–300.227	2.8515	3700
3800	20.786	72.790	206.262	187.107	–161.168	–302.402	2.7396	3800
3900	20.786	74.869	206.802	187.605	–159.089	–304.590	2.6326	3900
4000	20.786	76.948	207.329	188.092	–157.010	–306.789	2.5303	4000
4100	20.786	79.026	207.842	188.567	–154.932	–308.998	2.4322	4100
4200	20.786	81.105	208.343	189.032	–152.853	–311.215	2.3381	4200
4300	20.786	83.184	208.832	189.487	–150.774	–313.438	2.2478	4300
4400	20.786	85.262	209.310	189.932	–148.696	–315.664	2.1610	4400
4500	20.786	87.341	209.777	190.368	–146.617	–317.892	2.0774	4500
4600	20.786	89.419	210.234	190.795	–144.539	–320.121	1.9969	4600
4700	20.786	91.498	210.681	191.213	–142.460	–322.346	1.9193	4700
4800	20.786	93.577	211.118	191.623	–140.381	–324.567	1.8444	4800
4900	20.786	95.655	211.547	192.025	–138.303	–326.782	1.7721	4900
5000	20.786	97.734	211.967	192.420	–136.224	–328.990	1.7022	5000

TABLE A28.—THERMODYNAMIC PROPERTIES FOR CL^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	212.379	192.807	–134.145	–331.188	1.6346	5100
5200	20.786	101.891	212.782	193.188	–132.067	–333.375	1.5691	5200
5300	20.786	103.970	213.178	193.561	–129.988	–335.550	1.5057	5300
5400	20.786	106.048	213.567	193.928	–127.910	–337.712	1.4443	5400
5500	20.786	108.127	213.948	194.289	–125.831	–339.860	1.3847	5500
5600	20.786	110.206	214.323	194.643	–123.752	–341.991	1.3269	5600
5700	20.786	112.284	214.690	194.991	–121.674	–344.107	1.2708	5700
5800	20.786	114.363	215.052	195.334	–119.595	–346.205	1.2162	5800
5900	20.786	116.442	215.407	195.671	–117.516	–348.286	1.1632	5900
6000	20.786	118.520	215.757	196.003	–115.438	–350.349	1.1117	6000
6200	20.786	122.677	216.438	196.652	–111.280			6200
6400	20.786	126.835	217.098	197.280	–107.123			6400
6600	20.786	130.992	217.738	197.891	–102.966			6600
6800	20.786	135.149	218.358	198.483	–98.809			6800
7000	20.786	139.306	218.961	199.060	–94.651			7000
7200	20.786	143.464	219.546	199.621	–90.494			7200
7400	20.786	147.621	220.116	200.167	–86.337			7400
7600	20.786	151.778	220.670	200.699	–82.180			7600
7800	20.786	155.936	221.210	201.219	–78.022			7800
8000	20.786	160.093	221.737	201.725	–73.865			8000
8500	20.786	170.486	222.997	202.940	–63.472			8500
9000	20.786	180.879	224.185	204.087	–53.079			9000
9500	20.786	191.272	225.309	205.175	–42.686			9500
10000	20.786	201.665	226.375	206.208	–32.293			10000
10500	20.786	212.058	227.389	207.193	–21.900			10500
11000	20.786	222.452	228.356	208.133	–11.506			11000
11500	20.786	232.845	229.280	209.033	–1.113			11500
12000	20.786	243.238	230.165	209.895	9.280			12000
12500	20.786	253.631	231.013	210.723	19.673			12500
13000	20.786	264.024	231.828	211.519	30.066			13000
13500	20.786	274.417	232.613	212.286	40.459			13500
14000	20.786	284.810	233.369	213.025	50.852			14000
14500	20.786	295.204	234.098	213.739	61.246			14500
15000	20.786	305.597	234.803	214.430	71.639			15000
15500	20.786	315.990	235.485	215.098	82.032			15500
16000	20.786	326.383	236.144	215.746	92.425			16000
16500	20.786	336.776	236.784	216.373	102.818			16500
17000	20.786	347.169	237.405	216.983	113.211			17000
17500	20.786	357.562	238.007	217.575	123.604			17500
18000	20.786	367.956	238.593	218.151	133.998			18000
18500	20.786	378.349	239.162	218.711	144.391			18500
19000	20.786	388.742	239.717	219.256	154.784			19000
19500	20.786	399.135	240.257	219.788	165.177			19500
20000	20.786	409.528	240.783	220.306	175.570			20000

TABLE A29.—THERMODYNAMIC PROPERTIES FOR Co

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.360	----------	----------	422.082	426.853	----------	0
100	20.794	–4.281	156.134	198.945	424.161	428.410	–216.0183	100
200	21.452	–2.180	170.672	181.573	426.262	428.602	–104.0970	200
298.15	23.024	0.000	179.520	179.520	428.442	428.442	–67.2529	298.15
300	23.055	0.043	179.663	179.521	428.484	428.438	–66.7900	300
400	24.508	2.425	186.505	180.444	430.866	428.252	–48.1446	400
500	25.426	4.926	192.083	182.231	433.367	428.015	–36.9628	500
600	25.890	7.495	196.765	184.274	435.936	427.690	–29.5131	600
700	26.094	10.095	200.773	186.352	438.537	427.255	–24.1966	700
*800	26.187	12.710	204.264	188.377	441.151	426.268	–20.2179	800
900	26.251	15.332	207.352	190.317	443.773	425.546	–17.1278	900
1000	26.321	17.960	210.122	192.162	446.402	424.603	–14.6606	1000
1100	26.399	20.596	212.634	193.910	449.038	423.403	–12.6471	1100
1200	26.481	23.240	214.935	195.568	451.682	421.911	–10.9744	1200
1300	26.558	25.892	217.057	197.140	454.334	419.980	–9.5647	1300
*1400	26.624	28.551	219.028	198.634	456.993	417.482	–8.3627	1400
1500	26.674	31.216	220.867	200.056	459.658	415.999	–7.3262	1500
1600	26.706	33.885	222.589	201.411	462.327	414.775	–6.4222	1600
1700	26.719	36.557	224.209	202.705	464.998	413.651	–5.6268	1700
*1800	26.716	39.229	225.736	203.942	467.670	396.261	–4.9301	1800
1900	26.697	41.899	227.180	205.128	470.341	394.882	–4.3259	1900
2000	26.667	44.568	228.549	206.265	473.009	393.500	–3.7841	2000
2100	26.626	47.232	229.849	207.357	475.674	392.114	–3.2956	2100
2200	26.579	49.893	231.086	208.408	478.334	390.725	–2.8530	2200
2300	26.528	52.548	232.267	209.420	480.990	389.330	–2.4504	2300
2400	26.475	55.198	233.395	210.395	483.640	387.930	–2.0826	2400
2500	26.424	57.843	234.474	211.337	486.285	386.525	–1.7455	2500
2600	26.375	60.483	235.510	212.247	488.925	385.115	–1.4355	2600
2700	26.331	63.118	236.504	213.127	491.560	383.700	–1.1494	2700
2800	26.294	65.750	237.461	213.979	494.191	382.281	–0.8848	2800
2900	26.264	68.377	238.383	214.805	496.819	380.859	–0.6394	2900
3000	26.244	71.003	239.273	215.606	499.444	379.434	–0.4111	3000
3100	26.233	73.626	240.134	216.383	502.068	378.007	–0.1984	3100
3200	26.234	76.250	240.966	217.138	504.691	376.581	0.0003	3200
3300	26.246	78.874	241.774	217.873	507.315	375.154	0.1862	3300
3400	26.269	81.499	242.558	218.587	509.941	373.730	0.3605	3400
3500	26.306	84.128	243.320	219.283	512.569	372.308	0.5242	3500
3600	26.355	86.761	244.061	219.961	515.202	370.891	0.6783	3600
3700	26.416	89.399	244.784	220.622	517.841	369.480	0.8234	3700
3800	26.491	92.044	245.490	221.267	520.486	368.075	0.9605	3800
3900	26.579	94.698	246.179	221.897	523.139	366.678	1.0899	3900
4000	26.679	97.361	246.853	222.513	525.802	365.291	1.2125	4000
4100	26.792	100.034	247.513	223.115	528.476	363.914	1.3286	4100
4200	26.918	102.720	248.160	223.703	531.161	362.549	1.4388	4200
4300	27.056	105.418	248.795	224.279	533.860	361.198	1.5434	4300
4400	27.206	108.131	249.419	224.844	536.573	359.861	1.6430	4400
4500	27.368	110.860	250.032	225.397	539.301	358.539	1.7377	4500

TABLE A29.—THERMODYNAMIC PROPERTIES FOR Co (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	27.541	113.605	250.636	225.939	542.047	357.235	1.8280	4600
4700	27.725	116.368	251.230	226.471	544.810	355.948	1.9142	4700
4800	27.919	119.150	251.816	226.993	547.592	354.680	1.9965	4800
4900	28.123	121.952	252.393	227.505	550.394	353.431	2.0751	4900
5000	28.338	124.775	252.964	228.009	553.217	352.204	2.1503	5000
5100	28.561	127.620	253.527	228.503	556.061	350.999	2.2223	5100
5200	28.793	130.487	254.084	228.990	558.929	349.816	2.2914	5200
5300	29.033	133.379	254.634	229.469	561.820	348.657	2.3575	5300
5400	29.282	136.294	255.179	229.940	564.736	347.523	2.4211	5400
5500	29.537	139.234	255.719	230.404	567.676	346.413	2.4821	5500
5600	29.799	142.201	256.253	230.860	570.642	345.329	2.5408	5600
5700	30.066	145.193	256.783	231.311	573.635	344.272	2.5972	5700
5800	30.342	148.213	257.308	231.754	576.655	343.242	2.6515	5800
5900	30.623	151.262	257.829	232.192	579.703	342.240	2.7038	5900
6000	30.908	154.338	258.346	232.623	582.779	341.266	2.7542	6000
6200	31.495	160.577	259.369	233.470	589.018			6200
6400	32.096	166.934	260.378	234.295	595.376			6400
6600	32.711	173.413	261.375	235.100	601.854			6600
6800	33.333	180.014	262.360	235.888	608.456			6800
7000	33.960	186.738	263.335	236.658	615.180			7000
7200	34.586	193.585	264.299	237.412	622.027			7200
7400	35.212	200.557	265.254	238.152	628.998			7400
7600	35.825	207.645	266.199	238.877	636.087			7600
7800	36.452	214.873	267.138	239.590	643.315			7800
8000	37.041	222.199	268.065	240.290	650.640			8000
8500	38.416	240.978	270.340	241.990	669.420			8500
9000	39.651	260.396	272.558	243.625	688.838			9000
9500	40.591	280.210	274.697	245.201	708.652			9500
10000	41.325	300.423	276.766	246.724	728.864			10000
10500	41.817	322.017	278.894	248.226	750.458			10500
11000	42.074	342.999	280.846	249.664	771.440			11000
11500	42.111	364.054	282.718	251.061	792.496			11500
12000	41.947	385.077	284.507	252.418	813.519			12000
12500	41.605	405.971	286.213	253.736	834.413			12500
13000	41.109	426.656	287.836	255.016	855.098			13000
13500	40.487	447.060	289.376	256.261	875.501			13500
14000	39.764	467.126	290.836	257.469	895.568			14000
14500	38.968	486.812	292.217	258.644	915.253			14500
15000	38.122	506.085	293.524	259.785	934.527			15000
15500	37.249	524.928	294.760	260.894	953.370			15500
16000	36.370	543.333	295.929	261.970	971.775			16000
16500	35.502	561.300	297.035	263.016	989.741			16500
17000	34.660	578.839	298.082	264.033	1007.281			17000
17500	33.853	595.965	299.075	265.020	1024.407			17500
18000	33.088	612.699	300.018	265.979	1041.140			18000
18500	32.369	629.061	300.914	266.911	1057.503			18500
19000	31.693	645.075	301.768	267.817	1073.517			19000
19500	31.055	660.761	302.583	268.698	1089.202			19500
20000	30.443	676.135	303.362	269.555	1104.577			20000

***Assigned reference element phase change at 700.1 K, 1394 K, and 1768 K**

TABLE A30.—THERMODYNAMIC PROPERTIES FOR Co^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.292	----------	----------	1186.712	1185.285	----------	0
298.15	22.271	0.000	178.348	178.348	1193.003	1193.003	–200.1629	298.15
300	22.297	0.041	178.486	178.348	1193.045	1193.037	–198.8741	300
400	23.605	2.338	185.085	179.239	1195.342	1194.845	–146.9081	400
500	24.559	4.750	190.462	180.963	1197.753	1196.597	–115.6814	500
600	25.166	7.238	194.998	182.934	1200.242	1198.270	–94.8336	600
700	25.586	9.777	198.910	184.943	1202.780	1199.851	–79.9219	700
*800	25.947	12.354	202.350	186.908	1205.357	1200.906	–68.7277	800
900	26.307	14.966	205.427	188.798	1207.970	1202.253	–60.0108	900
1000	26.674	17.615	208.218	190.602	1210.619	1203.408	–53.0299	1000
1100	27.032	20.301	210.777	192.322	1213.304	1204.337	–47.3134	1100
1200	27.358	23.021	213.143	193.960	1216.024	1204.999	–42.5463	1200
1300	27.635	25.771	215.344	195.521	1218.774	1205.245	–38.5111	1300
*1400	27.854	28.546	217.401	197.011	1221.549	1204.941	–35.0524	1400
1500	28.013	31.339	219.328	198.435	1224.343	1205.666	–32.0546	1500
1600	28.114	34.146	221.140	199.798	1227.150	1206.658	–29.4296	1600
1700	28.164	36.961	222.846	201.104	1229.964	1207.756	–27.1114	1700
*1800	28.171	39.778	224.456	202.357	1232.781	1192.589	–25.0573	1800
1900	28.143	42.594	225.979	203.561	1235.597	1193.434	–23.2353	1900
2000	28.091	45.405	227.421	204.718	1238.409	1194.274	–21.5943	2000
2100	28.021	48.211	228.790	205.832	1241.214	1195.109	–20.1085	2100
2200	27.941	51.009	230.091	206.905	1244.013	1195.935	–18.7568	2200
2300	27.857	53.799	231.332	207.941	1246.802	1196.754	–17.5219	2300
2400	27.774	56.581	232.515	208.940	1249.584	1197.564	–16.3891	2400
2500	27.698	59.354	233.648	209.906	1252.358	1198.366	–15.3462	2500
2600	27.631	62.121	234.733	210.840	1255.124	1199.161	–14.3829	2600
2700	27.579	64.881	235.774	211.744	1257.884	1199.950	–13.4903	2700
2800	27.544	67.637	236.777	212.621	1260.640	1200.734	–12.6610	2800
2900	27.529	70.390	237.743	213.470	1263.394	1201.516	–11.8884	2900
3000	27.537	73.144	238.676	214.295	1266.147	1202.298	–11.1668	3000
3100	27.570	75.899	239.580	215.096	1268.902	1203.081	–10.4913	3100
3200	27.631	78.659	240.456	215.875	1271.662	1203.870	–9.8576	3200
3300	27.720	81.426	241.307	216.633	1274.429	1204.666	–9.2619	3300
3400	27.839	84.203	242.137	217.371	1277.207	1205.472	–8.7009	3400
3500	27.991	86.995	242.946	218.090	1279.998	1206.292	–8.1716	3500
3600	28.174	89.803	243.737	218.792	1282.806	1207.128	–7.6714	3600
3700	28.392	92.631	244.512	219.476	1285.634	1207.985	–7.1978	3700
3800	28.643	95.482	245.272	220.145	1288.485	1208.865	–6.7489	3800
3900	28.928	98.360	246.020	220.799	1291.364	1209.771	–6.3227	3900
4000	29.246	101.269	246.756	221.439	1294.272	1210.708	–5.9175	4000
4100	29.598	104.211	247.482	222.065	1297.214	1211.679	–5.5317	4100
4200	29.982	107.190	248.200	222.679	1300.193	1212.686	–5.1640	4200
4300	30.398	110.208	248.911	223.281	1303.212	1213.733	–4.8131	4300
4400	30.844	113.270	249.614	223.871	1306.273	1214.824	–4.4779	4400
4500	31.318	116.378	250.313	224.451	1309.381	1215.960	–4.1573	4500
4600	31.820	119.535	251.007	225.021	1312.538	1217.145	–3.8503	4600
4700	32.346	122.743	251.697	225.581	1315.746	1218.382	–3.5561	4700
4800	32.895	126.005	252.383	226.132	1319.008	1219.672	–3.2739	4800
4900	33.504	129.292	253.061	226.675	1322.295	1220.988	–3.0029	4900
5000	34.146	132.674	253.744	227.209	1325.677	1222.399	–2.7424	5000

TABLE A30.—THERMODYNAMIC PROPERTIES FOR Co^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	34.818	136.122	254.427	227.736	1329.125	1223.875	–2.4919	5100
5200	35.521	139.639	255.110	228.256	1332.642	1225.420	–2.2507	5200
5300	36.253	143.227	255.793	228.769	1336.230	1227.037	–2.0183	5300
5400	37.014	146.890	256.478	229.276	1339.894	1228.729	–1.7942	5400
5500	37.802	150.631	257.164	229.777	1343.634	1230.498	–1.5779	5500
5600	38.616	154.451	257.852	230.272	1347.455	1232.347	–1.3691	5600
5700	39.457	158.355	258.543	230.762	1351.358	1234.279	–1.1673	5700
5800	40.321	162.344	259.237	231.247	1355.347	1236.297	–0.9721	5800
5900	41.209	166.420	259.934	231.727	1359.423	1238.402	–0.7832	5900
6000	42.118	170.586	260.634	232.203	1363.589	1240.596	–0.6004	6000
6200	43.229	179.120	262.033	233.143	1372.124			6200
6400	44.342	187.878	263.423	234.067	1380.881			6400
6600	45.407	196.854	264.804	234.978	1389.857			6600
6800	46.392	206.036	266.175	235.875	1399.039			6800
7000	47.276	215.404	267.532	236.760	1408.407			7000
7200	48.047	224.938	268.875	237.634	1417.941			7200
7400	48.699	234.615	270.201	238.496	1427.619			7400
7600	49.231	244.410	271.507	239.348	1437.413			7600
7800	49.645	254.300	272.791	240.189	1447.303			7800
8000	49.946	264.260	274.052	241.020	1457.263			8000
8500	50.251	289.334	277.092	243.053	1482.338			8500
9000	50.021	314.422	279.960	245.025	1507.425			9000
9500	49.392	339.289	282.650	246.935	1532.292			9500
10000	48.488	363.768	285.161	248.784	1556.772			10000
10500	47.417	387.749	287.501	250.573	1580.753			10500
11000	46.267	411.172	289.681	252.301	1604.176			11000
11500	45.106	434.015	291.712	253.971	1627.018			11500
12000	43.981	456.284	293.607	255.584	1649.288			12000
12500	42.927	478.008	295.381	257.140	1671.011			12500
13000	41.964	499.226	297.046	258.644	1692.229			13000
13500	41.101	519.988	298.613	260.095	1712.991			13500
14000	40.339	540.345	300.094	261.498	1733.348			14000
14500	39.674	560.344	301.497	262.853	1753.347			14500
15000	39.098	580.034	302.832	264.163	1773.037			15000
15500	38.597	599.454	304.106	265.432	1792.457			15500
16000	38.161	618.642	305.324	266.659	1811.645			16000
16500	37.779	637.625	306.493	267.849	1830.628			16500
17000	37.439	656.428	307.615	269.002	1849.431			17000
17500	37.136	675.070	308.696	270.121	1868.073			17500
18000	36.865	693.568	309.738	271.207	1886.571			18000
18500	36.627	711.939	310.745	272.262	1904.942			18500
19000	36.428	730.202	311.719	273.288	1923.206			19000
19500	36.281	748.376	312.663	274.285	1941.379			19500
20000	36.203	766.494	313.581	275.256	1959.497			20000

*Assigned reference element phase change at 700.1 K, 1394 K, and 1768 K

TABLE A31.—THERMODYNAMIC PROPERTIES FOR Co^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.307	----------	----------	352.108	363.076	----------	0
298.15	22.439	0.000	178.414	178.414	358.414	358.414	–56.1383	298.15
300	22.465	0.042	178.553	178.414	358.456	358.371	–55.7511	300
400	23.756	2.355	185.201	179.312	360.770	356.039	–40.1978	400
500	24.582	4.777	190.600	181.047	363.191	353.643	–30.9280	500
600	24.937	7.256	195.119	183.026	365.670	351.150	–24.7909	600
700	24.962	9.753	198.969	185.036	368.167	348.533	–20.4392	700
*800	24.794	12.242	202.292	186.990	370.656	345.342	–17.2045	800
900	24.531	14.709	205.198	188.855	373.123	342.386	–14.7093	900
1000	24.233	17.147	207.767	190.620	375.562	339.174	–12.7310	1000
1100	23.932	19.555	210.063	192.285	377.970	335.667	–11.1285	1100
1200	23.646	21.934	212.133	193.854	380.348	331.831	–9.8074	1200
1300	23.383	24.285	214.015	195.334	382.700	327.521	–8.7032	1300
*1400	23.145	26.612	215.739	196.731	385.026	322.612	–7.7700	1400
1500	22.931	28.915	217.328	198.052	387.330	318.689	–6.9724	1500
1600	22.740	31.199	218.802	199.303	389.613	315.000	–6.2828	1600
1700	22.571	33.464	220.176	200.491	391.878	311.392	–5.6813	1700
*1800	22.420	35.713	221.461	201.621	394.128	291.501	–5.1613	1800
1900	22.286	37.948	222.670	202.697	396.363	287.607	–4.7190	1900
2000	22.166	40.171	223.810	203.724	398.585	283.701	–4.3263	2000
2100	22.059	42.382	224.889	204.707	400.797	279.783	–3.9759	2100
2200	21.964	44.583	225.913	205.648	402.998	275.856	–3.6617	2200
2300	21.878	46.775	226.887	206.550	405.190	271.919	–3.3790	2300
2400	21.801	48.959	227.817	207.417	407.373	267.974	–3.1235	2400
2500	21.731	51.136	228.705	208.251	409.550	264.022	–2.8919	2500
2600	21.668	53.306	229.556	209.054	411.720	260.063	–2.6813	2600
2700	21.611	55.469	230.373	209.829	413.884	256.098	–2.4893	2700
2800	21.559	57.628	231.158	210.576	416.042	252.128	–2.3137	2800
2900	21.512	59.781	231.913	211.299	418.196	248.153	–2.1528	2900
3000	21.468	61.930	232.642	211.999	420.345	244.173	–2.0050	3000
3100	21.429	64.075	233.345	212.676	422.490	240.189	–1.8689	3100
3200	21.393	66.216	234.025	213.332	424.631	236.201	–1.7435	3200
3300	21.359	68.354	234.683	213.970	426.768	232.210	–1.6277	3300
3400	21.328	70.488	235.320	214.588	428.903	228.216	–1.5205	3400
3500	21.300	72.620	235.938	215.189	431.034	224.218	–1.4212	3500
3600	21.274	74.748	236.537	215.774	433.163	220.218	–1.3290	3600
3700	21.249	76.874	237.120	216.343	435.289	216.216	–1.2435	3700
3800	21.227	78.998	237.686	216.897	437.413	212.211	–1.1639	3800
3900	21.206	81.120	238.237	217.438	439.534	208.204	–1.0898	3900
4000	21.186	83.239	238.774	217.964	441.654	204.195	–1.0207	4000
4100	21.168	85.357	239.297	218.478	443.771	200.184	–0.9563	4100
4200	21.151	87.473	239.807	218.980	445.887	196.171	–0.8962	4200
4300	21.135	89.587	240.304	219.470	448.002	192.156	–0.8401	4300
4400	21.120	91.700	240.790	219.949	450.114	188.140	–0.7876	4400
4500	21.106	93.811	241.265	220.418	452.226	184.123	–0.7384	4500
4600	21.093	95.921	241.728	220.876	454.336	180.104	–0.6925	4600
4700	21.081	98.030	242.182	221.324	456.444	176.084	–0.6495	4700
4800	21.069	100.137	242.626	221.764	458.552	172.063	–0.6092	4800
4900	21.058	102.244	243.060	222.194	460.658	168.040	–0.5714	4900
5000	21.048	104.349	243.485	222.615	462.763	164.017	–0.5360	5000

TABLE A31.—THERMODYNAMIC PROPERTIES FOR Co^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.038	106.453	243.902	223.029	464.868	159.992	–0.5028	5100
5200	21.029	108.557	244.310	223.434	466.971	155.967	–0.4717	5200
5300	21.020	110.659	244.711	223.832	469.073	151.941	–0.4425	5300
5400	21.012	112.761	245.104	224.222	471.175	147.914	–0.4151	5400
5500	21.004	114.861	245.489	224.605	473.276	143.886	–0.3895	5500
5600	20.996	116.961	245.867	224.982	475.376	139.857	–0.3654	5600
5700	20.989	119.061	246.239	225.351	477.475	135.828	–0.3428	5700
5800	20.983	121.159	246.604	225.714	479.574	131.797	–0.3217	5800
5900	20.976	123.257	246.963	226.072	481.672	127.767	–0.3019	5900
6000	20.970	125.354	247.315	226.423	483.769	123.735	–0.2833	6000
6200	20.959	129.547	248.003	227.108	487.962			6200
6400	20.948	133.738	248.668	227.771	492.152			6400
6600	20.939	137.927	249.312	228.414	496.341			6600
6800	20.930	142.114	249.937	229.038	500.528			6800
7000	20.922	146.299	250.544	229.644	504.713			7000
7200	20.915	150.483	251.133	230.233	508.897			7200
7400	20.908	154.665	251.706	230.805	513.079			7400
7600	20.902	158.846	252.264	231.363	517.260			7600
7800	20.896	163.026	252.806	231.906	521.440			7800
8000	20.891	167.205	253.335	232.435	525.619			8000
8500	20.879	177.647	254.602	233.702	536.061			8500
9000	20.869	188.084	255.795	234.896	546.499			9000
9500	20.861	198.517	256.923	236.026	556.931			9500
10000	20.854	208.945	257.993	237.098	567.360			10000
10500	20.848	219.371	259.010	238.118	577.785			10500
11000	20.842	229.793	259.980	239.089	588.207			11000
11500	20.837	240.213	260.906	240.018	598.627			11500
12000	20.833	250.631	261.793	240.907	609.045			12000
12500	20.830	261.046	262.643	241.759	619.461			12500
13000	20.826	271.460	263.460	242.579	629.875			13000
13500	20.824	281.873	264.246	243.367	640.287			13500
14000	20.821	292.284	265.003	244.126	650.698			14000
14500	20.819	302.694	265.734	244.858	661.108			14500
15000	20.817	313.103	266.440	245.566	671.517			15000
15500	20.815	323.510	267.122	246.251	681.925			15500
16000	20.813	333.917	267.783	246.913	692.332			16000
16500	20.811	344.323	268.423	247.555	702.738			16500
17000	20.810	354.729	269.045	248.178	713.143			17000
17500	20.809	365.133	269.648	248.783	723.548			17500
18000	20.807	375.537	270.234	249.371	733.952			18000
18500	20.806	385.941	270.804	249.942	744.355			18500
19000	20.805	396.343	271.359	250.499	754.758			19000
19500	20.804	406.746	271.899	251.041	765.160			19500
20000	20.803	417.148	272.426	251.569	775.562			20000

*Assigned reference element phase change at 700.1 K, 1394 K, and 1768 K

TABLE A32.—THERMODYNAMIC PROPERTIES FOR Cr

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	391.283	395.340	----------	0
100	20.786	–4.119	151.606	192.794	393.361	397.107	–199.7273	100
200	20.786	–2.040	166.014	176.215	395.440	397.602	–95.9455	200
298.15	20.786	0.000	174.313	174.313	397.480	397.480	–61.7638	298.15
300	20.786	0.038	174.442	174.314	397.518	397.475	–61.3345	300
*400	20.786	2.117	180.422	175.129	399.597	397.116	–44.0397	400
500	20.786	4.196	185.060	176.669	401.676	396.598	–33.6742	500
600	20.786	6.274	188.850	178.393	403.754	395.957	–26.7741	600
700	20.787	8.353	192.054	180.121	405.833	395.221	–21.8541	700
800	20.791	10.432	194.830	181.790	407.912	394.401	–18.1712	800
900	20.803	12.511	197.279	183.378	409.991	393.486	–15.3132	900
1000	20.835	14.593	199.473	184.880	412.073	392.452	–13.0323	1000
1100	20.901	16.680	201.461	186.298	414.160	391.273	–11.1714	1100
1200	21.015	18.775	203.284	187.639	416.255	389.937	–9.6256	1200
1300	21.191	20.885	204.973	188.908	418.365	388.432	–8.3224	1300
1400	21.441	23.016	206.552	190.112	420.496	386.752	–7.2099	1400
1500	21.768	25.175	208.042	191.258	422.655	384.895	–6.2502	1500
1600	22.174	27.372	209.459	192.352	424.852	382.866	–5.4146	1600
1700	22.653	29.613	210.818	193.399	427.093	380.666	–4.6815	1700
1800	23.198	31.905	212.128	194.403	429.385	378.298	–4.0336	1800
1900	23.798	34.254	213.398	195.369	431.734	375.764	–3.4577	1900
2000	24.440	36.666	214.635	196.302	434.146	373.069	–2.9430	2000
2100	25.109	39.143	215.843	197.204	436.623	370.212	–2.4808	2100
*2200	25.795	41.688	217.027	198.078	439.168	347.857	–2.0794	2200
2300	26.483	44.302	218.189	198.927	441.782	346.538	–1.7210	2300
2400	27.165	46.985	219.331	199.754	444.465	345.287	–1.3937	2400
2500	27.831	49.735	220.453	200.559	447.215	344.104	–1.0936	2500
2600	28.476	52.550	221.557	201.346	450.030	342.987	–0.8176	2600
2700	29.096	55.429	222.644	202.114	452.909	341.933	–0.5627	2700
2800	29.687	58.368	223.713	202.867	455.848	340.939	–0.3268	2800
2900	30.251	61.365	224.764	203.604	458.845	340.003	–0.1078	2900
3000	30.788	64.418	225.799	204.326	461.898	339.123	0.0960	3000
3100	31.302	67.522	226.817	205.036	465.002	338.294	0.2863	3100
3200	31.796	70.677	227.819	205.732	468.157	337.516	0.4642	3200
3300	32.274	73.881	228.804	206.416	471.361	336.787	0.6310	3300
3400	32.743	77.132	229.775	207.089	474.612	336.105	0.7876	3400
3500	33.207	80.429	230.731	207.751	477.909	335.469	0.9350	3500
3600	33.672	83.773	231.673	208.402	481.253	334.880	1.0739	3600
3700	34.143	87.164	232.602	209.044	484.644	334.338	1.2051	3700
3800	34.625	90.602	233.518	209.676	488.082	333.843	1.3293	3800
3900	35.123	94.089	234.424	210.299	491.569	333.397	1.4468	3900
4000	35.642	97.627	235.320	210.913	495.107	333.002	1.5584	4000
4100	36.184	101.218	236.206	211.519	498.698	332.659	1.6644	4100
4200	36.753	104.864	237.085	212.117	502.344	332.373	1.7653	4200
4300	37.351	108.567	237.956	212.708	506.047	332.143	1.8614	4300
4400	37.984	112.333	238.822	213.292	509.813	331.976	1.9530	4400
4500	38.649	116.163	239.683	213.869	513.643	331.873	2.0406	4500

TABLE A32.—THERMODYNAMIC PROPERTIES FOR Cr (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	39.352	120.061	240.539	214.439	517.541	331.838	2.1243	4600
4700	40.085	124.029	241.393	215.004	521.509	331.873	2.2045	4700
4800	40.868	128.076	242.245	215.562	525.556	331.987	2.2814	4800
4900	41.661	132.237	243.114	216.127	529.717	332.215	2.3557	4900
5000	42.491	136.445	243.964	216.675	533.925	332.490	2.4265	5000
5100	43.353	140.737	244.814	217.218	538.217	332.849	2.4947	5100
5200	44.245	145.116	245.664	217.757	542.596	333.295	2.5603	5200
5300	45.165	149.587	246.516	218.292	547.067	333.832	2.6235	5300
5400	46.109	154.150	247.369	218.822	551.630	334.463	2.6845	5400
5500	47.074	158.809	248.224	219.349	556.289	335.189	2.7434	5500
5600	48.054	163.565	249.081	219.872	561.045	336.012	2.8003	5600
5700	49.046	168.420	249.940	220.392	565.900	336.934	2.8553	5700
5800	50.043	173.374	250.801	220.909	570.854	337.955	2.9087	5800
5900	51.131	178.434	251.666	221.423	575.914	339.082	2.9603	5900
6000	52.195	183.600	252.535	221.935	581.080	340.315	3.0104	6000
6200	54.204	194.243	254.279	222.950	591.723			6200
6400	56.006	205.268	256.029	223.956	602.748			6400
6600	57.564	216.629	257.777	224.955	614.109			6600
6800	58.856	228.275	259.515	225.946	625.755			6800
7000	59.876	240.153	261.237	226.929	637.633			7000
7200	60.627	252.208	262.935	227.906	649.688			7200
7400	61.119	264.386	264.603	228.875	661.866			7400
7600	61.367	276.639	266.237	229.837	674.119			7600
7800	61.387	288.918	267.832	230.791	686.398			7800
8000	61.200	301.180	269.384	231.736	698.660			8000
8500	59.961	331.512	273.062	234.061	728.992			8500
9000	57.872	361.000	276.434	236.322	758.480			9000
9500	55.225	389.292	279.494	238.515	786.772			9500
10000	52.269	416.173	282.252	240.635	813.653			10000
10500	49.206	441.543	284.728	242.676	839.023			10500
11000	46.190	465.388	286.947	244.639	862.868			11000
11500	43.333	487.760	288.937	246.523	885.240			11500
12000	40.712	508.761	290.725	248.328	906.241			12000
12500	38.372	528.519	292.338	250.057	925.999			12500
13000	36.333	547.183	293.802	251.711	944.663			13000
13500	34.595	564.903	295.140	253.295	962.383			13500
14000	33.143	581.826	296.371	254.812	979.306			14000
14500	31.951	598.089	297.513	256.265	995.569			14500
15000	30.985	613.814	298.579	257.658	1011.294			15000
15500	30.205	629.104	299.582	258.994	1026.584			15500
16000	29.570	644.044	300.530	260.278	1041.524			16000
16500	29.039	658.692	301.432	261.511	1056.172			16500
17000	28.574	673.093	302.292	262.698	1070.573			17000
17500	28.140	687.271	303.114	263.841	1084.751			17500
18000	27.709	701.235	303.900	264.943	1098.715			18000
18500	27.257	714.976	304.654	266.006	1112.456			18500
19000	26.772	728.486	305.374	267.033	1125.966			19000
19500	26.247	741.741	306.063	268.025	1139.221			19500
20000	25.689	754.727	306.720	268.984	1152.207			20000

***Assigned reference element phase change at 311.5 K and 2130 K**

TABLE A33.—THERMODYNAMIC PROPERTIES FOR Cr^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1050.349	1048.209	----------	0
298.15	20.786	0.000	173.032	173.032	1056.547	1056.547	–176.1978	298.15
300	20.786	0.038	173.160	173.032	1056.585	1056.581	–175.0564	300
*400	20.786	2.117	179.140	173.847	1058.664	1058.300	–129.0313	400
500	20.786	4.196	183.778	175.387	1060.742	1059.860	–101.3728	500
600	20.786	6.274	187.568	177.111	1062.821	1061.298	–82.9076	600
700	20.786	8.353	190.772	178.840	1064.900	1062.641	–69.7008	700
800	20.786	10.432	193.548	180.508	1066.978	1063.899	–59.7834	800
900	20.786	12.510	195.996	182.096	1069.057	1065.062	–52.0611	900
1000	20.787	14.589	198.186	183.597	1071.136	1066.103	–45.8769	1000
1100	20.787	16.668	200.167	185.015	1073.214	1066.995	–40.8123	1100
1200	20.790	18.746	201.976	186.354	1075.293	1067.721	–36.5887	1200
1300	20.796	20.826	203.641	187.621	1077.372	1068.264	–33.0128	1300
1400	20.809	22.906	205.182	188.821	1079.453	1068.612	–29.9463	1400
1500	20.831	24.988	206.619	189.960	1081.534	1068.756	–27.2881	1500
1600	20.869	27.073	207.964	191.044	1083.619	1068.694	–24.9622	1600
1700	20.926	29.162	209.231	192.077	1085.709	1068.421	–22.9101	1700
1800	21.009	31.259	210.429	193.063	1087.805	1067.936	–21.0868	1800
1900	21.122	33.365	211.568	194.007	1089.912	1067.238	–19.4562	1900
2000	21.270	35.484	212.655	194.913	1092.031	1066.329	–17.9898	2000
2100	21.457	37.620	213.697	195.783	1094.167	1065.210	–16.6643	2100
*2200	21.687	39.777	214.700	196.620	1096.324	1044.545	–15.4763	2200
2300	21.962	41.959	215.670	197.427	1098.506	1044.873	–14.3978	2300
2400	22.283	44.171	216.612	198.207	1100.718	1045.230	–13.4090	2400
2500	22.652	46.417	217.528	198.962	1102.964	1045.622	–12.4989	2500
2600	23.069	48.703	218.425	199.693	1105.250	1046.053	–11.6584	2600
2700	23.534	51.033	219.304	200.403	1107.579	1046.529	–10.8799	2700
2800	24.045	53.411	220.169	201.094	1109.958	1047.053	–10.1567	2800
2900	24.601	55.843	221.022	201.766	1112.390	1047.631	–9.4830	2900
3000	25.200	58.333	221.866	202.422	1114.880	1048.266	–8.8538	3000
3100	25.839	60.885	222.703	203.063	1117.431	1048.963	–8.2649	3100
3200	26.517	63.502	223.534	203.690	1120.049	1049.726	–7.7123	3200
3300	27.230	66.189	224.361	204.303	1122.736	1050.559	–7.1929	3300
3400	27.974	68.949	225.185	204.906	1125.496	1051.465	–6.7036	3400
3500	28.748	71.785	226.007	205.497	1128.332	1052.446	–6.2419	3500
3600	29.547	74.700	226.828	206.078	1131.246	1053.506	–5.8054	3600
3700	30.368	77.695	227.648	206.650	1134.242	1054.648	–5.3920	3700
3800	31.207	80.774	228.469	207.213	1137.320	1055.872	–5.0000	3800
3900	32.062	83.937	229.291	207.769	1140.484	1057.181	–4.6277	3900
4000	32.928	87.186	230.114	208.317	1143.733	1058.576	–4.2734	4000
4100	33.802	90.523	230.937	208.859	1147.070	1060.058	–3.9361	4100
4200	34.680	93.947	231.763	209.394	1150.494	1061.628	–3.6143	4200
4300	35.560	97.459	232.589	209.924	1154.006	1063.285	–3.3070	4300
4400	36.438	101.059	233.416	210.448	1157.606	1065.031	–3.0132	4400
4500	37.310	104.746	234.245	210.968	1161.293	1066.864	–2.7320	4500
4600	38.175	108.521	235.075	211.483	1165.067	1068.784	–2.4626	4600
4700	39.028	112.381	235.905	211.994	1168.928	1070.790	–2.2041	4700
4800	39.868	116.326	236.735	212.501	1172.873	1072.880	–1.9560	4800
4900	40.692	120.354	237.566	213.004	1176.901	1075.054	–1.7175	4900
5000	41.497	124.464	238.396	213.503	1181.010	1077.309	–1.4880	5000

TABLE A33.—THERMODYNAMIC PROPERTIES FOR Cr^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	42.281	128.653	239.226	214.000	1185.199	1079.644	–1.2671	5100
5200	43.043	132.919	240.054	214.493	1189.466	1082.056	–1.0542	5200
5300	43.790	137.264	240.882	214.983	1193.811	1084.547	–0.8489	5300
5400	44.504	141.679	241.707	215.470	1198.226	1087.107	–0.6508	5400
5500	45.192	146.164	242.530	215.955	1202.711	1089.738	–0.4593	5500
5600	45.851	150.717	243.350	216.436	1207.263	1092.436	–0.2743	5600
5700	46.482	155.333	244.167	216.916	1211.880	1095.198	–0.0953	5700
5800	47.084	160.012	244.981	217.393	1216.559	1098.023	0.0779	5800
5900	47.656	164.749	245.791	217.867	1221.296	1100.905	0.2458	5900
6000	48.198	169.542	246.596	218.339	1226.089	1103.844	0.4084	6000
6200	49.192	179.283	248.193	219.277	1235.830			6200
6400	50.067	189.211	249.769	220.205	1245.758			6400
6600	50.829	199.302	251.322	221.124	1255.849			6600
6800	51.482	209.535	252.849	222.035	1266.082			6800
7000	52.034	219.889	254.350	222.937	1276.435			7000
7200	52.494	230.343	255.822	223.830	1286.890			7200
7400	52.871	240.881	257.266	224.714	1297.427			7400
7600	53.173	251.486	258.680	225.590	1308.033			7600
7800	53.411	262.146	260.064	226.456	1318.692			7800
8000	53.593	272.847	261.419	227.313	1329.394			8000
8500	53.862	299.720	264.677	229.416	1356.267			8500
9000	53.951	326.679	267.759	231.461	1383.226			9000
9500	53.946	353.655	270.676	233.449	1410.202			9500
10000	53.903	380.617	273.442	235.380	1437.164			10000
10500	53.853	407.554	276.070	237.256	1464.101			10500
11000	53.810	434.466	278.574	239.077	1491.012			11000
11500	53.775	461.354	280.965	240.847	1517.901			11500
12000	53.739	488.218	283.251	242.566	1544.765			12000
12500	53.698	515.060	285.443	244.238	1571.607			12500
13000	53.639	541.869	287.545	245.863	1598.416			13000
13500	53.548	568.627	289.565	247.444	1625.174			13500
14000	53.402	595.294	291.504	248.983	1651.840			14000
14500	53.202	621.849	293.367	250.481	1678.395			14500
15000	52.941	648.260	295.157	251.940	1704.807			15000
15500	52.609	674.479	296.875	253.360	1731.026			15500
16000	52.175	700.404	298.519	254.744	1756.951			16000
16500	51.666	726.035	300.094	256.092	1782.582			16500
17000	51.126	751.434	301.608	257.406	1807.981			17000
17500	50.551	776.562	303.063	258.688	1833.108			17500
18000	49.950	801.411	304.461	259.938	1857.958			18000
18500	49.229	825.663	305.785	261.155	1882.210			18500
19000	48.533	849.705	307.064	262.343	1906.252			19000
19500	47.800	873.315	308.287	263.501	1929.862			19500
20000	47.034	896.470	309.454	264.631	1953.017			20000

*Assigned reference element phase change at 311.5 K and 2130 K

TABLE A34.—THERMODYNAMIC PROPERTIES FOR Cr^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	320.826	331.080	----------	0
298.15	20.786	0.000	173.032	173.032	327.023	327.023	–50.5831	298.15
300	20.786	0.038	173.160	173.032	327.062	326.980	–50.2300	300
*400	20.786	2.117	179.140	173.848	329.141	324.542	–36.0446	400
500	20.786	4.196	183.779	175.387	331.219	321.945	–27.5996	500
600	20.786	6.274	187.568	177.111	333.298	319.226	–22.0163	600
700	20.786	8.353	190.773	178.840	335.376	316.411	–18.0628	700
800	20.786	10.432	193.548	180.509	337.455	313.512	–15.1243	800
900	20.786	12.510	195.996	182.096	339.534	310.518	–12.8603	900
1000	20.786	14.589	198.187	183.598	341.612	307.402	–11.0668	1000
1100	20.786	16.667	200.168	185.015	343.691	304.136	–9.6145	1100
1200	20.786	18.746	201.976	186.355	345.770	300.705	–8.4176	1200
1300	20.786	20.825	203.640	187.621	347.848	297.090	–7.4166	1300
1400	20.786	22.903	205.181	188.821	349.927	293.279	–6.5692	1400
1500	20.786	24.982	206.615	189.960	352.005	289.263	–5.8446	1500
1600	20.786	27.061	207.956	191.043	354.084	285.037	–5.2195	1600
1700	20.786	29.139	209.216	192.076	356.163	280.596	–4.6763	1700
1800	20.786	31.218	210.404	193.061	358.241	275.936	–4.2012	1800
1900	20.786	33.296	211.528	194.004	360.320	271.053	–3.7834	1900
2000	20.786	35.375	212.594	194.907	362.399	265.946	–3.4142	2000
2100	20.786	37.454	213.609	195.774	364.477	260.612	–3.0867	2100
*2200	20.786	39.532	214.576	196.606	366.556	235.712	–2.8107	2200
2300	20.786	41.611	215.500	197.408	368.634	231.779	–2.5694	2300
2400	20.786	43.690	216.384	198.180	370.713	227.846	–2.3519	2400
2500	20.786	45.768	217.233	198.925	372.792	223.913	–2.1552	2500
2600	20.786	47.847	218.048	199.645	374.870	219.980	–1.9768	2600
2700	20.786	49.926	218.833	200.342	376.949	216.047	–1.8146	2700
2800	20.786	52.004	219.588	201.016	379.028	212.114	–1.6667	2800
2900	20.786	54.083	220.318	201.669	381.106	208.181	–1.5315	2900
3000	20.786	56.161	221.023	202.302	383.185	204.248	–1.4076	3000
3100	20.786	58.240	221.704	202.917	385.263	200.315	–1.2940	3100
3200	20.786	60.319	222.364	203.515	387.342	196.382	–1.1896	3200
3300	20.786	62.397	223.004	204.095	389.421	192.449	–1.0934	3300
3400	20.786	64.476	223.624	204.661	391.499	188.516	–1.0047	3400
3500	20.786	66.555	224.227	205.211	393.578	184.583	–0.9228	3500
3600	20.786	68.633	224.812	205.748	395.657	180.650	–0.8471	3600
3700	20.786	70.712	225.382	206.271	397.735	176.717	–0.7770	3700
3800	20.786	72.790	225.936	206.781	399.814	172.784	–0.7121	3800
3900	20.786	74.869	226.476	207.279	401.892	168.851	–0.6519	3900
4000	20.786	76.948	227.002	207.765	403.971	164.918	–0.5960	4000
4100	20.786	79.026	227.516	208.241	406.050	160.985	–0.5441	4100
4200	20.786	81.105	228.017	208.706	408.128	157.052	–0.4959	4200
4300	20.786	83.184	228.506	209.161	410.207	153.119	–0.4510	4300
4400	20.786	85.262	228.984	209.606	412.286	149.186	–0.4093	4400
4500	20.786	87.341	229.451	210.042	414.364	145.253	–0.3704	4500
4600	20.786	89.419	229.908	210.469	416.443	141.320	–0.3343	4600
4700	20.786	91.498	230.355	210.887	418.521	137.387	–0.3006	4700
4800	20.786	93.577	230.792	211.297	420.600	133.454	–0.2692	4800
4900	20.786	95.655	231.221	211.699	422.679	129.521	–0.2400	4900
5000	20.786	97.734	231.641	212.094	424.757	125.588	–0.2128	5000

TABLE A34.—THERMODYNAMIC PROPERTIES FOR Cr^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	232.052	212.481	426.836	121.655	–0.1875	5100
5200	20.786	101.891	232.456	212.862	428.915	117.722	–0.1639	5200
5300	20.786	103.970	232.852	213.235	430.993	113.789	–0.1420	5300
5400	20.786	106.048	233.240	213.602	433.072	109.856	–0.1216	5400
5500	20.786	108.127	233.622	213.962	435.151	105.923	–0.1026	5500
5600	20.786	110.206	233.996	214.317	437.229	101.990	–0.0850	5600
5700	20.786	112.284	234.364	214.665	439.308	98.057	–0.0686	5700
5800	20.786	114.363	234.726	215.008	441.386	94.124	–0.0534	5800
5900	20.786	116.442	235.081	215.345	443.465	90.191	–0.0394	5900
6000	20.786	118.520	235.431	215.677	445.544	86.258	–0.0263	6000
6200	20.786	122.677	236.112	216.325	449.701			6200
6400	20.786	126.835	236.772	216.954	453.858			6400
6600	20.786	130.992	237.412	217.564	458.015			6600
6800	20.786	135.149	238.032	218.157	462.173			6800
7000	20.786	139.306	238.635	218.734	466.330			7000
7200	20.786	143.464	239.220	219.295	470.487			7200
7400	20.786	147.621	239.790	219.841	474.644			7400
7600	20.786	151.778	240.344	220.373	478.802			7600
7800	20.786	155.936	240.884	220.892	482.959			7800
8000	20.786	160.093	241.410	221.399	487.116			8000
8500	20.786	170.486	242.671	222.613	497.509			8500
9000	20.786	180.879	243.859	223.761	507.902			9000
9500	20.786	191.272	244.982	224.849	518.296			9500
10000	20.786	201.665	246.049	225.882	528.689			10000
10500	20.786	212.058	247.063	226.867	539.082			10500
11000	20.786	222.452	248.030	227.807	549.475			11000
11500	20.786	232.845	248.954	228.706	559.868			11500
12000	20.786	243.238	249.838	229.569	570.261			12000
12500	20.786	253.631	250.687	230.397	580.654			12500
13000	20.786	264.024	251.502	231.193	591.048			13000
13500	20.786	274.417	252.287	231.960	601.441			13500
14000	20.786	284.810	253.043	232.699	611.834			14000
14500	20.786	295.204	253.772	233.413	622.227			14500
15000	20.786	305.597	254.477	234.104	632.620			15000
15500	20.786	315.990	255.158	234.772	643.013			15500
16000	20.786	326.383	255.818	235.419	653.406			16000
16500	20.786	336.776	256.458	236.047	663.800			16500
17000	20.786	347.169	257.078	236.657	674.193			17000
17500	20.786	357.562	257.681	237.249	684.586			17500
18000	20.786	367.956	258.267	237.825	694.979			18000
18500	20.786	378.349	258.836	238.385	705.372			18500
19000	20.786	388.742	259.390	238.930	715.765			19000
19500	20.786	399.135	259.930	239.462	726.158			19500
20000	20.786	409.528	260.457	239.980	736.552			20000

*Assigned reference element phase change at 311.5 K and 2130 K

TABLE A35.—THERMODYNAMIC PROPERTIES FOR Cs

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	70.303	78.014	----------	0
100	20.786	–4.119	152.894	194.082	72.381	77.942	–35.5973	100
200	20.786	–2.040	167.302	177.503	74.460	77.342	–15.2982	200
298.15	20.786	0.000	175.602	175.602	76.500	76.500	–8.6817	298.15
300	20.786	0.038	175.730	175.602	76.538	76.478	–8.5991	300
*400	20.786	2.117	181.710	176.417	78.617	73.220	–5.3825	400
500	20.786	4.196	186.348	177.957	80.696	72.150	–3.4835	500
600	20.786	6.274	190.138	179.681	82.774	71.182	–2.2353	600
700	20.786	8.353	193.342	181.410	84.853	70.296	–1.3554	700
800	20.786	10.432	196.118	183.079	86.932	69.455	–0.7035	800
900	20.786	12.510	198.566	184.666	89.010	68.615	–0.2025	900
1000	20.787	14.589	200.756	186.167	91.089	67.736	0.1933	1000
1100	20.788	16.668	202.738	187.585	93.168	66.768	0.5128	1100
1200	20.791	18.747	204.547	188.924	95.247	65.666	0.7749	1200
1300	20.805	20.823	206.208	190.191	97.323	64.379	0.9927	1300
1400	20.828	22.905	207.751	191.390	99.405	62.867	1.1754	1400
1500	20.854	24.989	209.189	192.530	101.489	61.078	1.3297	1500
1600	20.890	27.076	210.536	193.613	103.576	58.966	1.4604	1600
1700	20.945	29.168	211.804	194.647	105.668	56.483	1.5714	1700
1800	21.028	31.266	213.003	195.633	107.766	53.582	1.6654	1800
1900	21.146	33.374	214.143	196.578	109.874	50.218	1.7448	1900
2000	21.306	35.497	215.232	197.483	111.997	46.348	1.8113	2000
2100	21.514	37.637	216.276	198.354	114.137			2100
2200	21.776	39.801	217.283	199.191	116.301			2200
2300	22.096	41.994	218.258	199.999	118.494			2300
2400	22.476	44.222	219.206	200.780	120.722			2400
2500	22.919	46.491	220.132	201.535	122.991			2500
2600	23.427	48.808	221.041	202.268	125.308			2600
2700	23.999	51.179	221.935	202.980	127.679			2700
2800	24.635	53.610	222.819	203.673	130.110			2800
2900	25.334	56.108	223.696	204.348	132.608			2900
3000	26.094	58.679	224.567	205.008	135.179			3000
3100	26.913	61.329	225.436	205.653	137.829			3100
3200	27.787	64.063	226.304	206.284	140.563			3200
3300	28.711	66.888	227.173	206.904	143.388			3300
3400	29.683	69.807	228.045	207.513	146.307			3400
3500	30.695	72.826	228.920	208.112	149.326			3500
3600	31.742	75.947	229.799	208.703	152.447			3600
3700	32.818	79.175	230.683	209.285	155.675			3700
3800	33.915	82.512	231.573	209.859	159.012			3800
3900	35.026	85.959	232.468	210.428	162.459			3900
4000	36.143	89.517	233.369	210.990	166.017			4000
4100	37.255	93.187	234.275	211.547	169.687			4100
4200	38.355	96.968	235.186	212.099	173.468			4200
4300	39.433	100.857	236.102	212.646	177.357			4300
4400	40.476	104.853	237.020	213.190	181.353			4400
4500	41.476	108.951	237.941	213.730	185.451			4500

TABLE A35.—THERMODYNAMIC PROPERTIES FOR Cs (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	42.419	113.146	238.863	214.266	189.646			4600
4700	43.294	117.433	239.785	214.799	193.933			4700
4800	44.088	121.802	240.705	215.329	198.302			4800
4900	44.787	126.247	241.621	215.856	202.747			4900
5000	45.379	130.756	242.532	216.381	207.256			5000
5100	46.363	135.345	243.441	216.903	211.845			5100
5200	47.157	140.023	244.349	217.422	216.523			5200
5300	47.783	144.771	245.254	217.938	221.271			5300
5400	48.261	149.574	246.151	218.452	226.074			5400
5500	48.609	154.419	247.040	218.964	230.919			5500
5600	48.842	159.292	247.918	219.473	235.792			5600
5700	48.973	164.184	248.784	219.980	240.684			5700
5800	49.016	169.084	249.636	220.484	245.584			5800
5900	48.981	173.984	250.474	220.985	250.484			5900
6000	48.877	178.878	251.297	221.484	255.378			6000
6200	48.498	188.619	252.894	222.471	265.119			6200
6400	47.938	198.265	254.425	223.446	274.765			6400
6600	47.243	207.785	255.890	224.407	284.285			6600
6800	46.451	217.156	257.289	225.354	293.656			6800
7000	45.589	226.361	258.623	226.285	302.861			7000
7200	44.683	235.389	259.894	227.202	311.889			7200
7400	43.750	244.232	261.106	228.102	320.732			7400
7600	42.804	252.888	262.260	228.985	329.388			7600
7800	41.859	261.354	263.360	229.853	337.854			7800
8000	40.922	269.631	264.408	230.704	346.131			8000
8500	38.658	289.521	266.820	232.759	366.021			8500
9000	36.555	308.316	268.969	234.712	384.816			9000
9500	34.646	326.108	270.894	236.566	402.608			9500
10000	32.936	342.995	272.626	238.327	419.495			10000
10500	31.420	359.076	274.196	239.998	435.576			10500
11000	30.088	374.446	275.626	241.585	450.946			11000
11500	28.922	389.192	276.937	243.094	465.692			11500
12000	27.907	403.393	278.146	244.530	479.893			12000
12500	27.026	417.121	279.267	245.897	493.621			12500
13000	26.265	430.440	280.312	247.201	506.940			13000
13500	25.607	443.403	281.291	248.446	519.903			13500
14000	25.041	456.062	282.211	249.635	532.562			14000
14500	24.556	468.458	283.081	250.774	544.958			14500
15000	24.140	480.629	283.907	251.865	557.129			15000
15500	23.784	492.608	284.692	252.911	569.108			15500
16000	23.482	504.423	285.442	253.916	580.923			16000
16500	23.226	516.098	286.161	254.882	592.598			16500
17000	23.009	527.655	286.851	255.812	604.155			17000
17500	22.827	539.112	287.515	256.709	615.612			17500
18000	22.674	550.487	288.156	257.573	626.987			18000
18500	22.546	561.789	288.776	258.409	638.289			18500
19000	22.439	573.035	289.375	259.216	649.535			19000
19500	22.348	584.231	289.957	259.996	660.731			19500
20000	22.271	595.386	290.522	260.753	671.886			20000

***Assigned reference element phase change at 301.59 K**

TABLE A36.—THERMODYNAMIC PROPERTIES FOR Cs^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	452.204	453.718	----------	0
298.15	20.786	0.000	169.838	169.838	458.402	458.402	–74.7929	298.15
300	20.786	0.038	169.967	169.839	458.440	458.419	–74.2976	300
*400	20.786	2.117	175.947	170.654	460.519	457.239	–54.4152	400
500	20.786	4.196	180.585	172.194	462.598	458.247	–42.4617	500
600	20.786	6.274	184.375	173.918	464.676	459.359	–34.4742	600
700	20.786	8.353	187.579	175.646	466.755	460.551	–28.7544	700
800	20.786	10.432	190.355	177.315	468.833	461.788	–24.4532	800
900	20.786	12.510	192.803	178.903	470.912	463.027	–21.0987	900
1000	20.786	14.589	194.993	180.404	472.991	464.227	–18.4081	1000
1100	20.786	16.667	196.974	181.822	475.069	465.337	–16.2011	1100
1200	20.786	18.746	198.783	183.161	477.148	466.313	–14.3578	1200
1300	20.786	20.825	200.447	184.428	479.227	467.107	–12.7951	1300
1400	20.786	22.903	201.987	185.628	481.305	467.671	–11.4536	1400
1500	20.786	24.982	203.421	186.767	483.384	467.955	–10.2900	1500
1600	20.786	27.061	204.763	187.850	485.462	467.913	–9.2716	1600
1700	20.786	29.139	206.023	188.882	487.541	467.495	–8.3733	1700
1800	20.786	31.218	207.211	189.868	489.620	466.654	–7.5759	1800
1900	20.786	33.296	208.335	190.810	491.698	465.339	–6.8641	1900
2000	20.786	35.375	209.401	191.713	493.777	463.503	–6.2257	2000
2100	20.786	37.454	210.415	192.580	495.856			2100
2200	20.786	39.532	211.382	193.413	497.934			2200
2300	20.786	41.611	212.306	194.214	500.013			2300
2400	20.786	43.690	213.191	194.987	502.091			2400
2500	20.786	45.768	214.039	195.732	504.170			2500
2600	20.786	47.847	214.855	196.452	506.249			2600
2700	20.786	49.926	215.639	197.148	508.327			2700
2800	20.786	52.004	216.395	197.822	510.406			2800
2900	20.786	54.083	217.124	198.475	512.485			2900
3000	20.786	56.161	217.829	199.109	514.563			3000
3100	20.786	58.240	218.511	199.724	516.642			3100
3200	20.786	60.319	219.171	200.321	518.720			3200
3300	20.786	62.397	219.810	200.902	520.799			3300
3400	20.786	64.476	220.431	201.467	522.878			3400
3500	20.786	66.555	221.033	202.018	524.956			3500
3600	20.786	68.633	221.619	202.554	527.035			3600
3700	20.786	70.712	222.188	203.077	529.114			3700
3800	20.786	72.790	222.743	203.587	531.192			3800
3900	20.786	74.869	223.283	204.086	533.271			3900
4000	20.786	76.948	223.809	204.572	535.350			4000
4100	20.786	79.026	224.322	205.048	537.428			4100
4200	20.786	81.105	224.823	205.512	539.507			4200
4300	20.786	83.184	225.312	205.967	541.585			4300
4400	20.786	85.262	225.790	206.412	543.664			4400
4500	20.786	87.341	226.257	206.848	545.743			4500
4600	20.786	89.419	226.714	207.275	547.821			4600
4700	20.786	91.498	227.161	207.693	549.900			4700
4800	20.786	93.577	227.599	208.104	551.979			4800
4900	20.786	95.655	228.027	208.506	554.057			4900
5000	20.786	97.734	228.447	208.901	556.136			5000

TABLE A36.—THERMODYNAMIC PROPERTIES FOR Cs^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	228.859	209.288	558.214			5100
5200	20.786	101.891	229.263	209.668	560.293			5200
5300	20.786	103.970	229.659	210.042	562.372			5300
5400	20.786	106.048	230.047	210.408	564.450			5400
5500	20.786	108.127	230.428	210.769	566.529			5500
5600	20.786	110.206	230.803	211.123	568.608			5600
5700	20.786	112.284	231.171	211.472	570.686			5700
5800	20.786	114.363	231.532	211.815	572.765			5800
5900	20.786	116.442	231.888	212.152	574.843			5900
6000	20.786	118.520	232.237	212.484	576.922			6000
6200	20.786	122.677	232.919	213.132	581.079			6200
6400	20.786	126.835	233.579	213.761	585.237			6400
6600	20.786	130.992	234.218	214.371	589.394			6600
6800	20.786	135.149	234.839	214.964	593.551			6800
7000	20.786	139.307	235.441	215.540	597.708			7000
7200	20.786	143.464	236.027	216.101	601.866			7200
7400	20.786	147.621	236.596	216.648	606.023			7400
7600	20.786	151.778	237.151	217.180	610.180			7600
7800	20.787	155.936	237.691	217.699	614.337			7800
8000	20.787	160.093	238.217	218.205	618.495			8000
8500	20.788	170.487	239.477	219.420	628.888			8500
9000	20.790	180.881	240.665	220.568	639.283			9000
9500	20.795	191.277	241.790	221.655	649.679			9500
10000	20.805	201.677	242.856	222.689	660.079			10000
10500	20.822	212.083	243.872	223.674	670.485			10500
11000	20.853	222.501	244.841	224.614	680.903			11000
11500	20.904	232.939	245.769	225.514	691.341			11500
12000	20.983	243.410	246.660	226.376	701.812			12000
12500	21.104	253.930	247.519	227.205	712.331			12500
13000	21.281	264.523	248.350	228.002	722.925			13000
13500	21.533	275.223	249.158	228.771	733.625			13500
14000	21.883	286.072	249.947	229.513	744.474			14000
14500	22.357	297.126	250.723	230.231	755.528			14500
15000	22.986	308.454	251.491	230.927	766.856			15000
15500	23.808	320.143	252.257	231.603	778.545			15500
16000	24.858	332.296	253.029	232.260	790.698			16000
16500	26.178	345.036	253.813	232.901	803.438			16500
17000	27.820	358.516	254.617	233.528	816.918			17000
17500	29.824	372.898	255.451	234.143	831.300			17500
18000	32.225	388.364	256.322	234.746	846.765			18000
18500	35.081	405.142	257.241	235.342	863.544			18500
19000	38.427	423.461	258.218	235.931	881.863			19000
19500	42.250	443.515	259.259	236.515	901.917			19500
20000	46.583	465.576	260.376	237.097	923.978			20000

*Assigned reference element phase change at 301.59 K

TABLE A37.—THERMODYNAMIC PROPERTIES FOR Cs^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	18.600	32.508	----------	0
298.15	20.786	0.000	169.839	169.839	24.797	24.797	–1.0207	298.15
300	20.786	0.038	169.967	169.839	24.836	24.737	–0.9939	300
*400	20.786	2.117	175.947	170.654	26.914	19.400	–0.0705	400
500	20.786	4.196	180.585	172.194	28.993	16.251	0.3979	500
600	20.786	6.274	184.375	173.918	31.072	13.205	0.6558	600
700	20.786	8.353	187.579	175.646	33.150	10.240	0.8024	700
800	20.786	10.432	190.355	177.315	35.229	7.320	0.8849	800
900	20.786	12.510	192.803	178.903	37.307	4.402	0.9279	900
1000	20.786	14.589	194.993	180.404	39.386	1.444	0.9452	1000
1100	20.786	16.667	196.974	181.822	41.465	–1.603	0.9451	1100
1200	20.786	18.746	198.783	183.161	43.543	–4.784	0.9327	1200
1300	20.786	20.825	200.447	184.428	45.622	–8.147	0.9112	1300
1400	20.786	22.903	201.987	185.628	47.701	–11.741	0.8829	1400
1500	20.786	24.982	203.421	186.767	49.779	–15.614	0.8490	1500
1600	20.786	27.061	204.763	187.850	51.858	–19.813	0.8106	1600
1700	20.786	29.139	206.023	188.882	53.936	–24.388	0.7684	1700
1800	20.786	31.218	207.211	189.868	56.015	–29.387	0.7226	1800
1900	20.786	33.296	208.335	190.810	58.094	–34.859	0.6737	1900
2000	20.786	35.375	209.401	191.714	60.172	–40.852	0.6218	2000
2100	20.786	37.454	210.415	192.580	62.251			2100
2200	20.786	39.532	211.382	193.413	64.330			2200
2300	20.786	41.611	212.306	194.215	66.408			2300
2400	20.786	43.690	213.191	194.987	68.487			2400
2500	20.786	45.768	214.039	195.732	70.565			2500
2600	20.786	47.847	214.855	196.452	72.644			2600
2700	20.786	49.926	215.639	197.148	74.723			2700
2800	20.786	52.004	216.395	197.822	76.801			2800
2900	20.786	54.083	217.125	198.475	78.880			2900
3000	20.786	56.161	217.829	199.109	80.959			3000
3100	20.786	58.240	218.511	199.724	83.037			3100
3200	20.786	60.319	219.171	200.321	85.116			3200
3300	20.786	62.397	219.810	200.902	87.195			3300
3400	20.786	64.476	220.431	201.467	89.273			3400
3500	20.786	66.555	221.033	202.018	91.352			3500
3600	20.786	68.633	221.619	202.554	93.430			3600
3700	20.786	70.712	222.189	203.077	95.509			3700
3800	20.786	72.790	222.743	203.588	97.588			3800
3900	20.786	74.869	223.283	204.086	99.666			3900
4000	20.786	76.948	223.809	204.572	101.745			4000
4100	20.786	79.026	224.322	205.048	103.824			4100
4200	20.786	81.105	224.823	205.513	105.902			4200
4300	20.786	83.184	225.312	205.967	107.981			4300
4400	20.786	85.262	225.790	206.412	110.059			4400
4500	20.786	87.341	226.257	206.848	112.138			4500
4600	20.786	89.419	226.714	207.275	114.217			4600
4700	20.786	91.498	227.161	207.694	116.295			4700
4800	20.786	93.577	227.599	208.104	118.374			4800
4900	20.786	95.655	228.027	208.506	120.453			4900
5000	20.786	97.734	228.447	208.901	122.531			5000

TABLE A37.—THERMODYNAMIC PROPERTIES FOR Cs^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	228.859	209.288	124.610			5100
5200	20.786	101.891	229.263	209.668	126.688			5200
5300	20.786	103.970	229.659	210.042	128.767			5300
5400	20.786	106.048	230.047	210.409	130.846			5400
5500	20.786	108.127	230.429	210.769	132.924			5500
5600	20.786	110.206	230.803	211.124	135.003			5600
5700	20.786	112.284	231.171	211.472	137.082			5700
5800	20.786	114.363	231.533	211.815	139.160			5800
5900	20.786	116.442	231.888	212.152	141.239			5900
6000	20.786	118.520	232.237	212.484	143.317			6000
6200	20.786	122.677	232.919	213.132	147.475			6200
6400	20.786	126.835	233.579	213.761	151.632			6400
6600	20.786	130.992	234.218	214.371	155.789			6600
6800	20.786	135.149	234.839	214.964	159.946			6800
7000	20.786	139.306	235.441	215.540	164.104			7000
7200	20.786	143.464	236.027	216.101	168.261			7200
7400	20.786	147.621	236.597	216.648	172.418			7400
7600	20.786	151.778	237.151	217.180	176.575			7600
7800	20.786	155.936	237.691	217.699	180.733			7800
8000	20.786	160.093	238.217	218.205	184.890			8000
8500	20.786	170.486	239.477	219.420	195.283			8500
9000	20.786	180.879	240.665	220.568	205.676			9000
9500	20.786	191.272	241.789	221.655	216.069			9500
10000	20.786	201.665	242.855	222.689	226.463			10000
10500	20.786	212.058	243.870	223.673	236.856			10500
11000	20.786	222.452	244.837	224.614	247.249			11000
11500	20.786	232.845	245.761	225.513	257.642			11500
12000	20.786	243.238	246.645	226.375	268.035			12000
12500	20.786	253.631	247.494	227.203	278.428			12500
13000	20.786	264.024	248.309	227.999	288.821			13000
13500	20.786	274.417	249.093	228.766	299.215			13500
14000	20.786	284.810	249.849	229.506	309.608			14000
14500	20.786	295.204	250.579	230.220	320.001			14500
15000	20.786	305.597	251.283	230.910	330.394			15000
15500	20.786	315.990	251.965	231.579	340.787			15500
16000	20.786	326.383	252.625	232.226	351.180			16000
16500	20.786	336.776	253.265	232.854	361.573			16500
17000	20.786	347.169	253.885	233.463	371.966			17000
17500	20.786	357.562	254.488	234.056	382.360			17500
18000	20.786	367.956	255.073	234.631	392.753			18000
18500	20.786	378.349	255.643	235.192	403.146			18500
19000	20.786	388.742	256.197	235.737	413.539			19000
19500	20.786	399.135	256.737	236.269	423.932			19500
20000	20.786	409.528	257.263	236.787	434.325			20000

*Assigned reference element phase change at 301.59 K

TABLE A38.—THERMODYNAMIC PROPERTIES FOR Cu

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	331.203	336.207	----------	0
100	20.786	–4.119	143.692	184.880	333.281	337.616	–169.3666	100
200	20.786	–2.040	158.100	168.300	335.360	337.682	–81.1727	200
298.15	20.786	0.000	166.399	166.399	337.400	337.400	–52.1495	298.15
300	20.786	0.038	166.528	166.399	337.438	337.393	–51.7851	300
400	20.786	2.117	172.507	167.215	339.517	336.979	–37.1069	400
500	20.786	4.196	177.146	168.754	341.596	336.491	–28.3119	500
600	20.786	6.274	180.936	170.478	343.674	335.946	–22.4576	600
700	20.786	8.353	184.140	172.207	345.753	335.354	–18.2831	700
800	20.786	10.432	186.915	173.876	347.832	334.713	–15.1579	800
900	20.786	12.510	189.364	175.463	349.910	334.019	–12.7321	900
1000	20.787	14.589	191.554	176.965	351.989	333.263	–10.7956	1000
1100	20.789	16.668	193.535	178.383	354.068	332.431	–9.2150	1100
1200	20.793	18.747	195.344	179.722	356.147	331.503	–7.9013	1200
1300	20.804	20.827	197.009	180.988	358.227	330.458	–6.7930	1300
*1400	20.823	22.908	198.551	182.188	360.308	316.143	–5.8614	1400
1500	20.856	24.992	199.989	183.328	362.392	314.947	–5.0765	1500
1600	20.909	27.080	201.336	184.412	364.480	313.755	–4.3923	1600
1700	20.985	29.174	202.606	185.445	366.574	312.570	–3.7909	1700
1800	21.091	31.278	203.809	186.432	368.678	311.393	–3.2584	1800
1900	21.231	33.394	204.952	187.377	370.794	310.229	–2.7836	1900
2000	21.407	35.525	206.046	188.283	372.925	309.081	–2.3580	2000
2100	21.622	37.676	207.095	189.154	375.076	307.952	–1.9743	2100
2200	21.878	39.851	208.107	189.993	377.251	306.846	–1.6268	2200
2300	22.174	42.053	209.086	190.802	379.453	305.769	–1.3106	2300
2400	22.508	44.287	210.036	191.584	381.687	304.722	–1.0217	2400
2500	22.878	46.556	210.963	192.340	383.956	303.711	–0.7569	2500
2600	23.282	48.864	211.868	193.074	386.264	302.739	–0.5132	2600
2700	23.716	51.213	212.754	193.786	388.613	301.809	–0.2883	2700
2800	24.174	53.608	213.625	194.480	391.008	300.923	–0.0801	2800
2900	24.653	56.049	214.482	195.155	393.449	300.084	0.1132	2900
3000	25.147	58.539	215.326	195.813	395.939	299.294	0.2932	3000
3100	25.652	61.079	216.159	196.456	398.479	298.554	0.4611	3100
3200	26.162	63.670	216.981	197.084	401.070	297.865	0.6181	3200
3300	26.673	66.311	217.794	197.700	403.711	297.227	0.7653	3300
3400	27.181	69.004	218.598	198.302	406.404	296.640	0.9035	3400
3500	27.680	71.747	219.393	198.894	409.147	296.103	1.0336	3500
3600	28.169	74.540	220.180	199.474	411.940	295.615	1.1562	3600
3700	28.642	77.380	220.958	200.044	414.780	295.176	1.2721	3700
3800	29.098	80.268	221.728	200.605	417.668	294.783	1.3816	3800
3900	29.534	83.199	222.489	201.156	420.599	294.435	1.4855	3900
4000	29.948	86.174	223.242	201.699	423.574	294.129	1.5840	4000
4100	30.340	89.188	223.987	202.233	426.588	293.864	1.6777	4100
4200	30.708	92.241	224.722	202.760	429.641	293.636	1.7668	4200
4300	31.051	95.329	225.449	203.279	432.729	293.444	1.8517	4300
4400	31.371	98.450	226.166	203.791	435.850	293.286	1.9326	4400
4500	31.666	101.602	226.875	204.297	439.002	293.158	2.0100	4500

TABLE A38.—THERMODYNAMIC PROPERTIES FOR Cu (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	31.938	104.783	227.574	204.795	442.183	293.058	2.0840	4600
4700	32.187	107.989	228.263	205.287	445.389	292.984	2.1547	4700
4800	32.414	111.219	228.943	205.773	448.619	292.935	2.2226	4800
4900	32.622	114.471	229.614	206.252	451.871	292.907	2.2876	4900
5000	32.811	117.743	230.275	206.726	455.143	292.898	2.3501	5000
5100	32.983	121.033	230.926	207.194	458.433	292.908	2.4101	5100
5200	33.139	124.339	231.568	207.657	461.739	292.934	2.4678	5200
5300	33.281	127.660	232.201	208.114	465.060	292.975	2.5233	5300
5400	33.411	130.994	232.824	208.566	468.394	293.030	2.5768	5400
5500	33.532	134.341	233.438	209.013	471.741	293.097	2.6283	5500
5600	33.644	137.700	234.044	209.454	475.100	293.176	2.6780	5600
5700	33.748	141.070	234.640	209.891	478.470	293.265	2.7260	5700
5800	33.848	144.449	235.228	210.323	481.849	293.365	2.7723	5800
5900	33.944	147.839	235.807	210.750	485.239	293.474	2.8171	5900
6000	34.037	151.237	236.378	211.172	488.637	293.593	2.8604	6000
6200	34.220	158.061	237.497	212.003	495.461			6200
6400	34.383	164.908	238.584	212.817	502.308			6400
6600	34.582	171.805	239.645	213.614	509.205			6600
6800	34.801	178.742	240.680	214.395	516.142			6800
7000	35.044	185.726	241.693	215.160	523.126			7000
7200	35.309	192.757	242.683	215.911	530.157			7200
7400	35.610	199.849	243.654	216.648	537.249			7400
7600	35.940	207.003	244.608	217.371	544.403			7600
7800	36.300	214.227	245.546	218.082	551.627			7800
8000	36.689	221.525	246.470	218.780	558.925			8000
8500	37.588	240.133	248.729	220.478	577.533			8500
9000	38.520	259.161	250.904	222.108	596.561			9000
9500	39.411	278.646	253.011	223.679	616.046			9500
10000	40.220	298.558	255.053	225.197	635.958			10000
10500	40.916	318.848	257.033	226.666	656.248			10500
11000	41.477	339.452	258.950	228.090	676.852			11000
11500	41.891	360.300	260.803	229.473	697.700			11500
12000	42.152	381.317	262.592	230.816	718.717			12000
12500	42.259	402.426	264.315	232.121	739.826			12500
13000	42.218	423.552	265.973	233.392	760.952			13000
13500	42.038	444.621	267.563	234.628	782.021			13500
14000	41.730	465.568	269.087	235.832	802.968			14000
14500	41.307	486.332	270.544	237.004	823.732			14500
15000	40.787	506.860	271.936	238.145	844.260			15000
15500	40.184	527.105	273.264	239.257	864.505			15500
16000	39.515	547.033	274.529	240.339	884.433			16000
16500	38.797	566.612	275.734	241.394	904.012			16500
17000	38.044	585.823	276.881	242.421	923.223			17000
17500	37.274	604.653	277.973	243.421	942.053			17500
18000	36.498	623.096	279.012	244.395	960.496			18000
18500	35.730	641.152	280.001	245.344	978.552			18500
19000	34.980	658.828	280.944	246.269	996.228			19000
19500	34.257	676.136	281.843	247.170	1013.536			19500
20000	33.568	693.091	282.702	248.047	1030.491			20000

***Assigned reference element phase change at 1358 K**

TABLE A39.—THERMODYNAMIC PROPERTIES FOR Cu^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1082.882	1081.689	----------	0
298.15	20.786	0.000	160.636	160.636	1089.080	1089.080	–183.0426	298.15
300	20.786	0.038	160.764	160.636	1089.118	1089.112	–181.8660	300
400	20.786	2.117	166.744	161.451	1091.197	1090.776	–134.4264	400
500	20.786	4.196	171.383	162.991	1093.275	1092.366	–105.9196	500
600	20.786	6.274	175.172	164.715	1095.354	1093.900	–86.8877	600
700	20.786	8.353	178.377	166.444	1097.433	1095.387	–73.2746	700
800	20.786	10.432	181.152	168.113	1099.511	1096.824	–63.0510	800
900	20.786	12.510	183.600	169.700	1101.590	1098.209	–55.0891	900
1000	20.786	14.589	185.790	171.202	1103.669	1099.531	–48.7117	1000
1100	20.786	16.667	187.772	172.619	1105.747	1100.778	–43.4877	1100
1200	20.786	18.746	189.580	173.958	1107.826	1101.928	–39.1296	1200
1300	20.786	20.825	191.244	175.225	1109.904	1102.960	–35.4383	1300
*1400	20.786	22.903	192.784	176.425	1111.983	1090.722	–32.2867	1400
1500	20.786	24.982	194.219	177.564	1114.062	1091.599	–29.5727	1500
1600	20.786	27.061	195.560	178.647	1116.140	1092.476	–27.1960	1600
1700	20.787	29.139	196.820	179.680	1118.219	1093.354	–25.0973	1700
1800	20.787	31.218	198.008	180.665	1120.298	1094.231	–23.2302	1800
1900	20.788	33.297	199.132	181.608	1122.376	1095.108	–21.5583	1900
2000	20.789	35.376	200.199	182.511	1124.455	1095.986	–20.0525	2000
2100	20.793	37.455	201.213	183.377	1126.534	1096.863	–18.6889	2100
2200	20.798	39.534	202.180	184.210	1128.614	1097.742	–17.4483	2200
2300	20.806	41.614	203.105	185.012	1130.694	1098.620	–16.3147	2300
2400	20.819	43.695	203.991	185.784	1132.775	1099.500	–15.2747	2400
2500	20.838	45.778	204.841	186.530	1134.858	1100.382	–14.3171	2500
2600	20.866	47.863	205.659	187.250	1136.943	1101.265	–13.4325	2600
2700	20.903	49.952	206.447	187.946	1139.031	1102.152	–12.6128	2700
2800	20.953	52.044	207.208	188.621	1141.124	1103.044	–11.8510	2800
2900	21.019	54.143	207.944	189.274	1143.223	1103.941	–11.1412	2900
3000	21.103	56.249	208.658	189.909	1145.329	1104.845	–10.4781	3000
3100	21.207	58.364	209.352	190.525	1147.444	1105.759	–9.8573	3100
3200	21.336	60.491	210.027	191.124	1149.571	1106.685	–9.2748	3200
3300	21.491	62.632	210.686	191.707	1151.712	1107.625	–8.7272	3300
3400	21.674	64.790	211.330	192.274	1153.870	1108.581	–8.2114	3400
3500	21.889	66.968	211.962	192.828	1156.048	1109.558	–7.7245	3500
3600	22.138	69.169	212.582	193.368	1158.249	1110.557	–7.2644	3600
3700	22.422	71.397	213.192	193.896	1160.477	1111.584	–6.8287	3700
3800	22.743	73.655	213.794	194.411	1162.735	1112.640	–6.4155	3800
3900	23.102	75.947	214.389	194.916	1165.027	1113.731	–6.0232	3900
4000	23.500	78.277	214.979	195.410	1167.356	1114.859	–5.6501	4000
4100	23.938	80.648	215.565	195.895	1169.728	1116.030	–5.2948	4100
4200	24.414	83.065	216.147	196.370	1172.145	1117.246	–4.9561	4200
4300	24.930	85.532	216.728	196.837	1174.612	1118.511	–4.6328	4300
4400	25.483	88.053	217.307	197.295	1177.132	1119.830	–4.3238	4400
4500	26.072	90.630	217.886	197.746	1179.710	1121.206	–4.0282	4500
4600	26.696	93.268	218.466	198.190	1182.348	1122.643	–3.7451	4600
4700	27.353	95.970	219.047	198.628	1185.050	1124.144	–3.4737	4700
4800	28.040	98.740	219.630	199.060	1187.820	1125.712	–3.2133	4800
4900	28.755	101.579	220.216	199.485	1190.659	1127.350	–2.9631	4900
5000	29.493	104.492	220.804	199.906	1193.571	1129.061	–2.7226	5000

TABLE A39.—THERMODYNAMIC PROPERTIES FOR Cu^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	30.253	107.479	221.396	200.321	1196.559	1130.847	–2.4911	5100
5200	31.030	110.543	221.991	200.732	1199.623	1132.709	–2.2682	5200
5300	31.821	113.685	222.589	201.139	1202.765	1134.650	–2.0534	5300
5400	32.621	116.907	223.191	201.542	1205.987	1136.671	–1.8461	5400
5500	33.428	120.210	223.797	201.941	1209.290	1138.772	–1.6460	5500
5600	34.236	123.593	224.407	202.337	1212.673	1140.954	–1.4527	5600
5700	35.043	127.057	225.020	202.729	1216.137	1143.217	–1.2658	5700
5800	35.844	130.601	225.636	203.119	1219.681	1145.560	–1.0850	5800
5900	36.635	134.225	226.256	203.506	1223.305	1147.982	–0.9100	5900
6000	37.413	137.928	226.878	203.890	1227.008	1150.483	–0.7404	6000
6200	38.915	145.562	228.130	204.652	1234.642			6200
6400	40.326	153.488	229.388	205.405	1242.568			6400
6600	41.623	161.685	230.649	206.151	1250.765			6600
6800	42.790	170.128	231.909	206.890	1259.208			6800
7000	43.816	178.792	233.165	207.623	1267.871			7000
7200	44.692	187.645	234.412	208.350	1276.725			7200
7400	45.417	196.658	235.646	209.071	1285.738			7400
7600	45.991	205.802	236.865	209.786	1294.881			7600
7800	46.419	215.045	238.066	210.496	1304.125			7800
8000	46.708	224.360	239.245	211.200	1313.439			8000
8500	46.896	247.790	242.086	212.934	1336.870			8500
9000	46.471	271.153	244.757	214.629	1360.233			9000
9500	45.633	294.192	247.248	216.281	1383.272			9500
10000	44.562	316.747	249.562	217.888	1405.827			10000
10500	43.404	338.740	251.709	219.448	1427.820			10500
11000	42.267	360.155	253.701	220.960	1449.235			11000
11500	41.226	381.023	255.557	222.424	1470.102			11500
12000	40.327	401.404	257.292	223.841	1490.483			12000
12500	39.599	421.377	258.922	225.212	1510.457			12500
13000	39.050	441.026	260.464	226.539	1530.106			13000
13500	38.691	460.450	261.930	227.823	1549.530			13500
14000	38.514	479.736	263.333	229.066	1568.816			14000
14500	38.511	498.971	264.683	230.271	1588.051			14500
15000	38.664	518.230	265.988	231.440	1607.310			15000
15500	38.992	537.625	267.260	232.575	1626.705			15500
16000	39.456	557.201	268.503	233.678	1646.281			16000
16500	40.061	577.047	269.724	234.752	1666.127			16500
17000	40.784	597.213	270.928	235.798	1686.293			17000
17500	41.520	617.601	272.109	236.817	1706.680			17500
18000	42.202	638.131	273.263	237.812	1727.211			18000
18500	43.107	659.349	274.425	238.785	1748.429			18500
19000	43.995	680.882	275.573	239.737	1769.962			19000
19500	44.978	703.002	276.721	240.670	1792.081			19500
20000	45.984	725.610	277.865	241.584	1814.690			20000

*Assigned reference element phase change at 1358 K

TABLE A40.—THERMODYNAMIC PROPERTIES FOR Cu^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	206.521	217.723	----------	0
298.15	20.786	0.000	160.636	160.636	212.719	212.719	–31.7033	298.15
300	20.786	0.038	160.765	160.636	212.757	212.674	–31.4735	300
400	20.786	2.117	166.744	161.452	214.836	210.181	–22.2651	400
500	20.786	4.196	171.383	162.991	216.914	207.614	–16.8067	500
600	20.786	6.274	175.173	164.715	218.993	204.991	–13.2133	600
700	20.786	8.353	178.377	166.444	221.072	202.320	–10.6797	700
800	20.786	10.432	181.152	168.113	223.150	199.600	–8.8046	800
900	20.786	12.510	183.601	169.700	225.229	196.828	–7.3663	900
1000	20.786	14.589	185.791	171.202	227.307	193.993	–6.2318	1000
1100	20.786	16.667	187.772	172.620	229.386	191.082	–5.3173	1100
1200	20.786	18.746	189.580	173.959	231.465	188.075	–4.5669	1200
1300	20.786	20.825	191.244	175.225	233.543	184.950	–3.9423	1300
*1400	20.786	22.903	192.785	176.425	235.622	168.554	–3.4311	1400
1500	20.786	24.982	194.219	177.564	237.701	165.274	–3.0159	1500
1600	20.786	27.061	195.560	178.647	239.779	161.994	–2.6597	1600
1700	20.786	29.139	196.820	179.680	241.858	158.714	–2.3517	1700
1800	20.786	31.218	198.009	180.665	243.936	155.434	–2.0835	1800
1900	20.786	33.296	199.132	181.608	246.015	152.154	–1.8486	1900
2000	20.786	35.375	200.199	182.511	248.094	148.874	–1.6416	2000
2100	20.786	37.454	201.213	183.378	250.172	145.594	–1.4585	2100
2200	20.786	39.532	202.180	184.211	252.251	142.314	–1.2957	2200
2300	20.786	41.611	203.104	185.012	254.330	139.034	–1.1505	2300
2400	20.786	43.690	203.988	185.784	256.408	135.754	–1.0205	2400
2500	20.786	45.768	204.837	186.530	258.487	132.474	–0.9037	2500
2600	20.786	47.847	205.652	187.250	260.566	129.194	–0.7985	2600
2700	20.786	49.926	206.437	187.946	262.644	125.914	–0.7036	2700
2800	20.786	52.004	207.193	188.620	264.723	122.634	–0.6177	2800
2900	20.786	54.083	207.922	189.273	266.801	119.354	–0.5399	2900
3000	20.786	56.161	208.627	189.906	268.880	116.074	–0.4692	3000
3100	20.786	58.240	209.308	190.521	270.959	112.794	–0.4049	3100
3200	20.786	60.319	209.968	191.119	273.037	109.514	–0.3464	3200
3300	20.786	62.397	210.608	191.700	275.116	106.234	–0.2930	3300
3400	20.786	64.476	211.228	192.265	277.195	102.954	–0.2443	3400
3500	20.786	66.555	211.831	192.815	279.273	99.674	–0.1998	3500
3600	20.786	68.633	212.417	193.352	281.352	96.394	–0.1592	3600
3700	20.786	70.712	212.986	193.875	283.430	93.114	–0.1220	3700
3800	20.786	72.790	213.540	194.385	285.509	89.834	–0.0880	3800
3900	20.786	74.869	214.080	194.883	287.588	86.554	–0.0569	3900
4000	20.786	76.948	214.607	195.370	289.666	83.274	–0.0285	4000
4100	20.786	79.026	215.120	195.845	291.745	79.994	–0.0025	4100
4200	20.786	81.105	215.621	196.310	293.824	76.714	0.0213	4200
4300	20.786	83.184	216.110	196.765	295.902	73.434	0.0430	4300
4400	20.786	85.262	216.588	197.210	297.981	70.154	0.0628	4400
4500	20.786	87.341	217.055	197.646	300.059	66.874	0.0809	4500
4600	20.786	89.419	217.512	198.073	302.138	63.594	0.0973	4600
4700	20.786	91.498	217.959	198.491	304.217	60.314	0.1123	4700
4800	20.786	93.577	218.396	198.901	306.295	57.034	0.1259	4800
4900	20.786	95.655	218.825	199.303	308.374	53.754	0.1382	4900
5000	20.786	97.734	219.245	199.698	310.453	50.474	0.1493	5000

TABLE A40.—THERMODYNAMIC PROPERTIES FOR Cu^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	219.657	200.085	312.531	47.194	0.1593	5100
5200	20.786	101.891	220.060	200.466	314.610	43.914	0.1683	5200
5300	20.786	103.970	220.456	200.839	316.688	40.634	0.1763	5300
5400	20.786	106.048	220.845	201.206	318.767	37.354	0.1834	5400
5500	20.786	108.127	221.226	201.567	320.846	34.074	0.1897	5500
5600	20.786	110.206	221.601	201.921	322.924	30.794	0.1952	5600
5700	20.786	112.284	221.968	202.269	325.003	27.514	0.2000	5700
5800	20.786	114.363	222.330	202.612	327.082	24.234	0.2041	5800
5900	20.786	116.442	222.685	202.949	329.160	20.954	0.2075	5900
6000	20.786	118.520	223.035	203.281	331.239	17.674	0.2104	6000
6200	20.786	122.677	223.716	203.930	335.396			6200
6400	20.786	126.835	224.376	204.558	339.553			6400
6600	20.786	130.992	225.016	205.169	343.711			6600
6800	20.786	135.149	225.636	205.761	347.868			6800
7000	20.786	139.306	226.239	206.338	352.025			7000
7200	20.786	143.464	226.824	206.899	356.182			7200
7400	20.786	147.621	227.394	207.445	360.340			7400
7600	20.786	151.778	227.948	207.977	364.497			7600
7800	20.786	155.936	228.488	208.497	368.654			7800
8000	20.786	160.093	229.015	209.003	372.811			8000
8500	20.786	170.486	230.275	210.218	383.205			8500
9000	20.786	180.879	231.463	211.365	393.598			9000
9500	20.786	191.272	232.587	212.453	403.991			9500
10000	20.786	201.665	233.653	213.486	414.384			10000
10500	20.786	212.058	234.667	214.471	424.777			10500
11000	20.786	222.452	235.634	215.411	435.170			11000
11500	20.786	232.845	236.558	216.311	445.563			11500
12000	20.786	243.238	237.443	217.173	455.957			12000
12500	20.786	253.631	238.291	218.001	466.350			12500
13000	20.786	264.024	239.106	218.797	476.743			13000
13500	20.786	274.417	239.891	219.564	487.136			13500
14000	20.786	284.810	240.647	220.303	497.529			14000
14500	20.786	295.204	241.376	221.017	507.922			14500
15000	20.786	305.597	242.081	221.708	518.315			15000
15500	20.786	315.990	242.763	222.376	528.708			15500
16000	20.786	326.383	243.422	223.024	539.102			16000
16500	20.786	336.776	244.062	223.651	549.495			16500
17000	20.786	347.169	244.683	224.261	559.888			17000
17500	20.786	357.562	245.285	224.853	570.281			17500
18000	20.786	367.956	245.871	225.429	580.674			18000
18500	20.786	378.349	246.440	225.989	591.067			18500
19000	20.786	388.742	246.995	226.534	601.460			19000
19500	20.786	399.135	247.535	227.066	611.854			19500
20000	20.786	409.528	248.061	227.584	622.247			20000

*Assigned reference element phase change at 1358 K

TABLE A41.—THERMODYNAMIC PROPERTIES FOR D

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	215.523	219.807	----------	0
100	20.786	–4.119	100.644	141.832	217.601	220.511	–112.8688	100
200	20.786	–2.040	115.052	125.253	219.680	221.113	–55.2191	200
298.15	20.786	0.000	123.352	123.352	221.720	221.720	–36.1863	298.15
300	20.786	0.038	123.480	123.352	221.759	221.732	–35.9467	300
400	20.786	2.117	129.460	124.167	223.837	222.349	–26.2831	400
500	20.786	4.196	134.098	125.707	225.916	222.963	–20.4686	500
600	20.786	6.274	137.888	127.431	227.995	223.568	–16.5816	600
700	20.786	8.353	141.092	129.160	230.073	224.156	–13.7977	700
800	20.786	10.432	143.868	130.829	232.152	224.722	–11.7044	800
900	20.786	12.510	146.316	132.416	234.230	225.261	–10.0722	900
1000	20.786	14.589	148.506	133.917	236.309	225.773	–8.7634	1000
1100	20.786	16.667	150.487	135.335	238.388	226.255	–7.6902	1100
1200	20.786	18.746	152.296	136.674	240.466	226.709	–6.7940	1200
1300	20.786	20.825	153.960	137.941	242.545	227.136	–6.0343	1300
1400	20.786	22.903	155.500	139.141	244.624	227.537	–5.3818	1400
1500	20.786	24.982	156.934	140.280	246.702	227.916	–4.8154	1500
1600	20.786	27.061	158.276	141.363	248.781	228.274	–4.3190	1600
1700	20.786	29.139	159.536	142.395	250.859	228.610	–3.8803	1700
1800	20.786	31.218	160.724	143.381	252.938	228.930	–3.4898	1800
1900	20.786	33.296	161.848	144.324	255.017	229.231	–3.1399	1900
2000	20.786	35.375	162.914	145.227	257.095	229.519	–2.8246	2000
2100	20.786	37.454	163.928	146.093	259.174	229.791	–2.5390	2100
2200	20.786	39.532	164.895	146.926	261.253	230.050	–2.2791	2200
2300	20.786	41.611	165.819	147.728	263.331	230.295	–2.0415	2300
2400	20.786	43.690	166.704	148.500	265.410	230.529	–1.8234	2400
2500	20.786	45.768	167.553	149.245	267.488	230.754	–1.6227	2500
2600	20.786	47.847	168.368	149.965	269.567	230.966	–1.4371	2600
2700	20.786	49.926	169.152	150.661	271.646	231.169	–1.2652	2700
2800	20.786	52.004	169.908	151.335	273.724	231.360	–1.1054	2800
2900	20.786	54.083	170.638	151.988	275.803	231.544	–0.9565	2900
3000	20.786	56.161	171.342	152.622	277.882	231.719	–0.8175	3000
3100	20.786	58.240	172.024	153.237	279.960	231.885	–0.6873	3100
3200	20.786	60.319	172.684	153.834	282.039	232.043	–0.5652	3200
3300	20.786	62.397	173.324	154.415	284.118	232.191	–0.4503	3300
3400	20.786	64.476	173.944	154.981	286.196	232.331	–0.3422	3400
3500	20.786	66.555	174.547	155.531	288.275	232.465	–0.2402	3500
3600	20.786	68.633	175.132	156.067	290.353	232.588	–0.1438	3600
3700	20.786	70.712	175.702	156.590	292.432	232.704	–0.0526	3700
3800	20.786	72.790	176.256	157.101	294.511	232.813	0.0339	3800
3900	20.786	74.869	176.796	157.599	296.589	232.914	0.1160	3900
4000	20.786	76.948	177.322	158.085	298.668	233.006	0.1940	4000
4100	20.786	79.026	177.835	158.561	300.747	233.092	0.2682	4100
4200	20.786	81.105	178.336	159.026	302.825	233.168	0.3389	4200
4300	20.786	83.184	178.825	159.480	304.904	233.238	0.4064	4300
4400	20.786	85.262	179.303	159.926	306.982	233.300	0.4708	4400
4500	20.786	87.341	179.770	160.361	309.061	233.355	0.5323	4500

TABLE A41.—THERMODYNAMIC PROPERTIES FOR D (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.786	89.419	180.227	160.788	311.140	233.403	0.5912	4600
4700	20.786	91.498	180.674	161.207	313.218	233.442	0.6476	4700
4800	20.786	93.577	181.112	161.617	315.297	233.473	0.7016	4800
4900	20.786	95.655	181.541	162.019	317.376	233.498	0.7535	4900
5000	20.786	97.734	181.961	162.414	319.454	233.518	0.8033	5000
5100	20.786	99.813	182.372	162.801	321.533	233.527	0.8511	5100
5200	20.786	101.891	182.776	163.181	323.611	233.533	0.8971	5200
5300	20.786	103.970	183.172	163.555	325.690	233.532	0.9414	5300
5400	20.786	106.048	183.560	163.922	327.769	233.529	0.9840	5400
5500	20.786	108.127	183.942	164.282	329.847	233.514	1.0251	5500
5600	20.786	110.206	184.316	164.637	331.926	233.497	1.0647	5600
5700	20.786	112.284	184.684	164.985	334.005	233.476	1.1029	5700
5800	20.786	114.363	185.046	165.328	336.083	233.449	1.1397	5800
5900	20.786	116.442	185.401	165.665	338.162	233.419	1.1754	5900
6000	20.786	118.520	185.750	165.997	340.240	233.389	1.2098	6000
6200	20.786	122.678	186.432	166.645	344.398	233.311	1.2754	6200
6400	20.786	126.835	187.092	167.274	348.555	233.225	1.3368	6400
6600	20.786	130.992	187.731	167.884	352.712	233.136	1.3944	6600
6800	20.787	135.149	188.352	168.477	356.870	233.048	1.4487	6800
7000	20.787	139.307	188.955	169.054	361.027	232.964	1.4998	7000
7200	20.787	143.464	189.540	169.615	365.184	232.887	1.5481	7200
7400	20.788	147.622	190.110	170.161	369.342	232.821	1.5938	7400
7600	20.788	151.779	190.664	170.693	373.499	232.770	1.6370	7600
7800	20.789	155.937	191.204	171.212	377.657	232.737	1.6780	7800
8000	20.790	160.095	191.730	171.719	381.815	232.726	1.7170	8000
8500	20.795	170.491	192.991	172.933	392.211	232.812	1.8064	8500
9000	20.803	180.890	194.180	174.081	402.610	233.094	1.8859	9000
9500	20.818	191.295	195.305	175.169	413.015	233.593	1.9572	9500
10000	20.832	201.702	196.372	176.202	423.422	234.330	2.0215	10000
10500	20.861	212.125	197.390	177.187	433.845	235.325	2.0799	10500
11000	20.904	222.544	198.358	178.127	444.264	236.554	2.1332	11000
11500	20.982	233.015	199.290	179.027	454.735	238.073	2.1822	11500
12000	21.085	243.530	200.184	179.890	465.250	239.870	2.2274	12000
12500	21.209	254.103	201.047	180.719	475.823	241.942	2.2693	12500
13000	21.353	264.743	201.882	181.517	486.463	244.297	2.3084	13000
13500	21.515	275.459	202.691	182.287	497.179	246.925	2.3450	13500
14000	21.690	286.260	203.477	183.030	507.980	249.824	2.3793	14000
14500	21.877	297.152	204.241	183.748	518.872	252.982	2.4116	14500
15000	22.071	308.138	204.986	184.443	529.859	256.392	2.4422	15000
15500	22.270	319.223	205.713	185.118	540.944	260.048	2.4712	15500
16000	22.470	330.409	206.424	185.773	552.129	263.946	2.4988	16000
16500	22.670	341.693	207.118	186.409	563.413	268.071	2.5251	16500
17000	22.867	353.078	207.797	187.028	574.798	272.416	2.5502	17000
17500	23.060	364.560	208.463	187.631	586.280	276.961	2.5744	17500
18000	23.250	376.137	209.115	188.218	597.858	281.711	2.5975	18000
18500	23.436	387.808	209.755	188.793	609.529	286.636	2.6198	18500
19000	23.621	399.573	210.382	189.352	621.293	291.743	2.6413	19000
19500	23.805	411.429	210.998	189.899	633.150	297.028	2.6620	19500
20000	23.994	423.378	211.603	190.435	645.099	302.479	2.6821	20000

TABLE A42.—THERMODYNAMIC PROPERTIES FOR D^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1534.127	1532.214	----------	0
298.15	20.786	0.000	117.585	117.585	1540.324	1540.324	–266.3998	298.15
300	20.786	0.038	117.714	117.585	1540.363	1540.374	–264.7357	300
400	20.786	2.117	123.693	118.401	1542.441	1543.070	–197.6335	400
500	20.786	4.196	128.332	119.940	1544.520	1545.763	–157.3012	500
600	20.786	6.274	132.122	121.664	1546.599	1548.446	–130.3657	600
700	20.786	8.353	135.326	123.393	1548.677	1551.113	–111.0927	700
800	20.786	10.432	138.101	125.062	1550.756	1553.758	–96.6131	800
900	20.786	12.510	140.550	126.649	1552.835	1556.376	–85.3320	900
1000	20.786	14.589	142.740	128.151	1554.913	1558.966	–76.2920	1000
1100	20.786	16.667	144.721	129.569	1556.992	1561.527	–68.8834	1100
1200	20.786	18.746	146.530	130.908	1559.070	1564.059	–62.6994	1200
1300	20.786	20.825	148.193	132.174	1561.149	1566.565	–57.4584	1300
1400	20.786	22.903	149.734	133.374	1563.228	1569.045	–52.9590	1400
1500	20.786	24.982	151.168	134.513	1565.306	1571.503	–49.0533	1500
1600	20.786	27.061	152.509	135.596	1567.385	1573.939	–45.6305	1600
1700	20.786	29.139	153.770	136.629	1569.464	1576.354	–42.6057	1700
1800	20.786	31.218	154.958	137.614	1571.542	1578.752	–39.9129	1800
1900	20.786	33.296	156.081	138.557	1573.621	1581.132	–37.4999	1900
2000	20.786	35.375	157.148	139.460	1575.699	1583.498	–35.3250	2000
2100	20.786	37.454	158.162	140.327	1577.778	1585.849	–33.3542	2100
2200	20.786	39.532	159.129	141.160	1579.857	1588.186	–31.5600	2200
2300	20.786	41.611	160.053	141.961	1581.935	1590.510	–29.9193	2300
2400	20.786	43.690	160.937	142.733	1584.014	1592.823	–28.4132	2400
2500	20.786	45.768	161.786	143.479	1586.093	1595.126	–27.0256	2500
2600	20.786	47.847	162.601	144.199	1588.171	1597.417	–25.7428	2600
2700	20.786	49.926	163.386	144.895	1590.250	1599.699	–24.5534	2700
2800	20.786	52.004	164.142	145.569	1592.328	1601.969	–23.4474	2800
2900	20.786	54.083	164.871	146.222	1594.407	1604.231	–22.4162	2900
3000	20.786	56.161	165.576	146.855	1596.486	1606.485	–21.4524	3000
3100	20.786	58.240	166.257	147.470	1598.564	1608.729	–20.5495	3100
3200	20.786	60.319	166.917	148.068	1600.643	1610.966	–19.7018	3200
3300	20.786	62.397	167.557	148.649	1602.722	1613.192	–18.9044	3300
3400	20.786	64.476	168.177	149.214	1604.800	1615.411	–18.1529	3400
3500	20.786	66.555	168.780	149.764	1606.879	1617.624	–17.4434	3500
3600	20.786	68.633	169.366	150.301	1608.957	1619.825	–16.7723	3600
3700	20.786	70.712	169.935	150.824	1611.036	1622.020	–16.1367	3700
3800	20.786	72.790	170.489	151.334	1613.115	1624.207	–15.5337	3800
3900	20.786	74.869	171.029	151.832	1615.193	1626.387	–14.9609	3900
4000	20.786	76.948	171.556	152.319	1617.272	1628.557	–14.4160	4000
4100	20.786	79.026	172.069	152.794	1619.351	1630.722	–13.8969	4100
4200	20.786	81.105	172.570	153.259	1621.429	1632.877	–13.4020	4200
4300	20.786	83.184	173.059	153.714	1623.508	1635.026	–12.9294	4300
4400	20.786	85.262	173.537	154.159	1625.587	1637.166	–12.4777	4400
4500	20.786	87.341	174.004	154.595	1627.665	1639.300	–12.0455	4500
4600	20.786	89.419	174.461	155.022	1629.744	1641.426	–11.6316	4600
4700	20.786	91.498	174.908	155.440	1631.822	1643.545	–11.2348	4700
4800	20.786	93.577	175.345	155.850	1633.901	1645.654	–10.8540	4800
4900	20.786	95.655	175.774	156.253	1635.980	1647.757	–10.4883	4900
5000	20.786	97.734	176.194	156.647	1638.058	1649.856	–10.1368	5000

TABLE A42.—THERMODYNAMIC PROPERTIES FOR D^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	176.606	157.034	1640.137	1651.943	–9.7986	5100
5200	20.786	101.891	177.009	157.415	1642.216	1654.028	–9.4731	5200
5300	20.786	103.970	177.405	157.788	1644.294	1656.106	–9.1594	5300
5400	20.786	106.048	177.794	158.155	1646.373	1658.182	–8.8570	5400
5500	20.786	108.127	178.175	158.516	1648.451	1660.245	–8.5651	5500
5600	20.786	110.206	178.550	158.870	1650.530	1662.307	–8.2834	5600
5700	20.786	112.284	178.918	159.219	1652.609	1664.365	–8.0112	5700
5800	20.786	114.363	179.279	159.561	1654.687	1666.417	–7.7481	5800
5900	20.786	116.442	179.634	159.899	1656.766	1668.465	–7.4936	5900
6000	20.786	118.520	179.984	160.230	1658.845	1670.513	–7.2473	6000
6200	20.786	122.677	180.665	160.879	1663.002	1674.593	–6.7776	6200
6400	20.786	126.835	181.325	161.507	1667.159	1678.664	–6.3362	6400
6600	20.786	130.992	181.965	162.118	1671.316	1682.732	–5.9205	6600
6800	20.786	135.149	182.585	162.711	1675.474	1686.801	–5.5283	6800
7000	20.786	139.306	183.188	163.287	1679.631	1690.875	–5.1577	7000
7200	20.786	143.464	183.774	163.848	1683.788	1694.954	–4.8068	7200
7400	20.786	147.621	184.343	164.394	1687.945	1699.046	–4.4741	7400
7600	20.786	151.778	184.897	164.927	1692.103	1703.152	–4.1581	7600
7800	20.786	155.936	185.437	165.446	1696.260	1707.276	–3.8576	7800
8000	20.786	160.093	185.964	165.952	1700.417	1711.421	–3.5714	8000
8500	20.786	170.486	187.224	167.167	1710.810	1721.898	–2.9122	8500
9000	20.786	180.879	188.412	168.314	1721.203	1732.566	–2.3225	9000
9500	20.786	191.272	189.536	169.402	1731.597	1743.447	–1.7917	9500
10000	20.786	201.665	190.602	170.435	1741.990	1754.562	–1.3109	10000
10500	20.786	212.058	191.616	171.420	1752.383	1765.921	–0.8731	10500
11000	20.786	222.452	192.583	172.360	1762.776	1777.518	–0.4725	11000
11500	20.786	232.845	193.507	173.260	1773.169	1789.352	–0.1043	11500
12000	20.786	243.238	194.392	174.122	1783.562	1801.420	0.2354	12000
12500	20.786	253.631	195.240	174.950	1793.955	1813.706	0.5501	12500
13000	20.786	264.024	196.055	175.746	1804.348	1826.207	0.8426	13000
13500	20.786	274.417	196.840	176.513	1814.742	1838.904	1.1153	13500
14000	20.786	284.810	197.596	177.252	1825.135	1851.790	1.3703	14000
14500	20.786	295.204	198.325	177.966	1835.528	1864.842	1.6093	14500
15000	20.786	305.597	199.030	178.657	1845.921	1878.051	1.8341	15000
15500	20.786	315.990	199.712	179.325	1856.314	1891.409	2.0458	15500
16000	20.786	326.383	200.372	179.973	1866.707	1904.907	2.2456	16000
16500	20.786	336.776	201.011	180.600	1877.100	1918.534	2.4348	16500
17000	20.786	347.169	201.632	181.210	1887.494	1932.281	2.6140	17000
17500	20.786	357.562	202.234	181.802	1897.887	1946.130	2.7843	17500
18000	20.786	367.956	202.820	182.378	1908.280	1960.089	2.9462	18000
18500	20.786	378.349	203.389	182.938	1918.673	1974.129	3.1004	18500
19000	20.786	388.742	203.944	183.484	1929.066	1988.258	3.2477	19000
19500	20.786	399.135	204.484	184.015	1939.459	2002.473	3.3883	19500
20000	20.786	409.528	205.010	184.533	1949.852	2016.761	3.5229	20000

TABLE A43.—THERMODYNAMIC PROPERTIES FOR D^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	136.555	147.037	----------	0
298.15	20.786	0.000	117.592	117.592	142.753	142.753	–23.7485	298.15
300	20.786	0.038	117.720	117.592	142.791	142.726	–23.5943	300
400	20.786	2.117	123.700	118.408	144.870	141.265	–17.4105	400
500	20.786	4.196	128.339	119.947	146.948	139.800	–13.7389	500
600	20.786	6.274	132.128	121.671	149.027	138.326	–11.3168	600
700	20.786	8.353	135.333	123.400	151.106	136.836	–9.6053	700
800	20.786	10.432	138.108	125.069	153.184	135.323	–8.3357	800
900	20.786	12.510	140.556	126.656	155.263	133.784	–7.3593	900
1000	20.786	14.589	142.747	128.158	157.342	132.217	–6.5872	1000
1100	20.786	16.667	144.728	129.575	159.420	130.620	–5.9631	1100
1200	20.786	18.746	146.536	130.915	161.499	128.995	–5.4493	1200
1300	20.786	20.825	148.200	132.181	163.577	127.344	–5.0201	1300
1400	20.786	22.903	149.741	133.381	165.656	125.667	–4.6569	1400
1500	20.786	24.982	151.175	134.520	167.735	123.967	–4.3464	1500
1600	20.786	27.061	152.516	135.603	169.813	122.246	–4.0785	1600
1700	20.786	29.139	153.776	136.636	171.892	120.503	–3.8454	1700
1800	20.786	31.218	154.964	137.621	173.971	118.744	–3.6411	1800
1900	20.786	33.296	156.088	138.564	176.049	116.967	–3.4611	1900
2000	20.786	35.375	157.154	139.467	178.128	115.176	–3.3015	2000
2100	20.786	37.454	158.169	140.334	180.206	113.370	–3.1594	2100
2200	20.786	39.532	159.136	141.166	182.285	111.550	–3.0322	2200
2300	20.786	41.611	160.060	141.968	184.364	109.717	–2.9180	2300
2400	20.786	43.690	160.944	142.740	186.442	107.872	–2.8150	2400
2500	20.786	45.768	161.793	143.486	188.521	106.018	–2.7219	2500
2600	20.786	47.847	162.608	144.205	190.600	104.151	–2.6375	2600
2700	20.786	49.926	163.393	144.902	192.678	102.276	–2.5607	2700
2800	20.786	52.004	164.148	145.576	194.757	100.389	–2.4906	2800
2900	20.786	54.083	164.878	146.229	196.835	98.494	–2.4267	2900
3000	20.786	56.161	165.583	146.862	198.914	96.590	–2.3681	3000
3100	20.786	58.240	166.264	147.477	200.993	94.678	–2.3144	3100
3200	20.786	60.319	166.924	148.075	203.071	92.757	–2.2650	3200
3300	20.786	62.397	167.564	148.655	205.150	90.826	–2.2196	3300
3400	20.786	64.476	168.184	149.221	207.229	88.888	–2.1778	3400
3500	20.786	66.555	168.787	149.771	209.307	86.943	–2.1392	3500
3600	20.786	68.633	169.372	150.308	211.386	84.987	–2.1036	3600
3700	20.786	70.712	169.942	150.831	213.465	83.025	–2.0706	3700
3800	20.786	72.790	170.496	151.341	215.543	81.055	–2.0401	3800
3900	20.786	74.869	171.036	151.839	217.622	79.077	–2.0119	3900
4000	20.786	76.948	171.562	152.326	219.700	77.090	–1.9858	4000
4100	20.786	79.026	172.076	152.801	221.779	75.098	–1.9615	4100
4200	20.786	81.105	172.577	153.266	223.858	73.095	–1.9390	4200
4300	20.786	83.184	173.066	153.721	225.936	71.087	–1.9182	4300
4400	20.786	85.262	173.544	154.166	228.015	69.070	–1.8988	4400
4500	20.786	87.341	174.011	154.602	230.094	67.046	–1.8809	4500
4600	20.786	89.419	174.468	155.029	232.172	65.016	–1.8642	4600
4700	20.786	91.498	174.915	155.447	234.251	62.977	–1.8488	4700
4800	20.786	93.577	175.352	155.857	236.329	60.929	–1.8344	4800
4900	20.786	95.655	175.781	156.259	238.408	58.875	–1.8211	4900
5000	20.786	97.734	176.201	156.654	240.487	56.816	–1.8088	5000

TABLE A43.—THERMODYNAMIC PROPERTIES FOR D^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	176.612	157.041	242.565	54.747	–1.7973	5100
5200	20.786	101.891	177.016	157.422	244.644	52.674	–1.7868	5200
5300	20.786	103.970	177.412	157.795	246.723	50.595	–1.7770	5300
5400	20.786	106.048	177.800	158.162	248.801	48.513	–1.7679	5400
5500	20.786	108.127	178.182	158.522	250.880	46.419	–1.7596	5500
5600	20.786	110.206	178.556	158.877	252.958	44.324	–1.7519	5600
5700	20.786	112.284	178.924	159.225	255.037	42.225	–1.7448	5700
5800	20.786	114.363	179.286	159.568	257.116	40.119	–1.7383	5800
5900	20.786	116.442	179.641	159.905	259.194	38.010	–1.7323	5900
6000	20.786	118.520	179.991	160.237	261.273	35.901	–1.7269	6000
6200	20.786	122.677	180.672	160.885	265.430	31.666	–1.7174	6200
6400	20.786	126.835	181.332	161.514	269.587	27.423	–1.7096	6400
6600	20.786	130.992	181.972	162.124	273.745	23.177	–1.7033	6600
6800	20.786	135.149	182.592	162.717	277.902	18.931	–1.6984	6800
7000	20.786	139.306	183.195	163.294	282.059	14.690	–1.6948	7000
7200	20.786	143.464	183.780	163.855	286.216	10.455	–1.6921	7200
7400	20.786	147.621	184.350	164.401	290.374	6.232	–1.6905	7400
7600	20.786	151.778	184.904	164.933	294.531	2.024	–1.6897	7600
7800	20.786	155.936	185.444	165.452	298.688	–2.167	–1.6897	7800
8000	20.786	160.093	185.970	165.959	302.846	–6.337	–1.6904	8000
8500	20.786	170.486	187.231	167.173	313.239	–16.646	–1.6948	8500
9000	20.786	180.879	188.419	168.321	323.632	–26.764	–1.7022	9000
9500	20.786	191.272	189.543	169.409	334.025	–36.669	–1.7119	9500
10000	20.786	201.665	190.609	170.442	344.418	–46.340	–1.7233	10000
10500	20.786	212.058	191.623	171.427	354.811	–55.768	–1.7360	10500
11000	20.786	222.452	192.590	172.367	365.204	–64.957	–1.7496	11000
11500	20.786	232.845	193.514	173.266	375.597	–73.909	–1.7639	11500
12000	20.786	243.238	194.398	174.129	385.991	–82.627	–1.7787	12000
12500	20.786	253.631	195.247	174.957	396.384	–91.128	–1.7938	12500
13000	20.786	264.024	196.062	175.753	406.777	–99.413	–1.8091	13000
13500	20.786	274.417	196.847	176.520	417.170	–107.502	–1.8245	13500
14000	20.786	284.810	197.603	177.259	427.563	–115.403	–1.8399	14000
14500	20.786	295.204	198.332	177.973	437.956	–123.137	–1.8553	14500
15000	20.786	305.597	199.037	178.664	448.349	–130.714	–1.8705	15000
15500	20.786	315.990	199.718	179.332	458.743	–138.143	–1.8856	15500
16000	20.786	326.383	200.378	179.979	469.136	–145.430	–1.9005	16000
16500	20.786	336.776	201.018	180.607	479.529	–152.590	–1.9153	16500
17000	20.786	347.169	201.638	181.217	489.922	–159.629	–1.9298	17000
17500	20.786	357.562	202.241	181.809	500.315	–166.566	–1.9441	17500
18000	20.786	367.956	202.827	182.385	510.708	–173.394	–1.9582	18000
18500	20.786	378.349	203.396	182.945	521.101	–180.140	–1.9721	18500
19000	20.786	388.742	203.950	183.490	531.495	–186.797	–1.9857	19000
19500	20.786	399.135	204.490	184.022	541.888	–193.369	–1.9991	19500
20000	20.786	409.528	205.017	184.540	552.281	–199.867	–2.0123	20000

TABLE A44.—THERMODYNAMIC PROPERTIES FOR e^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–6.197	0	----------	0
298.15	20.786	0.000	20.979	20.979	0.000	0	0	298.15
300	20.786	0.038	21.108	20.979	0.038	0	0	300
400	20.786	2.117	27.087	21.795	2.117	0	0	400
500	20.786	4.196	31.726	23.334	4.196	0	0	500
600	20.786	6.274	35.516	25.058	6.274	0	0	600
700	20.786	8.353	38.720	26.787	8.353	0	0	700
800	20.786	10.432	41.495	28.456	10.432	0	0	800
900	20.786	12.510	43.944	30.043	12.510	0	0	900
1000	20.786	14.589	46.134	31.545	14.589	0	0	1000
1100	20.786	16.667	48.115	32.963	16.667	0	0	1100
1200	20.786	18.746	49.923	34.302	18.746	0	0	1200
1300	20.786	20.825	51.587	35.568	20.825	0	0	1300
1400	20.786	22.903	53.128	36.768	22.903	0	0	1400
1500	20.786	24.982	54.562	37.907	24.982	0	0	1500
1600	20.786	27.061	55.903	38.990	27.061	0	0	1600
1700	20.786	29.139	57.163	40.023	29.139	0	0	1700
1800	20.786	31.218	58.352	41.008	31.218	0	0	1800
1900	20.786	33.296	59.475	41.951	33.296	0	0	1900
2000	20.786	35.375	60.542	42.854	35.375	0	0	2000
2100	20.786	37.454	61.556	43.721	37.454	0	0	2100
2200	20.786	39.532	62.523	44.554	39.532	0	0	2200
2300	20.786	41.611	63.447	45.355	41.611	0	0	2300
2400	20.786	43.690	64.331	46.127	43.690	0	0	2400
2500	20.786	45.768	65.180	46.873	45.768	0	0	2500
2600	20.786	47.847	65.995	47.593	47.847	0	0	2600
2700	20.786	49.926	66.780	48.289	49.926	0	0	2700
2800	20.786	52.004	67.536	48.963	52.004	0	0	2800
2900	20.786	54.083	68.265	49.616	54.083	0	0	2900
3000	20.786	56.161	68.970	50.249	56.161	0	0	3000
3100	20.786	58.240	69.651	50.864	58.240	0	0	3100
3200	20.786	60.319	70.311	51.462	60.319	0	0	3200
3300	20.786	62.397	70.951	52.043	62.397	0	0	3300
3400	20.786	64.476	71.571	52.608	64.476	0	0	3400
3500	20.786	66.555	72.174	53.158	66.555	0	0	3500
3600	20.786	68.633	72.760	53.695	68.633	0	0	3600
3700	20.786	70.712	73.329	54.218	70.712	0	0	3700
3800	20.786	72.790	73.883	54.728	72.790	0	0	3800
3900	20.786	74.869	74.423	55.226	74.869	0	0	3900
4000	20.786	76.948	74.950	55.713	76.948	0	0	4000
4100	20.786	79.026	75.463	56.188	79.026	0	0	4100
4200	20.786	81.105	75.964	56.653	81.105	0	0	4200
4300	20.786	83.184	76.453	57.108	83.184	0	0	4300
4400	20.786	85.262	76.931	57.553	85.262	0	0	4400
4500	20.786	87.341	77.398	57.989	87.341	0	0	4500
4600	20.786	89.419	77.855	58.416	89.419	0	0	4600
4700	20.786	91.498	78.302	58.834	91.498	0	0	4700
4800	20.786	93.577	78.739	59.244	93.577	0	0	4800
4900	20.786	95.655	79.168	59.646	95.655	0	0	4900
5000	20.786	97.734	79.588	60.041	97.734	0	0	5000

TABLE A44.—THERMODYNAMIC PROPERTIES FOR e^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	80.000	60.428	99.813	0	0	5100
5200	20.786	101.891	80.403	60.809	101.891	0	0	5200
5300	20.786	103.970	80.799	61.182	103.970	0	0	5300
5400	20.786	106.048	81.188	61.549	106.048	0	0	5400
5500	20.786	108.127	81.569	61.910	108.127	0	0	5500
5600	20.786	110.206	81.944	62.264	110.206	0	0	5600
5700	20.786	112.284	82.311	62.612	112.284	0	0	5700
5800	20.786	114.363	82.673	62.955	114.363	0	0	5800
5900	20.786	116.442	83.028	63.292	116.442	0	0	5900
6000	20.786	118.520	83.378	63.624	118.520	0	0	6000
6200	20.786	122.677	84.059	64.273	122.677	0	0	6200
6400	20.786	126.835	84.719	64.901	126.835	0	0	6400
6600	20.786	130.992	85.359	65.512	130.992	0	0	6600
6800	20.786	135.149	85.979	66.104	135.149	0	0	6800
7000	20.786	139.306	86.582	66.681	139.306	0	0	7000
7200	20.786	143.464	87.167	67.242	143.464	0	0	7200
7400	20.786	147.621	87.737	67.788	147.621	0	0	7400
7600	20.786	151.778	88.291	68.321	151.778	0	0	7600
7800	20.786	155.936	88.831	68.840	155.936	0	0	7800
8000	20.786	160.093	89.358	69.346	160.093	0	0	8000
8500	20.786	170.486	90.618	70.561	170.486	0	0	8500
9000	20.786	180.879	91.806	71.708	180.879	0	0	9000
9500	20.786	191.272	92.930	72.796	191.272	0	0	9500
10000	20.786	201.665	93.996	73.829	201.665	0	0	10000
10500	20.786	212.058	95.010	74.814	212.058	0	0	10500
11000	20.786	222.452	95.977	75.754	222.452	0	0	11000
11500	20.786	232.845	96.901	76.654	232.845	0	0	11500
12000	20.786	243.238	97.786	77.516	243.238	0	0	12000
12500	20.786	253.631	98.634	78.344	253.631	0	0	12500
13000	20.786	264.024	99.449	79.140	264.024	0	0	13000
13500	20.786	274.417	100.234	79.907	274.417	0	0	13500
14000	20.786	284.810	100.990	80.646	284.810	0	0	14000
14500	20.786	295.204	101.719	81.360	295.204	0	0	14500
15000	20.786	305.597	102.424	82.051	305.597	0	0	15000
15500	20.786	315.990	103.106	82.719	315.990	0	0	15500
16000	20.786	326.383	103.765	83.367	326.383	0	0	16000
16500	20.786	336.776	104.405	83.994	336.776	0	0	16500
17000	20.786	347.169	105.026	84.604	347.169	0	0	17000
17500	20.786	357.562	105.628	85.196	357.562	0	0	17500
18000	20.786	367.956	106.214	85.772	367.956	0	0	18000
18500	20.786	378.349	106.783	86.332	378.349	0	0	18500
19000	20.786	388.742	107.338	86.878	388.742	0	0	19000
19500	20.786	399.135	107.878	87.409	399.135	0	0	19500
20000	20.786	409.528	108.404	87.927	409.528	0	0	20000

TABLE A45.—THERMODYNAMIC PROPERTIES FOR F

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.518	----------	----------	72.862	77.274	----------	0
100	21.205	–4.433	134.481	178.807	74.947	77.906	–38.1183	100
200	22.605	–2.233	149.671	160.834	77.147	78.642	–17.7001	200
298.15	22.747	0.000	158.752	158.752	79.380	79.380	–10.9108	298.15
300	22.743	0.042	158.893	158.752	79.422	79.393	–10.8251	300
400	22.432	2.302	165.396	159.641	81.682	80.043	–7.3561	400
500	22.101	4.528	170.365	161.309	83.908	80.587	–5.2588	500
600	21.833	6.724	174.370	163.163	86.104	81.046	–3.8519	600
700	21.629	8.897	177.719	165.009	88.277	81.442	–2.8415	700
800	21.475	11.052	180.597	166.782	90.432	81.792	–2.0803	800
900	21.357	13.193	183.119	168.460	92.573	82.106	–1.4858	900
1000	21.266	15.324	185.364	170.040	94.704	82.391	–1.0085	1000
1100	21.195	17.447	187.388	171.527	96.827	82.654	–0.6166	1100
1200	21.138	19.563	189.229	172.926	98.943	82.897	–0.2891	1200
1300	21.092	21.675	190.919	174.246	101.055	83.123	–0.0112	1300
1400	21.054	23.782	192.481	175.494	103.162	83.335	0.2277	1400
1500	21.023	25.886	193.932	176.675	105.266	83.532	0.4352	1500
1600	20.996	27.987	195.288	177.797	107.367	83.718	0.6172	1600
1700	20.974	30.085	196.560	178.863	109.465	83.892	0.7781	1700
1800	20.956	32.182	197.759	179.880	111.562	84.057	0.9215	1800
1900	20.939	34.276	198.891	180.851	113.656	84.213	1.0500	1900
2000	20.925	36.370	199.965	181.780	115.750	84.362	1.1659	2000
2100	20.913	38.462	200.986	182.671	117.842	84.505	1.2708	2100
2200	20.903	40.552	201.958	183.525	119.932	84.645	1.3665	2200
2300	20.893	42.642	202.887	184.347	122.022	84.783	1.4539	2300
2400	20.885	44.731	203.776	185.138	124.111	84.921	1.5342	2400
2500	20.878	46.819	204.629	185.901	126.199	85.061	1.6082	2500
2600	20.871	48.907	205.447	186.637	128.287	85.206	1.6766	2600
2700	20.865	50.993	206.235	187.349	130.373	85.356	1.7401	2700
2800	20.860	53.080	206.994	188.037	132.460	85.514	1.7991	2800
2900	20.855	55.165	207.726	188.703	134.545	85.682	1.8542	2900
3000	20.851	57.251	208.433	189.349	136.631	85.861	1.9056	3000
3100	20.847	59.336	209.116	189.976	138.716	86.052	1.9539	3100
3200	20.843	61.420	209.778	190.584	140.800	86.256	1.9993	3200
3300	20.840	63.504	210.419	191.176	142.884	86.476	2.0420	3300
3400	20.837	65.588	211.041	191.751	144.968	86.710	2.0823	3400
3500	20.834	67.672	211.645	192.311	147.052	86.961	2.1204	3500
3600	20.832	69.755	212.232	192.856	149.135	87.229	2.1565	3600
3700	20.829	71.838	212.803	193.387	151.218	87.513	2.1908	3700
3800	20.827	73.921	213.358	193.906	153.301	87.815	2.2234	3800
3900	20.825	76.003	213.899	194.411	155.383	88.135	2.2544	3900
4000	20.823	78.086	214.427	194.905	157.466	88.472	2.2839	4000
4100	20.822	80.168	214.941	195.388	159.548	88.827	2.3122	4100
4200	20.820	82.250	215.443	195.859	161.630	89.199	2.3392	4200
4300	20.818	84.332	215.932	196.320	163.712	89.589	2.3650	4300
4400	20.817	86.414	216.411	196.772	165.794	89.995	2.3898	4400
4500	20.816	88.495	216.879	197.213	167.875	90.419	2.4136	4500

TABLE A45.—THERMODYNAMIC PROPERTIES FOR F (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.814	90.577	217.336	197.646	169.957	90.860	2.4365	4600
4700	20.813	92.658	217.784	198.069	172.038	91.316	2.4585	4700
4800	20.812	94.740	218.222	198.485	174.120	91.789	2.4797	4800
4900	20.811	96.821	218.651	198.892	176.201	92.278	2.5001	4900
5000	20.810	98.902	219.072	199.291	178.282	92.781	2.5198	5000
5100	20.809	100.983	219.484	199.683	180.363	93.300	2.5389	5100
5200	20.808	103.064	219.888	200.068	182.444	93.833	2.5573	5200
5300	20.808	105.145	220.284	200.446	184.525	94.380	2.5751	5300
5400	20.807	107.225	220.673	200.817	186.605	94.940	2.5924	5400
5500	20.806	109.306	221.055	201.181	188.686	95.514	2.6092	5500
5600	20.805	111.387	221.430	201.539	190.767	96.101	2.6254	5600
5700	20.805	113.467	221.798	201.892	192.847	96.700	2.6412	5700
5800	20.804	115.547	222.160	202.238	194.927	97.311	2.6565	5800
5900	20.804	117.628	222.516	202.579	197.008	97.934	2.6714	5900
6000	20.803	119.708	222.865	202.914	199.088	98.567	2.6859	6000
6200	20.802	123.869	223.547	203.568	203.249			6200
6400	20.801	128.029	224.208	204.203	207.409			6400
6600	20.800	132.189	224.848	204.819	211.569			6600
6800	20.799	136.349	225.469	205.417	215.729			6800
7000	20.799	140.509	226.072	205.999	219.889			7000
7200	20.798	144.669	226.658	206.565	224.049			7200
7400	20.797	148.828	227.227	207.115	228.208			7400
7600	20.797	152.988	227.782	207.652	232.368			7600
7800	20.796	157.147	228.322	208.175	236.527			7800
8000	20.796	161.306	228.849	208.685	240.686			8000
8500	20.795	171.704	230.109	209.909	251.084			8500
9000	20.795	182.101	231.298	211.065	261.481			9000
9500	20.795	192.498	232.422	212.159	271.878			9500
10000	20.796	202.896	233.489	213.199	282.276			10000
10500	20.802	213.268	234.501	214.189	292.648			10500
11000	20.815	223.672	235.469	215.135	303.052			11000
11500	20.831	234.083	236.394	216.039	313.463			11500
12000	20.851	244.504	237.281	216.906	323.884			12000
12500	20.875	254.935	238.133	217.738	334.315			12500
13000	20.906	265.380	238.952	218.538	344.760			13000
13500	20.944	275.842	239.742	219.309	355.222			13500
14000	20.992	286.325	240.504	220.053	365.705			14000
14500	21.051	296.836	241.242	220.771	376.216			14500
15000	21.124	307.378	241.957	221.465	386.758			15000
15500	21.213	317.963	242.651	222.137	397.343			15500
16000	21.319	328.595	243.326	222.789	407.975			16000
16500	21.444	339.284	243.984	223.421	418.664			16500
17000	21.590	350.043	244.626	224.035	429.423			17000
17500	21.758	360.877	245.254	224.633	440.257			17500
18000	21.949	371.804	245.870	225.214	451.184			18000
18500	22.165	382.831	246.474	225.781	462.211			18500
19000	22.406	393.974	247.068	226.333	473.354			19000
19500	22.672	405.241	247.654	226.872	484.621			19500
20000	22.963	416.649	248.232	227.399	496.029			20000

TABLE A46.—THERMODYNAMIC PROPERTIES FOR F^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.711	----------	----------	1760.106	1758.321	----------	0
298.15	23.497	0.000	161.730	161.730	1766.816	1766.816	–305.2838	298.15
300	23.487	0.043	161.875	161.730	1766.860	1766.869	–303.3750	300
400	22.904	2.363	168.553	162.645	1769.179	1769.658	–226.4118	400
500	22.404	4.627	173.607	164.352	1771.444	1772.318	–180.1618	500
600	22.036	6.848	177.658	166.244	1773.665	1774.880	–149.2827	600
700	21.770	9.038	181.033	168.122	1775.854	1777.373	–127.1946	700
800	21.577	11.205	183.927	169.921	1778.021	1779.813	–110.6055	800
900	21.433	13.355	186.460	171.621	1780.171	1782.214	–97.6852	900
1000	21.325	15.493	188.712	173.219	1782.309	1784.585	–87.3352	1000
1100	21.241	17.621	190.740	174.722	1784.437	1786.931	–78.8557	1100
1200	21.174	19.741	192.586	176.135	1786.558	1789.257	–71.7801	1200
1300	21.121	21.856	194.278	177.466	1788.672	1791.565	–65.7854	1300
1400	21.079	23.966	195.842	178.723	1790.782	1793.858	–60.6405	1400
1500	21.043	26.072	197.295	179.914	1792.888	1796.137	–56.1759	1500
1600	21.014	28.175	198.652	181.043	1794.991	1798.403	–52.2644	1600
1700	20.989	30.275	199.925	182.117	1797.091	1800.658	–48.8087	1700
1800	20.969	32.373	201.125	183.140	1799.189	1802.902	–45.7331	1800
1900	20.951	34.469	202.258	184.116	1801.285	1805.138	–42.9779	1900
2000	20.936	36.563	203.332	185.050	1803.379	1807.367	–40.4951	2000
2100	20.923	38.656	204.353	185.946	1805.472	1809.590	–38.2461	2100
2200	20.912	40.748	205.326	186.805	1807.564	1811.809	–36.1989	2200
2300	20.902	42.838	206.256	187.630	1809.655	1814.026	–34.3275	2300
2400	20.894	44.928	207.145	188.425	1811.744	1816.244	–32.6099	2400
2500	20.888	47.017	207.998	189.191	1813.834	1818.464	–31.0278	2500
2600	20.883	49.106	208.817	189.930	1815.922	1820.688	–29.5656	2600
2700	20.879	51.194	209.605	190.644	1818.010	1822.918	–28.2101	2700
2800	20.877	53.282	210.364	191.335	1820.098	1825.156	–26.9499	2800
2900	20.876	55.369	211.097	192.004	1822.185	1827.405	–25.7751	2900
3000	20.876	57.457	211.804	192.652	1824.273	1829.664	–24.6773	3000
3100	20.879	59.544	212.489	193.281	1826.361	1831.937	–23.6490	3100
3200	20.882	61.633	213.152	193.892	1828.449	1834.224	–22.6838	3200
3300	20.888	63.721	213.795	194.485	1830.537	1836.526	–21.7760	3300
3400	20.895	65.810	214.418	195.062	1832.626	1838.845	–20.9205	3400
3500	20.904	67.900	215.024	195.624	1834.716	1841.181	–20.1128	3500
3600	20.914	69.991	215.613	196.171	1836.807	1843.534	–19.3491	3600
3700	20.927	72.083	216.186	196.704	1838.899	1845.906	–18.6257	3700
3800	20.941	74.176	216.745	197.224	1840.993	1848.297	–17.9395	3800
3900	20.957	76.271	217.289	197.732	1843.088	1850.708	–17.2876	3900
4000	20.974	78.368	217.820	198.228	1845.184	1853.138	–16.6676	4000
4100	20.993	80.466	218.338	198.712	1847.282	1855.587	–16.0770	4100
4200	21.014	82.566	218.844	199.185	1849.383	1858.056	–15.5137	4200
4300	21.037	84.669	219.339	199.648	1851.485	1860.546	–14.9760	4300
4400	21.061	86.774	219.822	200.101	1853.590	1863.054	–14.4620	4400
4500	21.086	88.881	220.296	200.545	1855.698	1865.582	–13.9702	4500
4600	21.113	90.991	220.760	200.979	1857.808	1868.130	–13.4991	4600
4700	21.142	93.104	221.214	201.405	1859.920	1870.696	–13.0475	4700
4800	21.171	95.220	221.660	201.822	1862.036	1873.282	–12.6141	4800
4900	21.202	97.338	222.096	202.231	1864.155	1875.887	–12.1978	4900
5000	21.234	99.460	222.525	202.633	1866.276	1878.510	–11.7975	5000

TABLE A46.—THERMODYNAMIC PROPERTIES FOR F^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.267	101.585	222.946	203.027	1868.401	1881.151	–11.4125	5100
5200	21.301	103.714	223.359	203.414	1870.530	1883.810	–11.0417	5200
5300	21.335	105.845	223.765	203.794	1872.662	1886.487	–10.6845	5300
5400	21.371	107.981	224.164	204.168	1874.797	1889.180	–10.3399	5400
5500	21.407	110.120	224.557	204.535	1876.936	1891.891	–10.0074	5500
5600	21.444	112.262	224.943	204.896	1879.078	1894.618	–9.6863	5600
5700	21.481	114.408	225.323	205.251	1881.225	1897.362	–9.3761	5700
5800	21.518	116.558	225.697	205.600	1883.375	1900.121	–9.0761	5800
5900	21.556	118.712	226.065	205.944	1885.528	1902.896	–8.7858	5900
6000	21.594	120.869	226.427	206.283	1887.686	1905.685	–8.5049	6000
6200	21.671	125.196	227.137	206.944	1892.012			6200
6400	21.748	129.538	227.826	207.586	1896.354			6400
6600	21.824	133.895	228.496	208.209	1900.711			6600
6800	21.900	138.267	229.149	208.816	1905.084			6800
7000	21.975	142.655	229.785	209.406	1909.471			7000
7200	22.048	147.057	230.405	209.980	1913.874			7200
7400	22.119	151.474	231.010	210.541	1918.290			7400
7600	22.189	155.905	231.601	211.087	1922.721			7600
7800	22.256	160.349	232.178	211.621	1927.166			7800
8000	22.320	164.807	232.742	212.142	1931.623			8000
8500	22.471	176.005	234.100	213.394	1942.822			8500
9000	22.605	187.275	235.388	214.580	1954.091			9000
9500	22.722	198.607	236.614	215.708	1965.424			9500
10000	22.822	209.994	237.782	216.783	1976.810			10000
10500	22.906	221.426	238.897	217.809	1988.243			10500
11000	22.976	232.897	239.965	218.792	1999.714			11000
11500	23.032	244.400	240.987	219.735	2011.216			11500
12000	23.075	255.927	241.969	220.641	2022.743			12000
12500	23.108	267.473	242.911	221.513	2034.290			12500
13000	23.131	279.034	243.818	222.354	2045.850			13000
13500	23.146	290.603	244.691	223.165	2057.419			13500
14000	23.152	302.178	245.533	223.949	2068.994			14000
14500	23.153	313.754	246.346	224.707	2080.571			14500
15000	23.147	325.330	247.130	225.442	2092.146			15000
15500	23.137	336.901	247.889	226.154	2103.717			15500
16000	23.122	348.466	248.624	226.845	2115.282			16000
16500	23.104	360.022	249.335	227.515	2126.838			16500
17000	23.083	371.569	250.024	228.167	2138.385			17000
17500	23.059	383.105	250.693	228.801	2149.921			17500
18000	23.034	394.628	251.342	229.419	2161.444			18000
18500	23.007	406.139	251.973	230.020	2172.955			18500
19000	22.980	417.635	252.586	230.605	2184.452			19000
19500	22.952	429.118	253.183	231.177	2195.935			19500
20000	22.923	440.587	253.764	231.734	2207.403			20000

TABLE A47.—THERMODYNAMIC PROPERTIES FOR F^-

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–261.289	–250.680	----------	0
298.15	20.786	0.000	145.578	145.578	–255.092	–255.092	45.9019	298.15
300	20.786	0.038	145.706	145.578	–255.054	–255.121	45.6263	300
400	20.786	2.117	151.686	146.393	–252.975	–256.731	34.4900	400
500	20.786	4.196	156.324	147.933	–250.896	–258.414	27.7649	500
600	20.786	6.274	160.114	149.657	–248.818	–260.151	23.2515	600
700	20.786	8.353	163.318	151.386	–246.739	–261.927	20.0057	700
800	20.786	10.432	166.094	153.055	–244.660	–263.732	17.5546	800
900	20.786	12.510	168.542	154.642	–242.582	–265.559	15.6349	900
1000	20.786	14.589	170.732	156.144	–240.503	–267.405	14.0885	1000
1100	20.786	16.667	172.714	157.561	–238.425	–269.265	12.8145	1100
1200	20.786	18.746	174.522	158.900	–236.346	–271.139	11.7454	1200
1300	20.786	20.825	176.186	160.167	–234.267	–273.024	10.8345	1300
1400	20.786	22.903	177.726	161.367	–232.189	–274.919	10.0483	1400
1500	20.786	24.982	179.161	162.506	–230.110	–276.825	9.3621	1500
1600	20.786	27.061	180.502	163.589	–228.031	–278.741	8.7576	1600
1700	20.786	29.139	181.762	164.621	–225.953	–280.665	8.2205	1700
1800	20.786	31.218	182.950	165.607	–223.874	–282.597	7.7398	1800
1900	20.786	33.296	184.074	166.550	–221.796	–284.535	7.3068	1900
2000	20.786	35.375	185.140	167.453	–219.717	–286.480	6.9144	2000
2100	20.786	37.454	186.155	168.319	–217.638	–288.428	6.5569	2100
2200	20.786	39.532	187.121	169.152	–215.560	–290.379	6.2297	2200
2300	20.786	41.611	188.045	169.954	–213.481	–292.332	5.9290	2300
2400	20.786	43.690	188.930	170.726	–211.402	–294.283	5.6514	2400
2500	20.786	45.768	189.779	171.471	–209.324	–296.230	5.3944	2500
2600	20.786	47.847	190.594	172.191	–207.245	–298.173	5.1556	2600
2700	20.786	49.926	191.378	172.887	–205.167	–300.110	4.9330	2700
2800	20.786	52.004	192.134	173.561	–203.088	–302.038	4.7250	2800
2900	20.786	54.083	192.864	174.215	–201.009	–303.956	4.5301	2900
3000	20.786	56.161	193.568	174.848	–198.931	–305.862	4.3470	3000
3100	20.786	58.240	194.250	175.463	–196.852	–307.756	4.1747	3100
3200	20.786	60.319	194.910	176.060	–194.773	–309.636	4.0122	3200
3300	20.786	62.397	195.550	176.641	–192.695	–311.500	3.8586	3300
3400	20.786	64.476	196.170	177.207	–190.616	–313.350	3.7131	3400
3500	20.786	66.555	196.773	177.757	–188.538	–315.182	3.5752	3500
3600	20.786	68.633	197.358	178.293	–186.459	–316.998	3.4442	3600
3700	20.786	70.712	197.928	178.816	–184.380	–318.797	3.3195	3700
3800	20.786	72.790	198.482	179.327	–182.302	–320.578	3.2008	3800
3900	20.786	74.869	199.022	179.825	–180.223	–322.341	3.0875	3900
4000	20.786	76.948	199.548	180.311	–178.144	–324.086	2.9792	4000
4100	20.786	79.026	200.062	180.787	–176.066	–325.813	2.8757	4100
4200	20.786	81.105	200.562	181.252	–173.987	–327.523	2.7767	4200
4300	20.786	83.184	201.052	181.707	–171.909	–329.215	2.6817	4300
4400	20.786	85.262	201.529	182.152	–169.830	–330.890	2.5906	4400
4500	20.786	87.341	201.997	182.587	–167.751	–332.549	2.5031	4500
4600	20.786	89.419	202.453	183.014	–165.673	–334.190	2.4189	4600
4700	20.786	91.498	202.900	183.433	–163.594	–335.814	2.3380	4700
4800	20.786	93.577	203.338	183.843	–161.515	–337.423	2.2601	4800
4900	20.786	95.655	203.767	184.245	–159.437	–339.015	2.1850	4900
5000	20.786	97.734	204.187	184.640	–157.358	–340.593	2.1125	5000

TABLE A47.—THERMODYNAMIC PROPERTIES FOR F^- (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	204.598	185.027	–155.279	–342.155	2.0426	5100
5200	20.786	101.891	205.002	185.407	–153.201	–343.703	1.9751	5200
5300	20.786	103.970	205.398	185.781	–151.122	–345.237	1.9097	5300
5400	20.786	106.048	205.786	186.148	–149.044	–346.757	1.8466	5400
5500	20.786	108.127	206.168	186.508	–146.965	–348.264	1.7855	5500
5600	20.786	110.206	206.542	186.863	–144.886	–349.758	1.7263	5600
5700	20.786	112.284	206.910	187.211	–142.808	–351.239	1.6689	5700
5800	20.786	114.363	207.272	187.554	–140.729	–352.709	1.6133	5800
5900	20.786	116.442	207.627	187.891	–138.650	–354.166	1.5594	5900
6000	20.786	118.520	207.976	188.223	–136.572	–355.613	1.5070	6000
6200	20.786	122.677	208.658	188.871	–132.415			6200
6400	20.786	126.835	209.318	189.500	–128.257			6400
6600	20.786	130.992	209.958	190.110	–124.100			6600
6800	20.786	135.149	210.578	190.703	–119.943			6800
7000	20.786	139.306	211.181	191.280	–115.786			7000
7200	20.786	143.464	211.766	191.841	–111.628			7200
7400	20.786	147.621	212.336	192.387	–107.471			7400
7600	20.786	151.778	212.890	192.919	–103.314			7600
7800	20.786	155.936	213.430	193.438	–99.157			7800
8000	20.786	160.093	213.956	193.945	–94.999			8000
8500	20.786	170.486	215.216	195.159	–84.606			8500
9000	20.786	180.879	216.405	196.307	–74.213			9000
9500	20.786	191.272	217.528	197.394	–63.820			9500
10000	20.786	201.665	218.595	198.428	–53.427			10000
10500	20.786	212.058	219.609	199.413	–43.034			10500
11000	20.786	222.452	220.576	200.353	–32.640			11000
11500	20.786	232.845	221.500	201.252	–22.247			11500
12000	20.786	243.238	222.384	202.115	–11.854			12000
12500	20.786	253.631	223.233	202.942	–1.461			12500
13000	20.786	264.024	224.048	203.739	8.932			13000
13500	20.786	274.417	224.833	204.505	19.325			13500
14000	20.786	284.810	225.589	205.245	29.718			14000
14500	20.786	295.204	226.318	205.959	40.111			14500
15000	20.786	305.597	227.023	206.650	50.505			15000
15500	20.786	315.990	227.704	207.318	60.898			15500
16000	20.786	326.383	228.364	207.965	71.291			16000
16500	20.786	336.776	229.004	208.593	81.684			16500
17000	20.786	347.169	229.624	209.203	92.077			17000
17500	20.786	357.562	230.227	209.795	102.470			17500
18000	20.786	367.956	230.812	210.370	112.863			18000
18500	20.786	378.349	231.382	210.931	123.257			18500
19000	20.786	388.742	231.936	211.476	133.650			19000
19500	20.786	399.135	232.476	212.008	144.043			19500
20000	20.786	409.528	233.003	212.526	154.436			20000

TABLE A48.—THERMODYNAMIC PROPERTIES FOR Fe

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.850	----------	----------	408.621	413.128	----------	0
100	21.387	–4.762	154.702	202.320	410.709	414.793	–208.8965	100
200	24.362	–2.472	170.452	182.811	412.999	415.314	–100.5005	200
298.15	25.675	0.000	180.490	180.490	415.471	415.471	–64.7864	298.15
300	25.682	0.048	180.649	180.490	415.519	415.473	–64.3376	300
400	25.533	2.616	188.038	181.499	418.087	415.413	–46.2534	400
500	24.889	5.138	193.670	183.393	420.609	415.082	–35.4075	500
600	24.203	7.592	198.146	185.492	423.063	414.450	–28.1852	600
700	23.610	9.982	201.831	187.571	425.453	413.514	–23.0361	700
800	23.133	12.318	204.951	189.553	427.789	412.236	–19.1845	800
900	22.764	14.612	207.653	191.418	430.083	410.501	–16.1995	900
1000	22.489	16.874	210.037	193.163	432.345	408.016	–13.8236	1000
*1100	22.298	19.113	212.171	194.795	434.584	404.612	–11.8946	1100
*1200	22.183	21.336	214.105	196.325	436.807	401.745	–10.2982	1200
1300	22.138	23.552	215.879	197.762	439.023	400.518	–8.9550	1300
1400	22.156	25.766	217.520	199.115	441.237	399.204	–7.8074	1400
1500	22.231	27.985	219.050	200.394	443.456	397.813	–6.8161	1500
1600	22.356	30.214	220.489	201.605	445.685	396.347	–5.9519	1600
*1700	22.523	32.457	221.849	202.757	447.928	393.862	–5.1928	1700
1800	22.726	34.720	223.142	203.853	450.191	391.928	–4.5220	1800
*1900	22.959	37.004	224.377	204.901	452.475	375.834	–3.9442	1900
2000	23.213	39.312	225.561	205.905	454.783	373.540	–3.4292	2000
2100	23.486	41.647	226.700	206.868	457.118	371.273	–2.9660	2100
2200	23.770	44.010	227.799	207.795	459.481	369.033	–2.5475	2200
2300	24.064	46.401	228.862	208.688	461.872	366.822	–2.1677	2300
2400	24.364	48.823	229.893	209.550	464.294	364.641	–1.8216	2400
2500	24.667	51.274	230.893	210.384	466.745	362.490	–1.5051	2500
2600	24.973	53.756	231.867	211.191	469.227	360.370	–1.2146	2600
2700	25.281	56.269	232.815	211.975	471.740	358.280	–0.9473	2700
2800	25.589	58.812	233.740	212.736	474.283	356.221	–0.7004	2800
2900	25.899	61.387	234.643	213.476	476.858	354.193	–0.4719	2900
3000	26.210	63.992	235.527	214.196	479.463	352.196	–0.2599	3000
3100	26.524	66.629	236.391	214.898	482.100	350.231	–0.0626	3100
3200	26.842	69.297	237.238	215.583	484.768	348.296	0.1213	3200
3300	27.163	71.997	238.069	216.252	487.468	346.394	0.2931	3300
3400	27.489	74.730	238.885	216.906	490.201	344.524	0.4539	3400
3500	27.821	77.495	239.687	217.545	492.966	342.687	0.6047	3500
3600	28.160	80.294	240.475	218.171	495.765	340.884	0.7464	3600
3700	28.506	83.128	241.251	218.784	498.599	339.115	0.8798	3700
3800	28.861	85.996	242.016	219.386	501.467	337.381	1.0054	3800
3900	29.223	88.900	242.771	219.976	504.371	335.682	1.1240	3900
4000	29.594	91.841	243.515	220.555	507.312	334.021	1.2362	4000
4100	29.974	94.819	244.250	221.124	510.290	332.397	1.3423	4100
4200	30.362	97.836	244.977	221.683	513.307	330.811	1.4429	4200
4300	30.759	100.892	245.696	222.233	516.363	329.265	1.5383	4300
4400	31.165	103.988	246.408	222.775	519.459	327.758	1.6290	4400
4500	31.579	107.125	247.113	223.308	522.596	326.293	1.7153	4500

TABLE A48.—THERMODYNAMIC PROPERTIES FOR Fe (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	32.001	110.304	247.812	223.833	525.775	324.870	1.7975	4600
4700	32.430	113.525	248.505	224.350	528.996	323.489	1.8758	4700
4800	32.867	116.790	249.192	224.861	532.261	322.151	1.9505	4800
4900	33.310	120.099	249.874	225.364	535.570	320.857	2.0219	4900
5000	33.759	123.452	250.552	225.861	538.923	319.608	2.0902	5000
5100	34.214	126.850	251.225	226.352	542.321	318.404	2.1555	5100
5200	34.674	130.294	251.893	226.837	545.765	317.245	2.2181	5200
5300	35.140	133.784	252.558	227.316	549.255	316.133	2.2782	5300
5400	35.610	137.321	253.219	227.789	552.792	315.068	2.3357	5400
5500	36.085	140.905	253.877	228.258	556.376	314.049	2.3911	5500
5600	36.562	144.536	254.531	228.721	560.007	313.077	2.4442	5600
5700	37.044	148.214	255.182	229.179	563.685	312.154	2.4954	5700
5800	37.528	151.941	255.830	229.633	567.412	311.278	2.5446	5800
5900	38.016	155.716	256.475	230.083	571.187	310.450	2.5921	5900
6000	38.503	159.537	257.117	230.528	575.008	309.669	2.6378	6000
6200	39.485	167.326	258.394	231.406	582.797			6200
6400	40.470	175.307	259.661	232.269	590.778			6400
6600	41.441	183.472	260.917	233.118	598.943			6600
6800	42.396	191.818	262.162	233.953	607.289			6800
7000	43.335	200.344	263.397	234.776	615.815			7000
7200	44.221	209.024	264.619	235.588	624.495			7200
7400	45.199	217.998	265.850	236.391	633.469			7400
7600	46.077	227.127	267.067	237.182	642.598			7600
7800	46.880	236.424	268.275	237.964	651.895			7800
8000	47.601	245.874	269.471	238.737	661.345			8000
8500	49.030	270.054	272.402	240.631	685.525			8500
9000	49.929	294.816	275.233	242.475	710.287			9000
9500	50.335	319.901	277.945	244.271	735.372			9500
10000	50.308	345.078	280.528	246.020	760.549			10000
10500	49.915	370.147	282.974	247.722	785.618			10500
11000	49.224	394.944	285.281	249.377	810.415			11000
11500	48.299	419.332	287.450	250.986	834.803			11500
12000	47.198	443.213	289.483	252.548	858.684			12000
12500	45.972	466.509	291.385	254.064	881.980			12500
13000	44.666	489.172	293.163	255.534	904.643			13000
13500	43.317	511.168	294.823	256.959	926.639			13500
14000	41.957	532.486	296.374	258.339	947.957			14000
14500	40.612	553.127	297.823	259.676	968.598			14500
15000	39.303	573.104	299.177	260.970	988.575			15000
15500	38.045	592.440	300.445	262.224	1007.911			15500
16000	36.851	611.160	301.634	263.437	1026.631			16000
16500	35.728	629.302	302.751	264.611	1044.773			16500
17000	34.681	646.901	303.802	265.749	1062.372			17000
17500	33.713	663.996	304.793	266.850	1079.467			17500
18000	32.823	680.627	305.730	267.917	1096.098			18000
18500	32.009	696.832	306.618	268.951	1112.303			18500
19000	31.267	712.648	307.462	269.954	1128.119			19000
19500	30.591	728.110	308.265	270.926	1143.581			19500
20000	29.973	743.248	309.031	271.869	1158.719			20000

TABLE A49.—THERMODYNAMIC PROPERTIES FOR Fe^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.936	----------	----------	1177.282	1175.592	----------	0
298.15	26.068	0.000	181.858	181.858	1184.218	1184.218	–198.2970	298.15
300	26.076	0.048	182.020	181.859	1184.266	1184.259	–197.0177	300
400	26.112	2.662	189.540	182.884	1186.880	1186.323	–145.4281	400
500	25.932	5.264	195.347	184.818	1189.482	1188.151	–114.4226	500
600	25.831	7.852	200.064	186.978	1192.069	1189.731	–93.7224	600
700	25.802	10.433	204.043	189.139	1194.651	1191.065	–78.9181	700
800	25.786	13.012	207.488	191.222	1197.230	1192.109	–67.8037	800
900	25.744	15.589	210.523	193.201	1199.807	1192.735	–59.1529	900
1000	25.661	18.160	213.231	195.071	1202.378	1192.638	–52.2304	1000
*1100	25.540	20.720	215.672	196.835	1204.938	1191.634	–46.5701	1100
*1200	25.391	23.267	217.888	198.499	1207.485	1191.169	–41.8549	1200
1300	25.225	25.798	219.914	200.069	1210.016	1192.335	–37.8645	1300
1400	25.054	28.312	221.777	201.554	1212.530	1193.400	–34.4410	1400
1500	24.886	30.809	223.499	202.960	1215.027	1194.365	–31.4715	1500
1600	24.726	33.289	225.100	204.295	1217.507	1195.230	–28.8712	1600
*1700	24.579	35.754	226.595	205.563	1219.972	1195.045	–26.5758	1700
1800	24.447	38.205	227.996	206.771	1222.423	1195.378	–24.5355	1800
*1900	24.330	40.644	229.315	207.923	1224.862	1181.518	–22.7290	1900
2000	24.230	43.072	230.560	209.024	1227.290	1181.422	–21.1050	2000
2100	24.144	45.491	231.740	210.078	1229.708	1181.317	–19.6358	2100
2200	24.074	47.901	232.861	211.088	1232.119	1181.204	–18.3002	2200
2300	24.018	50.306	233.930	212.058	1234.524	1181.085	–17.0810	2300
2400	23.975	52.705	234.952	212.991	1236.923	1180.960	–15.9634	2400
2500	23.945	55.101	235.930	213.889	1239.319	1180.833	–14.9354	2500
2600	23.927	57.495	236.868	214.755	1241.713	1180.702	–13.9865	2600
2700	23.921	59.887	237.771	215.591	1244.105	1180.571	–13.1080	2700
2800	23.925	62.279	238.641	216.399	1246.497	1180.439	–12.2924	2800
2900	23.941	64.673	239.481	217.180	1248.890	1180.309	–11.5331	2900
3000	23.967	67.068	240.293	217.937	1251.286	1180.180	–10.8245	3000
3100	24.003	69.466	241.079	218.671	1253.684	1180.055	–10.1617	3100
3200	24.049	71.869	241.842	219.383	1256.087	1179.934	–9.5404	3200
3300	24.105	74.276	242.583	220.075	1258.494	1179.817	–8.9568	3300
3400	24.170	76.690	243.304	220.748	1260.908	1179.707	–8.4076	3400
3500	24.245	79.111	244.005	221.402	1263.329	1179.604	–7.8898	3500
3600	24.330	81.539	244.690	222.040	1265.757	1179.509	–7.4008	3600
3700	24.423	83.977	245.357	222.661	1268.195	1179.423	–6.9383	3700
3800	24.526	86.424	246.010	223.267	1270.642	1179.346	–6.5001	3800
3900	24.637	88.882	246.649	223.858	1273.100	1179.281	–6.0845	3900
4000	24.756	91.352	247.274	224.436	1275.570	1179.227	–5.6896	4000
4100	24.883	93.834	247.887	225.000	1278.052	1179.185	–5.3140	4100
4200	25.019	96.329	248.488	225.552	1280.547	1179.156	–4.9564	4200
4300	25.161	98.838	249.078	226.093	1283.056	1179.141	–4.6153	4300
4400	25.311	101.361	249.658	226.622	1285.579	1179.141	–4.2898	4400
4500	25.467	103.900	250.229	227.140	1288.118	1179.156	–3.9787	4500
4600	25.629	106.455	250.790	227.648	1290.673	1179.187	–3.6812	4600
4700	25.798	109.026	251.343	228.146	1293.244	1179.235	–3.3963	4700
4800	25.971	111.615	251.888	228.635	1295.833	1179.299	–3.1233	4800
4900	26.149	114.221	252.426	229.115	1298.439	1179.381	–2.8614	4900
5000	26.332	116.845	252.956	229.587	1301.063	1179.482	–2.6099	5000

TABLE A49.—THERMODYNAMIC PROPERTIES FOR Fe^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	26.519	119.487	253.479	230.050	1303.705	1179.600	–2.3683	5100
5200	26.709	122.149	253.996	230.506	1306.366	1179.738	–2.1359	5200
5300	26.902	124.829	254.506	230.954	1309.047	1179.895	–1.9123	5300
5400	27.098	127.529	255.011	231.395	1311.747	1180.071	–1.6970	5400
5500	27.295	130.249	255.510	231.829	1314.467	1180.267	–1.4894	5500
5600	27.495	132.988	256.004	232.256	1317.206	1180.482	–1.2893	5600
5700	27.695	135.748	256.492	232.677	1319.966	1180.718	–1.0961	5700
5800	27.897	138.527	256.976	233.092	1322.745	1180.974	–0.9095	5800
5900	28.099	141.327	257.454	233.500	1325.545	1181.250	–0.7292	5900
6000	28.301	144.147	257.928	233.904	1328.365	1181.546	–0.5549	6000
6200	28.704	149.848	258.863	234.694	1334.065			6200
6400	29.102	155.628	259.780	235.463	1339.846			6400
6600	29.495	161.488	260.682	236.214	1345.706			6600
6800	29.879	167.426	261.568	236.947	1351.643			6800
7000	30.253	173.439	262.440	237.663	1357.657			7000
7200	30.616	179.526	263.297	238.363	1363.744			7200
7400	30.967	185.685	264.141	239.048	1369.903			7400
7600	31.304	191.912	264.971	239.719	1376.130			7600
7800	31.628	198.205	265.788	240.377	1382.423			7800
8000	31.937	204.562	266.593	241.023	1388.780			8000
8500	32.651	220.713	268.551	242.585	1404.931			8500
9000	33.284	237.200	270.436	244.080	1421.418			9000
9500	33.845	253.985	272.251	245.515	1438.203			9500
10000	34.351	271.036	274.000	246.896	1455.254			10000
10500	34.819	288.329	275.687	248.227	1472.547			10500
11000	35.267	305.850	277.317	249.513	1490.068			11000
11500	35.715	323.594	278.894	250.756	1507.812			11500
12000	36.183	341.565	280.424	251.960	1525.783			12000
12500	36.682	359.773	281.911	253.129	1543.991			12500
13000	37.232	378.242	283.359	254.264	1562.460			13000
13500	37.841	396.994	284.774	255.367	1581.212			13500
14000	38.507	416.047	286.160	256.442	1600.265			14000
14500	39.250	435.454	287.522	257.490	1619.671			14500
15000	40.058	455.229	288.862	258.514	1639.447			15000
15500	40.917	475.388	290.184	259.513	1659.606			15500
16000	41.821	495.954	291.489	260.492	1680.171			16000
16500	42.772	516.966	292.781	261.450	1701.184			16500
17000	43.753	538.432	294.061	262.389	1722.650			17000
17500	44.674	560.194	295.321	263.309	1744.412			17500
18000	45.628	582.466	296.573	264.214	1766.683			18000
18500	46.560	605.160	297.814	265.103	1789.378			18500
19000	47.394	628.082	299.033	265.976	1812.300			19000
19500	48.188	651.384	300.239	266.835	1835.602			19500
20000	48.855	674.801	301.419	267.679	1859.019			20000

*Assigned reference element phase change at 1042 K, 1184 K, 1665 K, and 1809 K

TABLE A50.—THERMODYNAMIC PROPERTIES FOR Fe^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.642	----------	----------	386.696	397.401	----------	0
298.15	25.023	0.000	180.200	180.200	393.338	393.338	–62.0199	298.15
300	25.047	0.046	180.355	180.200	393.384	393.300	–61.5950	300
400	25.748	2.595	187.683	181.195	395.933	391.142	–44.5175	400
500	25.632	5.169	193.426	183.088	398.507	388.784	–34.3301	500
600	25.172	7.711	198.061	185.210	401.049	386.161	–27.5820	600
700	24.628	10.201	201.901	187.329	403.539	383.247	–22.7964	700
800	24.109	12.637	205.155	189.359	405.975	379.991	–19.2359	800
900	23.652	15.025	207.968	191.274	408.363	376.270	–16.4918	900
1000	23.264	17.370	210.439	193.069	410.708	371.790	–14.3201	1000
*1100	22.938	19.679	212.641	194.750	413.017	366.378	–12.5677	1100
*1200	22.666	21.959	214.624	196.325	415.297	361.489	–11.1265	1200
1300	22.438	24.214	216.429	197.803	417.552	358.222	–9.9214	1300
1400	22.246	26.448	218.085	199.194	419.786	354.850	–8.8980	1400
1500	22.084	28.664	219.614	200.505	422.002	351.377	–8.0197	1500
1600	21.947	30.866	221.035	201.744	424.204	347.805	–7.2587	1600
*1700	21.829	33.054	222.362	202.918	426.392	343.187	–6.5948	1700
1800	21.728	35.232	223.607	204.033	428.570	339.089	–6.0124	1800
*1900	21.640	37.400	224.779	205.095	430.738	320.801	–5.5169	1900
2000	21.563	39.561	225.887	206.107	432.899	316.280	–5.0790	2000
2100	21.497	41.713	226.937	207.074	435.051	311.752	–4.6884	2100
2200	21.438	43.860	227.936	208.000	437.198	307.218	–4.3385	2200
2300	21.386	46.001	228.888	208.887	439.339	302.678	–4.0237	2300
2400	21.340	48.138	229.797	209.740	441.476	298.133	–3.7394	2400
2500	21.299	50.269	230.667	210.560	443.607	293.584	–3.4818	2500
2600	21.262	52.397	231.502	211.349	445.736	289.031	–3.2477	2600
2700	21.229	54.522	232.304	212.110	447.860	284.475	–3.0343	2700
2800	21.200	56.643	233.075	212.846	449.981	279.915	–2.8393	2800
2900	21.173	58.762	233.819	213.556	452.100	275.353	–2.6607	2900
3000	21.149	60.878	234.536	214.243	454.216	270.788	–2.4967	3000
3100	21.126	62.992	235.229	214.909	456.330	266.221	–2.3459	3100
3200	21.106	65.103	235.900	215.555	458.442	261.651	–2.2069	3200
3300	21.088	67.213	236.549	216.181	460.551	257.080	–2.0786	3300
3400	21.071	69.321	237.178	216.790	462.659	252.507	–1.9600	3400
3500	21.055	71.427	237.789	217.381	464.765	247.932	–1.8502	3500
3600	21.041	73.532	238.382	217.956	466.870	243.356	–1.7483	3600
3700	21.028	75.636	238.958	218.516	468.974	238.778	–1.6538	3700
3800	21.016	77.738	239.519	219.061	471.076	234.199	–1.5659	3800
3900	21.004	79.839	240.064	219.593	473.177	229.619	–1.4842	3900
4000	20.994	81.939	240.596	220.111	475.277	225.038	–1.4080	4000
4100	20.984	84.038	241.114	220.617	477.376	220.456	–1.3371	4100
4200	20.975	86.135	241.620	221.111	479.473	215.873	–1.2709	4200
4300	20.966	88.233	242.113	221.594	481.571	211.289	–1.2091	4300
4400	20.958	90.329	242.595	222.066	483.667	206.704	–1.1514	4400
4500	20.951	92.424	243.066	222.527	485.762	202.119	–1.0975	4500
4600	20.944	94.519	243.526	222.979	487.857	197.532	–1.0471	4600
4700	20.938	96.613	243.977	223.421	489.951	192.945	–0.9999	4700
4800	20.931	98.707	244.418	223.854	492.045	188.358	–0.9558	4800
4900	20.926	100.799	244.849	224.278	494.137	183.770	–0.9144	4900
5000	20.920	102.892	245.272	224.693	496.230	179.181	–0.8757	5000

TABLE A50.—THERMODYNAMIC PROPERTIES FOR Fe^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.915	104.983	245.686	225.101	498.321	174.592	–0.8395	5100
5200	20.910	107.075	246.092	225.501	500.413	170.002	–0.8056	5200
5300	20.906	109.165	246.490	225.893	502.504	165.412	–0.7738	5300
5400	20.901	111.256	246.881	226.278	504.594	160.821	–0.7440	5400
5500	20.897	113.346	247.265	226.656	506.684	156.230	–0.7161	5500
5600	20.893	115.435	247.641	227.028	508.773	151.638	–0.6900	5600
5700	20.890	117.524	248.011	227.393	510.863	147.046	–0.6656	5700
5800	20.886	119.613	248.374	227.751	512.951	142.454	–0.6427	5800
5900	20.883	121.702	248.731	228.104	515.040	137.862	–0.6213	5900
6000	20.880	123.790	249.082	228.450	517.128	133.269	–0.6013	6000
6200	20.874	127.965	249.767	229.127	521.303			6200
6400	20.869	132.139	250.429	229.783	525.478			6400
6600	20.864	136.313	251.071	230.418	529.651			6600
6800	20.859	140.485	251.694	231.035	533.823			6800
7000	20.855	144.656	252.299	231.634	537.994			7000
7200	20.851	148.827	252.886	232.216	542.165			7200
7400	20.848	152.997	253.457	232.782	546.335			7400
7600	20.845	157.166	254.013	233.334	550.504			7600
7800	20.842	161.335	254.555	233.871	554.673			7800
8000	20.839	165.503	255.082	234.395	558.841			8000
8500	20.833	175.921	256.346	235.649	569.259			8500
9000	20.828	186.336	257.536	236.832	579.674			9000
9500	20.824	196.749	258.662	237.952	590.087			9500
10000	20.820	207.160	259.730	239.014	600.498			10000
10500	20.817	217.570	260.746	240.025	610.908			10500
11000	20.814	227.978	261.714	240.989	621.316			11000
11500	20.812	238.384	262.640	241.911	631.722			11500
12000	20.810	248.790	263.525	242.793	642.128			12000
12500	20.808	259.194	264.375	243.639	652.532			12500
13000	20.806	269.598	265.191	244.453	662.936			13000
13500	20.805	280.000	265.976	245.235	673.339			13500
14000	20.804	290.403	266.733	245.990	683.741			14000
14500	20.802	300.804	267.463	246.718	694.142			14500
15000	20.801	311.205	268.168	247.421	704.543			15000
15500	20.800	321.606	268.850	248.101	714.944			15500
16000	20.800	332.006	269.510	248.760	725.344			16000
16500	20.799	342.405	270.150	249.399	735.743			16500
17000	20.798	352.804	270.771	250.018	746.142			17000
17500	20.797	363.203	271.374	250.620	756.541			17500
18000	20.797	373.602	271.960	251.204	766.940			18000
18500	20.796	384.000	272.530	251.773	777.338			18500
19000	20.796	394.398	273.084	252.327	787.736			19000
19500	20.795	404.796	273.625	252.866	798.134			19500
20000	20.795	415.193	274.151	253.391	808.531			20000

*Assigned reference element phase change at 1042 K, 1184 K, 1665 K, and 1809 K

TABLE A51.—THERMODYNAMIC PROPERTIES FOR Ge

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	--------	–7.399	----------	----------	360.401	365.038	----------	0
100	21.314	–5.313	139.666	192.799	362.487	366.503	–184.6568	100
200	27.486	–2.894	156.180	170.649	364.906	367.108	–88.8767	200
298.15	30.733	0.000	167.909	167.909	367.800	367.800	–57.2889	298.15
300	30.757	0.057	168.099	167.910	367.857	367.814	–56.8915	300
400	31.072	3.162	177.029	169.125	370.962	368.535	–40.8670	400
500	30.361	6.238	183.897	171.421	374.038	369.146	–31.2344	500
600	29.266	9.221	189.339	173.970	377.021	369.608	–24.8031	600
700	28.102	12.089	193.762	176.492	379.889	369.909	–20.2045	700
800	27.029	14.845	197.443	178.887	382.645	370.059	–16.7535	800
900	26.108	17.500	200.572	181.127	385.300	370.073	–14.0687	900
1000	25.349	20.072	203.282	183.210	387.872	369.969	–11.9212	1000
1100	24.741	22.575	205.668	185.146	390.375	369.763	–10.1648	1100
1200	24.264	25.024	207.800	186.946	392.824	369.471	–8.7022	1200
*1300	23.898	27.432	209.727	188.626	395.232	332.088	–7.5744	1300
1400	23.625	29.807	211.487	190.197	397.607	331.704	–6.6219	1400
1500	23.426	32.159	213.110	191.671	399.959	331.296	–5.7973	1500
1600	23.288	34.494	214.617	193.058	402.294	330.871	–5.0768	1600
1700	23.197	36.818	216.026	194.368	404.618	330.435	–4.4418	1700
1800	23.143	39.135	217.350	195.609	406.935	329.992	–3.8781	1800
1900	23.117	41.448	218.601	196.786	409.248	329.544	–3.3745	1900
2000	23.113	43.759	219.786	197.907	411.559	329.096	–2.9218	2000
2100	23.123	46.071	220.914	198.976	413.871	328.647	–2.5128	2100
2200	23.144	48.384	221.990	199.998	416.184	328.201	–2.1415	2200
2300	23.171	50.700	223.020	200.977	418.500	327.756	–1.8029	2300
2400	23.202	53.018	224.007	201.916	420.818	327.315	–1.4930	2400
2500	23.234	55.340	224.954	202.818	423.140	326.877	–1.2082	2500
2600	23.266	57.665	225.866	203.687	425.465	326.442	–0.9457	2600
2700	23.297	59.993	226.745	204.525	427.793	326.010	–0.7030	2700
2800	23.326	62.324	227.593	205.334	430.124	325.581	–0.4779	2800
2900	23.352	64.658	228.412	206.116	432.458	325.155	–0.2686	2900
3000	23.374	66.995	229.204	206.872	434.795	324.731	–0.0735	3000
3100	23.393	69.333	229.971	207.605	437.133	324.310	0.1088	3100
3200	23.408	71.673	230.713	208.316	439.473	323.890	0.2795	3200
3300	23.420	74.015	231.434	209.005	441.815	323.471	0.4396	3300
3400	23.429	76.357	232.133	209.675	444.157	323.054	0.5901	3400
3500	23.434	78.700	232.812	210.327	446.500	322.637	0.7318	3500
3600	23.436	81.044	233.473	210.961	448.844	322.221	0.8654	3600
3700	23.436	83.387	234.115	211.578	451.187	321.804	0.9917	3700
3800	23.432	85.731	234.740	212.179	453.531	321.388	1.1112	3800
3900	23.427	88.074	235.348	212.765	455.874	320.971	1.2244	3900
4000	23.419	90.416	235.941	213.337	458.216	320.553	1.3318	4000
4100	23.409	92.757	236.520	213.896	460.557	320.134	1.4338	4100
4200	23.398	95.098	237.084	214.441	462.898	319.715	1.5309	4200
4300	23.386	97.437	237.634	214.974	465.237	319.294	1.6233	4300
4400	23.372	99.775	238.171	215.495	467.575	318.872	1.7113	4400
4500	23.358	102.112	238.697	216.005	469.912	318.448	1.7954	4500

TABLE A51.—THERMODYNAMIC PROPERTIES FOR Ge (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	23.344	104.447	239.210	216.504	472.247	318.023	1.8757	4600
4700	23.329	106.780	239.712	216.992	474.580	317.597	1.9525	4700
4800	23.314	109.112	240.203	217.471	476.912	317.169	2.0260	4800
4900	23.300	111.443	240.683	217.940	479.243	316.740	2.0964	4900
5000	23.286	113.772	241.154	218.399	481.572	316.309	2.1639	5000
5100	23.273	116.100	241.615	218.850	483.900	315.877	2.2286	5100
5200	23.261	118.427	242.067	219.292	486.227	315.444	2.2908	5200
5300	23.251	120.752	242.510	219.726	488.552	315.009	2.3505	5300
5400	23.243	123.077	242.944	220.152	490.877	314.574	2.4080	5400
5500	23.237	125.401	243.371	220.570	493.201	314.138	2.4633	5500
5600	23.234	127.725	243.789	220.981	495.525	313.702	2.5165	5600
5700	23.234	130.048	244.200	221.385	497.848	313.265	2.5678	5700
5800	23.236	132.371	244.604	221.782	500.171	312.828	2.6173	5800
5900	23.241	134.695	245.002	222.172	502.495	312.392	2.6650	5900
6000	23.251	137.020	245.392	222.556	504.820	311.956	2.7110	6000
6200	23.283	141.672	246.155	223.305	509.472			6200
6400	23.327	146.330	246.894	224.030	514.130			6400
6600	23.399	151.002	247.613	224.734	518.802			6600
6800	23.493	155.690	248.313	225.417	523.490			6800
7000	23.606	160.395	248.995	226.081	528.195			7000
7200	23.745	165.125	249.661	226.727	532.925			7200
7400	23.898	169.864	250.309	227.355	537.664			7400
7600	24.088	174.663	250.949	227.967	542.463			7600
7800	24.298	179.501	251.577	228.564	547.301			7800
8000	24.527	184.383	252.195	229.148	552.183			8000
8500	25.170	196.804	253.701	230.548	564.604			8500
9000	25.901	209.568	255.160	231.875	577.368			9000
9500	26.703	222.717	256.582	233.138	590.517			9500
10000	27.556	236.280	257.973	234.345	604.080			10000
10500	28.442	250.278	259.339	235.503	618.078			10500
11000	29.342	264.724	260.683	236.617	632.524			11000
11500	30.238	279.619	262.007	237.692	647.419			11500
12000	31.113	294.959	263.312	238.732	662.759			12000
12500	31.950	310.726	264.600	239.741	678.526			12500
13000	32.732	326.899	265.868	240.722	694.699			13000
13500	33.447	343.447	267.117	241.677	711.247			13500
14000	34.080	360.333	268.345	242.607	728.133			14000
14500	34.619	377.511	269.551	243.516	745.311			14500
15000	35.056	394.934	270.732	244.403	762.734			15000
15500	35.381	412.549	271.887	245.271	780.349			15500
16000	35.589	430.296	273.014	246.121	798.096			16000
16500	35.674	448.117	274.111	246.952	815.917			16500
17000	35.635	465.949	275.176	247.767	833.749			17000
17500	35.471	483.731	276.206	248.565	851.531			17500
18000	35.183	501.400	277.202	249.346	869.200			18000
18500	34.775	518.894	278.161	250.112	886.694			18500
19000	34.254	536.155	279.081	250.863	903.955			19000
19500	33.626	553.129	279.963	251.598	920.929			19500
20000	32.904	569.766	280.806	252.317	937.566			20000

***Assigned reference element phase change at 1211.4 K**

TABLE A52.—THERMODYNAMIC PROPERTIES FOR Ge^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	--------	–6.206	----------	----------	1128.779	1127.218	----------	0
298.15	21.025	0.000	168.093	168.093	1134.984	1134.984	–190.5876	298.15
300	21.035	0.039	168.223	168.094	1135.023	1135.019	–189.3614	300
400	21.944	2.182	174.382	168.927	1137.166	1136.857	–139.9203	400
500	23.382	4.446	179.428	170.536	1139.430	1138.734	–110.2069	500
600	24.859	6.859	183.824	172.392	1141.844	1140.704	–90.3643	600
700	26.021	9.407	187.749	174.310	1144.391	1142.764	–76.1659	700
800	26.749	12.049	191.276	176.214	1147.033	1144.879	–65.4975	800
900	27.076	14.743	194.448	178.067	1149.727	1147.010	–57.1844	900
1000	27.100	17.454	197.305	179.851	1152.438	1149.124	–50.5215	1000
1100	26.920	20.156	199.880	181.557	1155.141	1151.196	–45.0602	1100
1200	26.618	22.834	202.210	183.182	1157.818	1153.211	–40.5009	1200
*1300	26.254	25.478	204.327	184.729	1160.462	1118.144	–36.7452	1300
1400	25.866	28.084	206.258	186.198	1163.068	1120.068	–33.5335	1400
1500	25.480	30.651	208.030	187.596	1165.635	1121.954	–30.7452	1500
1600	25.109	33.180	209.662	188.924	1168.165	1123.802	–28.3015	1600
1700	24.762	35.674	211.174	190.189	1170.658	1125.614	–26.1417	1700
1800	24.441	38.134	212.580	191.395	1173.118	1127.393	–24.2188	1800
1900	24.147	40.563	213.893	192.545	1175.547	1129.140	–22.4956	1900
2000	23.880	42.964	215.125	193.643	1177.948	1130.860	–20.9424	2000
2100	23.639	45.340	216.284	194.694	1180.324	1132.555	–19.5349	2100
2200	23.420	47.692	217.379	195.700	1182.677	1134.226	–18.2536	2200
2300	23.222	50.024	218.415	196.666	1185.009	1135.876	–17.0819	2300
2400	23.043	52.337	219.400	197.593	1187.322	1137.508	–16.0063	2400
2500	22.881	54.633	220.337	198.484	1189.618	1139.123	–15.0153	2500
2600	22.735	56.914	221.232	199.342	1191.899	1140.722	–14.0993	2600
2700	22.602	59.181	222.087	200.168	1194.165	1142.308	–13.2499	2700
2800	22.481	61.435	222.907	200.966	1196.419	1143.880	–12.4602	2800
2900	22.371	63.677	223.694	201.736	1198.662	1145.441	–11.7238	2900
3000	22.271	65.909	224.451	202.481	1200.894	1146.992	–11.0357	3000
3100	22.179	68.132	225.179	203.201	1203.116	1148.533	–10.3911	3100
3200	22.095	70.346	225.882	203.899	1205.330	1150.065	–9.7859	3200
3300	22.019	72.551	226.561	204.576	1207.536	1151.590	–9.2167	3300
3400	21.948	74.749	227.217	205.232	1209.734	1153.107	–8.6802	3400
3500	21.883	76.941	227.852	205.869	1211.925	1154.617	–8.1737	3500
3600	21.823	79.126	228.468	206.489	1214.111	1156.121	–7.6948	3600
3700	21.768	81.306	229.065	207.091	1216.290	1157.619	–7.2411	3700
3800	21.717	83.480	229.645	207.677	1218.464	1159.112	–6.8108	3800
3900	21.670	85.649	230.209	208.247	1220.634	1160.600	–6.4020	3900
4000	21.626	87.814	230.757	208.803	1222.798	1162.083	–6.0132	4000
4100	21.585	89.975	231.290	209.345	1224.959	1163.562	–5.6428	4100
4200	21.547	92.131	231.810	209.874	1227.115	1165.037	–5.2896	4200
4300	21.511	94.284	232.316	210.390	1229.268	1166.509	–4.9525	4300
4400	21.478	96.433	232.811	210.894	1231.418	1167.977	–4.6302	4400
4500	21.448	98.580	233.293	211.386	1233.564	1169.442	–4.3219	4500
4600	21.419	100.723	233.764	211.868	1235.707	1170.904	–4.0266	4600
4700	21.392	102.864	234.224	212.338	1237.848	1172.363	–3.7436	4700
4800	21.367	105.001	234.674	212.799	1239.986	1173.819	–3.4720	4800
4900	21.343	107.137	235.115	213.250	1242.121	1175.273	–3.2111	4900
5000	21.321	109.270	235.546	213.692	1244.254	1176.725	–2.9604	5000

TABLE A52.—THERMODYNAMIC PROPERTIES FOR Ge^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.300	111.401	235.968	214.124	1246.385	1178.175	–2.7192	5100
5200	21.280	113.530	236.381	214.548	1248.514	1179.622	–2.4870	5200
5300	21.262	115.657	236.786	214.964	1250.642	1181.068	–2.2633	5300
5400	21.245	117.783	237.184	215.372	1252.767	1182.512	–2.0476	5400
5500	21.229	119.906	237.573	215.772	1254.891	1183.955	–1.8396	5500
5600	21.214	122.028	237.956	216.165	1257.013	1185.395	–1.6386	5600
5700	21.200	124.149	238.331	216.550	1259.134	1186.835	–1.4446	5700
5800	21.188	126.269	238.700	216.929	1261.253	1188.273	–1.2569	5800
5900	21.176	128.387	239.062	217.301	1263.371	1189.710	–1.0754	5900
6000	21.165	130.504	239.417	217.667	1265.488	1191.145	–0.8998	6000
6200	21.146	134.735	240.111	218.380	1269.719			6200
6400	21.130	138.962	240.782	219.069	1273.947			6400
6600	21.119	143.187	241.432	219.737	1278.172			6600
6800	21.111	147.410	242.063	220.385	1282.394			6800
7000	21.107	151.632	242.674	221.013	1286.616			7000
7200	21.107	155.853	243.269	221.623	1290.837			7200
7400	21.111	160.075	243.847	222.216	1295.059			7400
7600	21.120	164.298	244.410	222.792	1299.282			7600
7800	21.133	168.523	244.959	223.354	1303.507			7800
8000	21.151	172.751	245.494	223.901	1307.736			8000
8500	21.220	183.343	246.779	225.209	1318.327			8500
9000	21.326	193.977	247.994	226.441	1328.962			9000
9500	21.472	204.675	249.151	227.606	1339.659			9500
10000	21.662	215.456	250.257	228.711	1350.441			10000
10500	21.899	226.344	251.319	229.763	1361.328			10500
11000	22.186	237.363	252.345	230.766	1372.347			11000
11500	22.526	248.538	253.338	231.726	1383.523			11500
12000	22.920	259.897	254.305	232.647	1394.882			12000
12500	23.370	271.467	255.249	233.532	1406.451			12500
13000	23.865	283.264	256.175	234.385	1418.248			13000
13500	24.406	295.315	257.084	235.209	1430.299			13500
14000	25.012	307.666	257.982	236.006	1442.651			14000
14500	25.667	320.330	258.871	236.779	1455.315			14500
15000	26.373	333.336	259.753	237.530	1468.320			15000
15500	27.126	346.707	260.630	238.261	1481.692			15500
16000	27.921	360.462	261.503	238.974	1495.447			16000
16500	28.702	374.710	262.384	239.674	1509.695			16500
17000	29.502	389.261	263.252	240.354	1524.245			17000
17500	30.309	404.213	264.119	241.021	1539.197			17500
18000	31.118	419.570	264.984	241.675	1554.554			18000
18500	31.919	435.330	265.848	242.316	1570.314			18500
19000	32.706	451.486	266.710	242.947	1586.471			19000
19500	33.472	468.031	267.569	243.567	1603.016			19500
20000	34.208	484.954	268.426	244.178	1619.938			20000

*Assigned reference element phase change at 1211.4 K

TABLE A53.—THERMODYNAMIC PROPERTIES FOR Ge^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	--------	–6.981	----------	----------	238.422	249.255	----------	0
298.15	21.985	0.000	180.831	180.831	245.403	245.403	–36.2667	298.15
300	21.971	0.041	180.967	180.832	245.443	245.362	–36.0017	300
400	21.470	2.209	187.210	181.686	247.612	243.068	–25.3662	400
500	21.227	4.343	191.971	183.286	249.745	240.658	–19.0470	500
600	21.092	6.458	195.828	185.065	251.861	238.173	–14.8771	600
700	21.011	8.563	199.073	186.840	253.966	235.633	–11.9300	700
800	20.958	10.661	201.875	188.548	256.064	233.047	–9.7436	800
900	20.922	12.755	204.341	190.169	258.158	230.420	–8.0621	900
1000	20.896	14.846	206.544	191.698	260.249	227.757	–6.7323	1000
1100	20.876	16.935	208.535	193.140	262.337	225.057	–5.6570	1100
1200	20.862	19.021	210.351	194.500	264.424	222.325	–4.7716	1200
*1300	20.851	21.107	212.020	195.784	266.510	182.542	–4.1405	1300
1400	20.842	23.192	213.565	197.000	268.594	179.788	–3.6205	1400
1500	20.834	25.275	215.003	198.152	270.678	177.033	–3.1767	1500
1600	20.829	27.359	216.347	199.248	272.761	174.277	–2.7943	1600
1700	20.824	29.441	217.610	200.291	274.844	171.521	–2.4622	1700
1800	20.820	31.523	218.800	201.287	276.926	168.765	–2.1717	1800
1900	20.816	33.605	219.925	202.238	279.008	166.008	–1.9161	1900
2000	20.813	35.687	220.993	203.150	281.089	163.251	–1.6897	2000
2100	20.811	37.768	222.008	204.024	283.170	160.493	–1.4884	2100
2200	20.809	39.849	222.977	204.863	285.251	157.736	–1.3085	2200
2300	20.807	41.930	223.901	205.671	287.332	154.978	–1.1470	2300
2400	20.805	44.010	224.787	206.449	289.413	152.220	–1.0017	2400
2500	20.803	46.091	225.636	207.200	291.493	149.462	–0.8704	2500
2600	20.802	48.171	226.452	207.925	293.573	146.703	–0.7513	2600
2700	20.801	50.251	227.237	208.626	295.653	143.945	–0.6432	2700
2800	20.800	52.331	227.994	209.304	297.734	141.186	–0.5447	2800
2900	20.799	54.411	228.724	209.961	299.813	138.428	–0.4547	2900
3000	20.798	56.491	229.429	210.598	301.893	135.669	–0.3724	3000
3100	20.797	58.571	230.111	211.217	303.973	132.910	–0.2970	3100
3200	20.797	60.650	230.771	211.818	306.053	130.151	–0.2278	3200
3300	20.796	62.730	231.411	212.402	308.132	127.392	–0.1641	3300
3400	20.796	64.810	232.032	212.970	310.212	124.633	–0.1054	3400
3500	20.795	66.889	232.634	213.523	312.292	121.874	–0.0513	3500
3600	20.795	68.969	233.220	214.062	314.371	119.115	–0.0013	3600
3700	20.794	71.048	233.790	214.588	316.450	116.356	0.0449	3700
3800	20.794	73.127	234.345	215.100	318.530	113.596	0.0876	3800
3900	20.793	75.207	234.885	215.601	320.609	110.837	0.1271	3900
4000	20.793	77.286	235.411	216.090	322.689	108.078	0.1638	4000
4100	20.793	79.365	235.924	216.567	324.768	105.318	0.1978	4100
4200	20.792	81.445	236.426	217.034	326.847	102.559	0.2293	4200
4300	20.792	83.524	236.915	217.491	328.926	99.800	0.2586	4300
4400	20.792	85.603	237.393	217.938	331.005	97.040	0.2857	4400
4500	20.792	87.682	237.860	218.375	333.085	94.281	0.3110	4500
4600	20.791	89.761	238.317	218.804	335.164	91.521	0.3344	4600
4700	20.791	91.840	238.764	219.224	337.243	88.762	0.3562	4700
4800	20.791	93.919	239.202	219.635	339.322	86.002	0.3764	4800
4900	20.791	95.999	239.631	220.039	341.401	83.243	0.3952	4900
5000	20.791	98.078	240.051	220.435	343.480	80.483	0.4127	5000

TABLE A53.—THERMODYNAMIC PROPERTIES FOR Ge^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.790	100.157	240.462	220.824	345.559	77.723	0.4289	5100
5200	20.790	102.236	240.866	221.205	347.638	74.964	0.4439	5200
5300	20.790	104.315	241.262	221.580	349.717	72.204	0.4579	5300
5400	20.790	106.394	241.651	221.948	351.796	69.445	0.4708	5400
5500	20.790	108.473	242.032	222.310	353.875	66.685	0.4828	5500
5600	20.790	110.552	242.407	222.665	355.954	63.925	0.4939	5600
5700	20.790	112.631	242.775	223.015	358.033	61.166	0.5041	5700
5800	20.789	114.710	243.136	223.359	360.112	58.406	0.5135	5800
5900	20.789	116.789	243.492	223.697	362.191	55.646	0.5222	5900
6000	20.789	118.867	243.841	224.030	364.270	52.887	0.5303	6000
6200	20.789	123.025	244.523	224.680	368.428			6200
6400	20.789	127.183	245.183	225.310	372.586			6400
6600	20.789	131.341	245.822	225.922	376.743			6600
6800	20.789	135.499	246.443	226.517	380.901			6800
7000	20.788	139.656	247.046	227.095	385.059			7000
7200	20.788	143.814	247.631	227.657	389.216			7200
7400	20.788	147.972	248.201	228.205	393.374			7400
7600	20.788	152.129	248.755	228.738	397.532			7600
7800	20.788	156.287	249.295	229.258	401.689			7800
8000	20.788	160.444	249.822	229.766	405.847			8000
8500	20.788	170.838	251.082	230.983	416.241			8500
9000	20.788	181.232	252.270	232.133	426.635			9000
9500	20.787	191.626	253.394	233.223	437.028			9500
10000	20.787	202.020	254.460	234.258	447.422			10000
10500	20.787	212.413	255.474	235.245	457.816			10500
11000	20.787	222.807	256.441	236.186	468.209			11000
11500	20.787	233.200	257.365	237.087	478.603			11500
12000	20.787	243.594	258.250	237.951	488.996			12000
12500	20.787	253.987	259.099	238.780	499.390			12500
13000	20.787	264.381	259.914	239.577	509.783			13000
13500	20.787	274.774	260.698	240.345	520.177			13500
14000	20.787	285.168	261.454	241.085	530.570			14000
14500	20.787	295.561	262.184	241.800	540.964			14500
15000	20.787	305.955	262.889	242.492	551.357			15000
15500	20.787	316.348	263.570	243.161	561.750			15500
16000	20.787	326.741	264.230	243.809	572.144			16000
16500	20.787	337.135	264.870	244.437	582.537			16500
17000	20.787	347.528	265.490	245.047	592.930			17000
17500	20.787	357.921	266.093	245.640	603.324			17500
18000	20.787	368.315	266.678	246.216	613.717			18000
18500	20.787	378.708	267.248	246.777	624.110			18500
19000	20.787	389.101	267.802	247.323	634.504			19000
19500	20.787	399.494	268.342	247.855	644.897			19500
20000	20.787	409.888	268.868	248.374	655.290			20000

*Assigned reference element phase change at 1211.4 K

TABLE A54.—THERMODYNAMIC PROPERTIES FOR H

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	211.801	216.035	----------	0
100	20.786	–4.119	92.010	133.198	213.880	216.615	–110.9696	100
200	20.786	–2.040	106.418	116.619	215.959	217.346	–54.3236	200
298.15	20.786	0.000	114.718	114.718	217.999	217.999	–35.6124	298.15
300	20.786	0.038	114.846	114.718	218.037	218.011	–35.3769	300
400	20.786	2.117	120.826	115.534	220.116	218.637	–25.8750	400
500	20.786	4.196	125.465	117.073	222.195	219.254	–20.1575	500
600	20.786	6.274	129.254	118.797	224.273	219.868	–16.3350	600
700	20.786	8.353	132.459	120.526	226.352	220.478	–13.5970	700
800	20.786	10.432	135.234	122.195	228.430	221.080	–11.5378	800
900	20.786	12.510	137.682	123.782	230.509	221.671	–9.9319	900
1000	20.786	14.589	139.873	125.284	232.588	222.248	–8.6437	1000
1100	20.786	16.667	141.854	126.701	234.666	222.807	–7.5871	1100
1200	20.786	18.746	143.662	128.041	236.745	223.347	–6.7044	1200
1300	20.786	20.825	145.326	129.307	238.824	223.865	–5.9557	1300
1400	20.786	22.903	146.867	130.507	240.902	224.361	–5.3125	1400
1500	20.786	24.982	148.301	131.646	242.981	224.836	–4.7539	1500
1600	20.786	27.061	149.642	132.729	245.059	225.289	–4.2641	1600
1700	20.786	29.139	150.902	133.762	247.138	225.721	–3.8310	1700
1800	20.786	31.218	152.090	134.747	249.217	226.133	–3.4454	1800
1900	20.786	33.296	153.214	135.690	251.295	226.526	–3.0997	1900
2000	20.786	35.375	154.280	136.593	253.374	226.899	–2.7881	2000
2100	20.786	37.454	155.295	137.460	255.453	227.255	–2.5057	2100
2200	20.786	39.532	156.262	138.292	257.531	227.594	–2.2486	2200
2300	20.786	41.611	157.186	139.094	259.610	227.918	–2.0135	2300
2400	20.786	43.690	158.070	139.866	261.688	228.226	–1.7977	2400
2500	20.786	45.768	158.919	140.612	263.767	228.520	–1.5988	2500
2600	20.786	47.847	159.734	141.331	265.846	228.800	–1.4151	2600
2700	20.786	49.926	160.519	142.028	267.924	229.066	–1.2448	2700
2800	20.786	52.004	161.275	142.702	270.003	229.321	–1.0864	2800
2900	20.786	54.083	162.004	143.355	272.082	229.563	–0.9388	2900
3000	20.786	56.161	162.709	143.988	274.160	229.793	–0.8009	3000
3100	20.786	58.240	163.390	144.603	276.239	230.013	–0.6718	3100
3200	20.786	60.319	164.050	145.201	278.317	230.221	–0.5506	3200
3300	20.786	62.397	164.690	145.781	280.396	230.419	–0.4367	3300
3400	20.786	64.476	165.310	146.347	282.475	230.606	–0.3294	3400
3500	20.786	66.555	165.913	146.897	284.553	230.783	–0.2281	3500
3600	20.786	68.633	166.498	147.434	286.632	230.950	–0.1324	3600
3700	20.786	70.712	167.068	147.957	288.711	231.108	–0.0418	3700
3800	20.786	72.790	167.622	148.467	290.789	231.256	0.0441	3800
3900	20.786	74.869	168.162	148.965	292.868	231.394	0.1256	3900
4000	20.786	76.948	168.688	149.452	294.946	231.523	0.2031	4000
4100	20.786	79.026	169.202	149.927	297.025	231.643	0.2768	4100
4200	20.786	81.105	169.703	150.392	299.104	231.753	0.3471	4200
4300	20.786	83.184	170.192	150.847	301.182	231.855	0.4142	4300
4400	20.786	85.262	170.670	151.292	303.261	231.948	0.4782	4400
4500	20.786	87.341	171.137	151.728	305.340	232.032	0.5394	4500

TABLE A54.—THERMODYNAMIC PROPERTIES FOR H (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.786	89.419	171.594	152.155	307.418	232.107	0.5979	4600
4700	20.786	91.498	172.041	152.573	309.497	232.174	0.6540	4700
4800	20.786	93.577	172.478	152.983	311.576	232.233	0.7078	4800
4900	20.786	95.655	172.907	153.385	313.654	232.283	0.7594	4900
5000	20.786	97.734	173.327	153.780	315.733	232.326	0.8089	5000
5100	20.786	99.813	173.738	154.167	317.811	232.360	0.8565	5100
5200	20.786	101.891	174.142	154.548	319.890	232.388	0.9023	5200
5300	20.786	103.970	174.538	154.921	321.969	232.409	0.9463	5300
5400	20.786	106.048	174.927	155.288	324.047	232.423	0.9887	5400
5500	20.786	108.127	175.308	155.648	326.126	232.431	1.0296	5500
5600	20.786	110.206	175.682	156.003	328.205	232.432	1.0690	5600
5700	20.786	112.284	176.050	156.351	330.283	232.428	1.1071	5700
5800	20.786	114.363	176.412	156.694	332.362	232.420	1.1438	5800
5900	20.786	116.442	176.767	157.031	334.440	232.406	1.1793	5900
6000	20.786	118.520	177.117	157.363	336.519	232.388	1.2135	6000
6200	20.786	122.678	177.798	158.011	340.676	232.341	1.2788	6200
6400	20.786	126.835	178.458	158.640	344.834	232.282	1.3400	6400
6600	20.786	130.992	179.098	159.250	348.991	232.216	1.3974	6600
6800	20.787	135.149	179.718	159.843	353.148	232.147	1.4514	6800
7000	20.787	139.307	180.321	160.420	357.306	232.080	1.5024	7000
7200	20.787	143.464	180.906	160.981	361.463	232.017	1.5505	7200
7400	20.788	147.622	181.476	161.527	365.620	231.963	1.5960	7400
7600	20.788	151.779	182.030	162.059	369.778	231.922	1.6391	7600
7800	20.789	155.937	182.570	162.578	373.936	231.897	1.6799	7800
8000	20.790	160.095	183.097	163.085	378.094	231.892	1.7187	8000
8500	20.795	170.491	184.357	164.299	388.490	231.986	1.8078	8500
9000	20.803	180.890	185.546	165.447	398.889	232.263	1.8870	9000
9500	20.818	191.295	186.671	166.535	409.294	232.754	1.9581	9500
10000	20.832	201.702	187.739	167.568	419.701	233.474	2.0222	10000
10500	20.861	212.125	188.756	168.553	430.124	234.447	2.0803	10500
11000	20.904	222.544	189.725	169.493	440.543	235.655	2.1335	11000
11500	20.983	233.015	190.656	170.394	451.014	237.151	2.1823	11500
12000	21.086	243.531	191.551	171.256	461.530	238.923	2.2273	12000
12500	21.209	254.104	192.414	172.086	472.103	240.972	2.2691	12500
13000	21.354	264.744	193.248	172.883	482.743	243.297	2.3080	13000
13500	21.516	275.461	194.057	173.653	493.460	245.898	2.3444	13500
14000	21.692	286.263	194.843	174.396	504.262	248.767	2.3786	14000
14500	21.879	297.155	195.608	175.115	515.154	251.901	2.4108	14500
15000	22.073	308.143	196.353	175.810	526.142	255.291	2.4412	15000
15500	22.272	319.230	197.080	176.484	537.229	258.929	2.4701	15500
16000	22.472	330.415	197.790	177.139	548.414	262.804	2.4975	16000
16500	22.673	341.703	198.485	177.776	559.701	266.910	2.5238	16500
17000	22.870	353.087	199.164	178.394	571.086	271.232	2.5488	17000
17500	23.064	364.571	199.830	178.997	582.570	275.762	2.5728	17500
18000	23.253	376.151	200.483	179.586	594.150	280.492	2.5959	18000
18500	23.439	387.824	201.122	180.159	605.823	285.407	2.6181	18500
19000	23.624	399.590	201.750	180.719	617.589	290.504	2.6394	19000
19500	23.809	411.447	202.366	181.266	629.446	295.773	2.6601	19500
20000	23.997	423.398	202.970	181.801	641.397	301.211	2.6801	20000

TABLE A55.—THERMODYNAMIC PROPERTIES FOR H^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1530.048	1528.085	----------	0
298.15	20.786	0.000	108.948	108.948	1536.246	1536.246	–265.7635	298.15
300	20.786	0.038	109.076	108.948	1536.284	1536.296	–264.1038	300
400	20.786	2.117	115.056	109.764	1538.363	1539.001	–197.1790	400
500	20.786	4.196	119.695	111.303	1540.442	1541.697	–156.9529	500
600	20.786	6.274	123.484	113.027	1542.520	1544.390	–130.0882	600
700	20.786	8.353	126.689	114.756	1544.599	1547.078	–110.8655	700
800	20.786	10.432	129.464	116.425	1546.678	1549.759	–96.4234	800
900	20.786	12.510	131.913	118.012	1548.756	1552.429	–85.1712	900
1000	20.786	14.589	134.103	119.514	1550.835	1555.084	–76.1539	1000
1100	20.786	16.667	136.084	120.931	1552.913	1557.722	–68.7635	1100
1200	20.786	18.746	137.892	122.271	1554.992	1560.340	–62.5944	1200
1300	20.786	20.825	139.556	123.537	1557.071	1562.937	–57.3657	1300
1400	20.786	22.903	141.097	124.737	1559.149	1565.512	–52.8765	1400
1500	20.786	24.982	142.531	125.876	1561.228	1568.065	–48.9796	1500
1600	20.786	27.061	143.872	126.959	1563.307	1570.597	–45.5641	1600
1700	20.786	29.139	145.132	127.992	1565.385	1573.108	–42.5457	1700
1800	20.786	31.218	146.320	128.977	1567.464	1575.598	–39.8583	1800
1900	20.786	33.296	147.444	129.920	1569.542	1578.069	–37.4501	1900
2000	20.786	35.375	148.511	130.823	1571.621	1580.521	–35.2793	2000
2100	20.786	37.454	149.525	131.690	1573.700	1582.956	–33.3122	2100
2200	20.786	39.532	150.492	132.522	1575.778	1585.374	–31.5212	2200
2300	20.786	41.611	151.416	133.324	1577.857	1587.776	–29.8834	2300
2400	20.786	43.690	152.300	134.096	1579.936	1590.163	–28.3798	2400
2500	20.786	45.768	153.149	134.842	1582.014	1592.535	–26.9945	2500
2600	20.786	47.847	153.964	135.561	1584.093	1594.894	–25.7138	2600
2700	20.786	49.926	154.749	136.258	1586.171	1597.239	–24.5262	2700
2800	20.786	52.004	155.505	136.932	1588.250	1599.572	–23.4219	2800
2900	20.786	54.083	156.234	137.585	1590.329	1601.893	–22.3922	2900
3000	20.786	56.161	156.939	138.218	1592.407	1604.202	–21.4297	3000
3100	20.786	58.240	157.620	138.833	1594.486	1606.500	–20.5281	3100
3200	20.786	60.319	158.280	139.431	1596.565	1608.787	–19.6816	3200
3300	20.786	62.397	158.920	140.012	1598.643	1611.063	–18.8853	3300
3400	20.786	64.476	159.540	140.577	1600.722	1613.329	–18.1348	3400
3500	20.786	66.555	160.143	141.127	1602.800	1615.585	–17.4262	3500
3600	20.786	68.633	160.728	141.664	1604.879	1617.831	–16.7559	3600
3700	20.786	70.712	161.298	142.187	1606.958	1620.067	–16.1211	3700
3800	20.786	72.790	161.852	142.697	1609.036	1622.293	–15.5188	3800
3900	20.786	74.869	162.392	143.195	1611.115	1624.510	–14.9466	3900
4000	20.786	76.948	162.918	143.682	1613.194	1626.718	–14.4023	4000
4100	20.786	79.026	163.432	144.157	1615.272	1628.916	–13.8839	4100
4200	20.786	81.105	163.933	144.622	1617.351	1631.105	–13.3895	4200
4300	20.786	83.184	164.422	145.077	1619.429	1633.286	–12.9174	4300
4400	20.786	85.262	164.900	145.522	1621.508	1635.457	–12.4662	4400
4500	20.786	87.341	165.367	145.958	1623.587	1637.620	–12.0345	4500
4600	20.786	89.419	165.824	146.385	1625.665	1639.773	–11.6210	4600
4700	20.786	91.498	166.271	146.803	1627.744	1641.919	–11.2246	4700
4800	20.786	93.577	166.708	147.213	1629.823	1644.056	–10.8441	4800
4900	20.786	95.655	167.137	147.615	1631.901	1646.186	–10.4788	4900
5000	20.786	97.734	167.557	148.010	1633.980	1648.307	–10.1276	5000

TABLE A55.—THERMODYNAMIC PROPERTIES FOR H^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	167.968	148.397	1636.059	1650.420	–9.7898	5100
5200	20.786	101.891	168.372	148.778	1638.137	1652.527	–9.4645	5200
5300	20.786	103.970	168.768	149.151	1640.216	1654.626	–9.1511	5300
5400	20.786	106.048	169.157	149.518	1642.294	1656.719	–8.8489	5400
5500	20.786	108.127	169.538	149.878	1644.373	1658.805	–8.5574	5500
5600	20.786	110.206	169.912	150.233	1646.452	1660.885	–8.2759	5600
5700	20.786	112.284	170.280	150.581	1648.530	1662.960	–8.0040	5700
5800	20.786	114.363	170.642	150.924	1650.609	1665.030	–7.7410	5800
5900	20.786	116.442	170.997	151.261	1652.688	1667.094	–7.4867	5900
6000	20.786	118.520	171.347	151.593	1654.766	1669.155	–7.2406	6000
6200	20.786	122.677	172.028	152.241	1658.923	1673.265	–6.7713	6200
6400	20.786	126.835	172.688	152.870	1663.081	1677.364	–6.3302	6400
6600	20.786	130.992	173.328	153.480	1667.238	1681.455	–5.9149	6600
6800	20.786	135.149	173.948	154.073	1671.395	1685.543	–5.5230	6800
7000	20.786	139.306	174.551	154.650	1675.552	1689.633	–5.1527	7000
7200	20.786	143.464	175.136	155.211	1679.710	1693.727	–4.8020	7200
7400	20.786	147.621	175.706	155.757	1683.867	1697.830	–4.4695	7400
7600	20.786	151.778	176.260	156.289	1688.024	1701.946	–4.1538	7600
7800	20.786	155.936	176.800	156.808	1692.181	1706.078	–3.8535	7800
8000	20.786	160.093	177.326	157.315	1696.339	1710.230	–3.5675	8000
8500	20.786	170.486	178.587	158.529	1706.732	1720.714	–2.9087	8500
9000	20.786	180.879	179.775	159.677	1717.125	1731.378	–2.3195	9000
9500	20.786	191.272	180.899	160.765	1727.518	1742.250	–1.7890	9500
10000	20.786	201.665	181.965	161.798	1737.911	1753.350	–1.3085	10000
10500	20.786	212.058	182.979	162.783	1748.304	1764.686	–0.8710	10500
11000	20.786	222.452	183.946	163.723	1758.698	1776.261	–0.4707	11000
11500	20.786	232.845	184.870	164.623	1769.091	1788.073	–0.1028	11500
12000	20.786	243.238	185.755	165.485	1779.484	1800.115	0.2367	12000
12500	20.786	253.631	186.603	166.313	1789.877	1812.377	0.5512	12500
13000	20.786	264.024	187.418	167.109	1800.270	1824.849	0.8434	13000
13500	20.786	274.417	188.203	167.876	1810.663	1837.518	1.1159	13500
14000	20.786	284.810	188.959	168.615	1821.056	1850.372	1.3707	14000
14500	20.786	295.204	189.688	169.329	1831.449	1863.399	1.6096	14500
15000	20.786	305.597	190.393	170.020	1841.843	1876.588	1.8341	15000
15500	20.786	315.990	191.074	170.688	1852.236	1889.926	2.0457	15500
16000	20.786	326.383	191.734	171.335	1862.629	1903.402	2.2454	16000
16500	20.786	336.776	192.374	171.963	1873.022	1917.007	2.4344	16500
17000	20.786	347.169	192.995	172.573	1883.415	1930.730	2.6135	17000
17500	20.786	357.562	193.597	173.165	1893.808	1944.563	2.7836	17500
18000	20.786	367.956	194.183	173.741	1904.201	1958.499	2.9454	18000
18500	20.786	378.349	194.752	174.301	1914.595	1972.528	3.0995	18500
19000	20.786	388.742	195.307	174.846	1924.988	1986.645	3.2466	19000
19500	20.786	399.135	195.846	175.378	1935.381	2000.842	3.3871	19500
20000	20.786	409.528	196.373	175.896	1945.774	2015.115	3.5216	20000

TABLE A56.—THERMODYNAMIC PROPERTIES FOR H^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	132.834	143.265	----------	0
298.15	20.786	0.000	108.961	108.961	139.031	139.031	–23.1744	298.15
300	20.786	0.038	109.090	108.962	139.070	139.005	–23.0242	300
400	20.786	2.117	115.070	109.777	141.148	137.552	–17.0023	400
500	20.786	4.196	119.708	111.317	143.227	136.091	–13.4275	500
600	20.786	6.274	123.498	113.041	145.306	134.626	–11.0700	600
700	20.786	8.353	126.702	114.769	147.384	133.157	–9.4043	700
800	20.786	10.432	129.478	116.438	149.463	131.681	–8.1689	800
900	20.786	12.510	131.926	118.026	151.542	130.194	–7.2188	900
1000	20.786	14.589	134.116	119.527	153.620	128.692	–6.4674	1000
1100	20.786	16.667	136.097	120.945	155.699	127.172	–5.8598	1100
1200	20.786	18.746	137.906	122.284	157.777	125.633	–5.3595	1200
1300	20.786	20.825	139.570	123.551	159.856	124.073	–4.9414	1300
1400	20.786	22.903	141.110	124.751	161.935	122.491	–4.5875	1400
1500	20.786	24.982	142.544	125.890	164.013	120.887	–4.2848	1500
1600	20.786	27.061	143.886	126.973	166.092	119.261	–4.0234	1600
1700	20.786	29.139	145.146	128.005	168.171	117.615	–3.7959	1700
1800	20.786	31.218	146.334	128.991	170.249	115.948	–3.5965	1800
1900	20.786	33.296	147.458	129.933	172.328	114.262	–3.4207	1900
2000	20.786	35.375	148.524	130.837	174.406	112.557	–3.2648	2000
2100	20.786	37.454	149.538	131.703	176.485	110.834	–3.1259	2100
2200	20.786	39.532	150.505	132.536	178.564	109.094	–3.0016	2200
2300	20.786	41.611	151.429	133.337	180.642	107.339	–2.8898	2300
2400	20.786	43.690	152.314	134.110	182.721	105.569	–2.7891	2400
2500	20.786	45.768	153.162	134.855	184.800	103.784	–2.6979	2500
2600	20.786	47.847	153.978	135.575	186.878	101.985	–2.6152	2600
2700	20.786	49.926	154.762	136.271	188.957	100.173	–2.5400	2700
2800	20.786	52.004	155.518	136.945	191.035	98.349	–2.4715	2800
2900	20.786	54.083	156.248	137.598	193.114	96.513	–2.4088	2900
3000	20.786	56.161	156.952	138.232	195.193	94.664	–2.3513	3000
3100	20.786	58.240	157.634	138.847	197.271	92.805	–2.2987	3100
3200	20.786	60.319	158.294	139.444	199.350	90.935	–2.2503	3200
3300	20.786	62.397	158.933	140.025	201.429	89.054	–2.2058	3300
3400	20.786	64.476	159.554	140.590	203.507	87.163	–2.1648	3400
3500	20.786	66.555	160.156	141.141	205.586	85.261	–2.1270	3500
3600	20.786	68.633	160.742	141.677	207.664	83.350	–2.0920	3600
3700	20.786	70.712	161.312	142.200	209.743	81.429	–2.0597	3700
3800	20.786	72.790	161.866	142.710	211.822	79.498	–2.0298	3800
3900	20.786	74.869	162.406	143.209	213.900	77.558	–2.0021	3900
4000	20.786	76.948	162.932	143.695	215.979	75.608	–1.9765	4000
4100	20.786	79.026	163.445	144.171	218.058	73.649	–1.9527	4100
4200	20.786	81.105	163.946	144.636	220.136	71.681	–1.9306	4200
4300	20.786	83.184	164.435	145.090	222.215	69.704	–1.9102	4300
4400	20.786	85.262	164.913	145.535	224.294	67.718	–1.8912	4400
4500	20.786	87.341	165.380	145.971	226.372	65.723	–1.8736	4500
4600	20.786	89.419	165.837	146.398	228.451	63.720	–1.8573	4600
4700	20.786	91.498	166.284	146.817	230.529	61.708	–1.8421	4700
4800	20.786	93.577	166.722	147.227	232.608	59.688	–1.8281	4800
4900	20.786	95.655	167.150	147.629	234.687	57.660	–1.8151	4900
5000	20.786	97.734	167.570	148.024	236.765	55.624	–1.8030	5000

TABLE A56.—THERMODYNAMIC PROPERTIES FOR H^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	167.982	148.411	238.844	53.580	–1.7918	5100
5200	20.786	101.891	168.386	148.791	240.923	51.530	–1.7814	5200
5300	20.786	103.970	168.782	149.165	243.001	49.472	–1.7719	5300
5400	20.786	106.048	169.170	149.532	245.080	47.407	–1.7630	5400
5500	20.786	108.127	169.552	149.892	247.158	45.336	–1.7549	5500
5600	20.786	110.206	169.926	150.246	249.237	43.259	–1.7473	5600
5700	20.786	112.284	170.294	150.595	251.316	41.177	–1.7404	5700
5800	20.786	114.363	170.655	150.938	253.394	39.089	–1.7341	5800
5900	20.786	116.442	171.011	151.275	255.473	36.997	–1.7283	5900
6000	20.786	118.520	171.360	151.607	257.552	34.900	–1.7230	6000
6200	20.786	122.677	172.042	152.255	261.709	30.696	–1.7138	6200
6400	20.786	126.835	172.702	152.884	265.866	26.479	–1.7062	6400
6600	20.786	130.992	173.341	153.494	270.023	22.256	–1.7002	6600
6800	20.786	135.149	173.962	154.087	274.181	18.030	–1.6955	6800
7000	20.786	139.306	174.564	154.663	278.338	13.805	–1.6920	7000
7200	20.786	143.464	175.150	155.224	282.495	9.585	–1.6896	7200
7400	20.786	147.621	175.719	155.771	286.652	5.374	–1.6881	7400
7600	20.786	151.778	176.274	156.303	290.810	1.175	–1.6875	7600
7800	20.786	155.936	176.814	156.822	294.967	–3.007	–1.6877	7800
8000	20.786	160.093	177.340	157.328	299.124	–7.170	–1.6885	8000
8500	20.786	170.486	178.600	158.543	309.517	–17.472	–1.6932	8500
9000	20.786	180.879	179.788	159.691	319.910	–27.595	–1.7009	9000
9500	20.786	191.272	180.912	160.778	330.304	–37.509	–1.7108	9500
10000	20.786	201.665	181.978	161.812	340.697	–47.195	–1.7224	10000
10500	20.786	212.058	182.992	162.796	351.090	–56.646	–1.7353	10500
11000	20.786	222.452	183.959	163.737	361.483	–65.857	–1.7492	11000
11500	20.786	232.845	184.883	164.636	371.876	–74.831	–1.7637	11500
12000	20.786	243.238	185.768	165.498	382.269	–83.575	–1.7787	12000
12500	20.786	253.631	186.617	166.326	392.662	–92.099	–1.7939	12500
13000	20.786	264.024	187.432	167.122	403.055	–100.414	–1.8094	13000
13500	20.786	274.417	188.216	167.889	413.449	–108.531	–1.8250	13500
14000	20.786	284.810	188.972	168.629	423.842	–116.463	–1.8405	14000
14500	20.786	295.204	189.702	169.343	434.235	–124.222	–1.8559	14500
15000	20.786	305.597	190.406	170.033	444.628	–131.820	–1.8713	15000
15500	20.786	315.990	191.088	170.702	455.021	–139.268	–1.8866	15500
16000	20.786	326.383	191.748	171.349	465.414	–146.579	–1.9016	16000
16500	20.786	336.776	192.388	171.977	475.807	–153.760	–1.9164	16500
17000	20.786	347.169	193.008	172.586	486.201	–160.823	–1.9311	17000
17500	20.786	357.562	193.611	173.179	496.594	–167.776	–1.9455	17500
18000	20.786	367.956	194.196	173.754	506.987	–174.627	–1.9597	18000
18500	20.786	378.349	194.766	174.314	517.380	–181.384	–1.9737	18500
19000	20.786	388.742	195.320	174.860	527.773	–188.054	–1.9874	19000
19500	20.786	399.135	195.860	175.392	538.166	–194.642	–2.0009	19500
20000	20.786	409.528	196.386	175.910	548.559	–201.155	–2.0141	20000

TABLE A57.—THERMODYNAMIC PROPERTIES FOR He

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–6.197	0	----------	0
100	20.786	–4.119	103.446	144.634	–4.119	0	0	100
200	20.786	–2.040	117.854	128.055	–2.040	0	0	200
298.15	20.786	0.000	126.154	126.154	0.000	0	0	298.15
300	20.786	0.038	126.282	126.154	0.038	0	0	300
400	20.786	2.117	132.262	126.969	2.117	0	0	400
500	20.786	4.196	136.900	128.509	4.196	0	0	500
600	20.786	6.274	140.690	130.233	6.274	0	0	600
700	20.786	8.353	143.894	131.962	8.353	0	0	700
800	20.786	10.432	146.670	133.631	10.432	0	0	800
900	20.786	12.510	149.118	135.218	12.510	0	0	900
1000	20.786	14.589	151.308	136.720	14.589	0	0	1000
1100	20.786	16.667	153.290	138.137	16.667	0	0	1100
1200	20.786	18.746	155.098	139.476	18.746	0	0	1200
1300	20.786	20.825	156.762	140.743	20.825	0	0	1300
1400	20.786	22.903	158.302	141.943	22.903	0	0	1400
1500	20.786	24.982	159.736	143.082	24.982	0	0	1500
1600	20.786	27.061	161.078	144.165	27.061	0	0	1600
1700	20.786	29.139	162.338	145.197	29.139	0	0	1700
1800	20.786	31.218	163.526	146.183	31.218	0	0	1800
1900	20.786	33.296	164.650	147.126	33.296	0	0	1900
2000	20.786	35.375	165.716	148.029	35.375	0	0	2000
2100	20.786	37.454	166.730	148.895	37.454	0	0	2100
2200	20.786	39.532	167.697	149.728	39.532	0	0	2200
2300	20.786	41.611	168.621	150.530	41.611	0	0	2300
2400	20.786	43.690	169.506	151.302	43.690	0	0	2400
2500	20.786	45.768	170.355	152.047	45.768	0	0	2500
2600	20.786	47.847	171.170	152.767	47.847	0	0	2600
2700	20.786	49.926	171.954	153.463	49.926	0	0	2700
2800	20.786	52.004	172.710	154.137	52.004	0	0	2800
2900	20.786	54.083	173.440	154.791	54.083	0	0	2900
3000	20.786	56.161	174.144	155.424	56.161	0	0	3000
3100	20.786	58.240	174.826	156.039	58.240	0	0	3100
3200	20.786	60.319	175.486	156.636	60.319	0	0	3200
3300	20.786	62.397	176.126	157.217	62.397	0	0	3300
3400	20.786	64.476	176.746	157.783	64.476	0	0	3400
3500	20.786	66.555	177.349	158.333	66.555	0	0	3500
3600	20.786	68.633	177.934	158.869	68.633	0	0	3600
3700	20.786	70.712	178.504	159.392	70.712	0	0	3700
3800	20.786	72.790	179.058	159.903	72.790	0	0	3800
3900	20.786	74.869	179.598	160.401	74.869	0	0	3900
4000	20.786	76.948	180.124	160.887	76.948	0	0	4000
4100	20.786	79.026	180.638	161.363	79.026	0	0	4100
4200	20.786	81.105	181.138	161.828	81.105	0	0	4200
4300	20.786	83.184	181.628	162.283	83.184	0	0	4300
4400	20.786	85.262	182.105	162.728	85.262	0	0	4400
4500	20.786	87.341	182.573	163.163	87.341	0	0	4500

TABLE A57.—THERMODYNAMIC PROPERTIES FOR He (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K^\circ$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.786	89.419	183.029	163.590	89.419	0	0	4600
4700	20.786	91.498	183.476	164.009	91.498	0	0	4700
4800	20.786	93.577	183.914	164.419	93.577	0	0	4800
4900	20.786	95.655	184.343	164.821	95.655	0	0	4900
5000	20.786	97.734	184.763	165.216	97.734	0	0	5000
5100	20.786	99.813	185.174	165.603	99.813	0	0	5100
5200	20.786	101.891	185.578	165.983	101.891	0	0	5200
5300	20.786	103.970	185.974	166.357	103.970	0	0	5300
5400	20.786	106.048	186.362	166.724	106.048	0	0	5400
5500	20.786	108.127	186.744	167.084	108.127	0	0	5500
5600	20.786	110.206	187.118	167.439	110.206	0	0	5600
5700	20.786	112.284	187.486	167.787	112.284	0	0	5700
5800	20.786	114.363	187.848	168.130	114.363	0	0	5800
5900	20.786	116.442	188.203	168.467	116.442	0	0	5900
6000	20.786	118.520	188.552	168.799	118.520	0	0	6000
6200	20.786	122.677	189.234	169.447	122.677	0	0	6200
6400	20.786	126.835	189.894	170.076	126.835	0	0	6400
6600	20.786	130.992	190.534	170.686	130.992	0	0	6600
6800	20.786	135.149	191.154	171.279	135.149	0	0	6800
7000	20.786	139.306	191.757	171.856	139.306	0	0	7000
7200	20.786	143.464	192.342	172.417	143.464	0	0	7200
7400	20.786	147.621	192.912	172.963	147.621	0	0	7400
7600	20.786	151.778	193.466	173.495	151.778	0	0	7600
7800	20.786	155.936	194.006	174.014	155.936	0	0	7800
8000	20.786	160.093	194.532	174.521	160.093	0	0	8000
8500	20.786	170.486	195.792	175.735	170.486	0	0	8500
9000	20.786	180.879	196.980	176.883	180.879	0	0	9000
9500	20.786	191.272	198.104	177.970	191.272	0	0	9500
10000	20.786	201.665	199.171	179.004	201.665	0	0	10000
10500	20.786	212.058	200.185	179.989	212.058	0	0	10500
11000	20.786	222.452	201.152	180.929	222.452	0	0	11000
11500	20.786	232.845	202.076	181.828	232.845	0	0	11500
12000	20.786	243.238	202.960	182.691	243.238	0	0	12000
12500	20.787	253.631	203.809	183.518	253.631	0	0	12500
13000	20.787	264.025	204.624	184.315	264.025	0	0	13000
13500	20.788	274.417	205.408	185.081	274.417	0	0	13500
14000	20.789	284.812	206.165	185.821	284.812	0	0	14000
14500	20.790	295.207	206.894	186.535	295.207	0	0	14500
15000	20.793	305.603	207.599	187.226	305.603	0	0	15000
15500	20.796	316.000	208.281	187.894	316.000	0	0	15500
16000	20.800	326.399	208.941	188.541	326.399	0	0	16000
16500	20.805	336.801	209.581	189.169	336.801	0	0	16500
17000	20.813	347.205	210.202	189.779	347.205	0	0	17000
17500	20.822	357.613	210.806	190.371	357.613	0	0	17500
18000	20.833	368.027	211.393	190.947	368.027	0	0	18000
18500	20.847	378.447	211.963	191.507	378.447	0	0	18500
19000	20.864	388.874	212.520	192.053	388.874	0	0	19000
19500	20.886	399.312	213.062	192.584	399.312	0	0	19500
20000	20.913	409.761	213.591	193.103	409.761	0	0	20000

TABLE A58.—THERMODYNAMIC PROPERTIES FOR He^+

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K^\circ$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	2372.324	2372.324	----------	0
298.15	20.786	0.000	131.915	131.915	2378.521	2378.521	–415.2998	298.15
300	20.786	0.038	132.044	131.916	2378.560	2378.560	–412.7302	300
400	20.786	2.117	138.024	132.731	2380.639	2380.639	–309.1558	400
500	20.786	4.196	142.662	134.270	2382.717	2382.717	–246.9564	500
600	20.786	6.274	146.452	135.994	2384.796	2384.796	–205.4536	600
700	20.786	8.353	149.656	137.723	2386.874	2386.874	–175.7829	700
800	20.786	10.432	152.432	139.392	2388.953	2388.953	–153.5103	800
900	20.786	12.510	154.880	140.980	2391.032	2391.032	–136.1721	900
1000	20.786	14.589	157.070	142.481	2393.110	2393.110	–122.2894	1000
1100	20.786	16.667	159.051	143.899	2395.189	2395.189	–110.9210	1100
1200	20.786	18.746	160.860	145.238	2397.268	2397.268	–101.4391	1200
1300	20.786	20.825	162.523	146.504	2399.346	2399.346	–93.4090	1300
1400	20.786	22.903	164.064	147.704	2401.425	2401.425	–86.5200	1400
1500	20.786	24.982	165.498	148.843	2403.503	2403.503	–80.5444	1500
1600	20.786	27.061	166.839	149.927	2405.582	2405.582	–75.3113	1600
1700	20.786	29.139	168.100	150.959	2407.661	2407.661	–70.6898	1700
1800	20.786	31.218	169.288	151.944	2409.739	2409.739	–66.5782	1800
1900	20.786	33.296	170.412	152.887	2411.818	2411.818	–62.8963	1900
2000	20.786	35.375	171.478	153.790	2413.897	2413.897	–59.5797	2000
2100	20.786	37.454	172.492	154.657	2415.975	2415.975	–56.5764	2100
2200	20.786	39.532	173.459	155.490	2418.054	2418.054	–53.8437	2200
2300	20.786	41.611	174.383	156.291	2420.132	2420.132	–51.3466	2300
2400	20.786	43.690	175.268	157.064	2422.211	2422.211	–49.0555	2400
2500	20.786	45.768	176.116	157.809	2424.290	2424.290	–46.9460	2500
2600	20.786	47.847	176.931	158.529	2426.368	2426.368	–44.9970	2600
2700	20.786	49.926	177.716	159.225	2428.447	2428.447	–43.1909	2700
2800	20.786	52.004	178.472	159.899	2430.526	2430.526	–41.5123	2800
2900	20.786	54.083	179.201	160.552	2432.604	2432.604	–39.9482	2900
3000	20.786	56.161	179.906	161.185	2434.683	2434.683	–38.4871	3000
3100	20.786	58.240	180.587	161.800	2436.761	2436.761	–37.1191	3100
3200	20.786	60.319	181.247	162.398	2438.840	2438.840	–35.8354	3200
3300	20.786	62.397	181.887	162.979	2440.919	2440.919	–34.6286	3300
3400	20.786	64.476	182.508	163.544	2442.997	2442.997	–33.4918	3400
3500	20.786	66.555	183.110	164.095	2445.076	2445.076	–32.4190	3500
3600	20.786	68.633	183.696	164.631	2447.155	2447.155	–31.4050	3600
3700	20.786	70.712	184.265	165.154	2449.233	2449.233	–30.4449	3700
3800	20.786	72.790	184.820	165.664	2451.312	2451.312	–29.5347	3800
3900	20.786	74.869	185.359	166.162	2453.391	2453.391	–28.6703	3900
4000	20.786	76.948	185.886	166.649	2455.469	2455.469	–27.8485	4000
4100	20.786	79.026	186.399	167.124	2457.548	2457.548	–27.0661	4100
4200	20.786	81.105	186.900	167.589	2459.626	2459.626	–26.3204	4200
4300	20.786	83.184	187.389	168.044	2461.705	2461.705	–25.6087	4300
4400	20.786	85.262	187.867	168.489	2463.784	2463.784	–24.9288	4400
4500	20.786	87.341	188.334	168.925	2465.862	2465.862	–24.2786	4500
4600	20.786	89.419	188.791	169.352	2467.941	2467.941	–23.6561	4600
4700	20.786	91.498	189.238	169.770	2470.020	2470.020	–23.0596	4700
4800	20.786	93.577	189.676	170.180	2472.098	2472.098	–22.4875	4800
4900	20.786	95.655	190.104	170.583	2474.177	2474.177	–21.9382	4900
5000	20.786	97.734	190.524	170.977	2476.255	2476.255	–21.4105	5000

TABLE A58.—THERMODYNAMIC PROPERTIES FOR He^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	190.936	171.365	2478.334	2478.334	–20.9031	5100
5200	20.786	101.891	191.339	171.745	2480.413	2480.413	–20.4148	5200
5300	20.786	103.970	191.735	172.118	2482.491	2482.491	–19.9445	5300
5400	20.786	106.048	192.124	172.485	2484.570	2484.570	–19.4912	5400
5500	20.786	108.127	192.505	172.846	2486.649	2486.649	–19.0541	5500
5600	20.786	110.206	192.880	173.200	2488.727	2488.727	–18.6322	5600
5700	20.786	112.284	193.248	173.549	2490.806	2490.806	–18.2248	5700
5800	20.786	114.363	193.609	173.891	2492.884	2492.884	–17.8311	5800
5900	20.786	116.442	193.965	174.229	2494.963	2494.963	–17.4504	5900
6000	20.786	118.520	194.314	174.560	2497.042	2497.042	–17.0821	6000
6200	20.786	122.677	194.995	175.209	2501.199	2501.199	–16.3803	6200
6400	20.786	126.835	195.655	175.837	2505.356	2505.356	–15.7212	6400
6600	20.786	130.992	196.295	176.448	2509.513	2509.513	–15.1011	6600
6800	20.786	135.149	196.916	177.041	2513.671	2513.671	–14.5165	6800
7000	20.786	139.306	197.518	177.617	2517.828	2517.828	–13.9644	7000
7200	20.786	143.464	198.104	178.178	2521.985	2521.985	–13.4421	7200
7400	20.786	147.621	198.673	178.724	2526.142	2526.142	–12.9472	7400
7600	20.786	151.778	199.228	179.257	2530.300	2530.300	–12.4776	7600
7800	20.786	155.936	199.767	179.776	2534.457	2534.457	–12.0313	7800
8000	20.786	160.093	200.294	180.282	2538.614	2538.614	–11.6067	8000
8200	20.786	164.250	200.807	180.776	2542.772	2542.772	–11.2021	8200
8400	20.786	168.407	201.308	181.259	2546.929	2546.929	–10.8161	8400
8600	20.786	172.565	201.797	181.731	2551.086	2551.086	–10.4475	8600
8800	20.786	176.722	202.275	182.193	2555.243	2555.243	–10.0951	8800
9000	20.786	180.879	202.742	182.644	2559.401	2559.401	–9.7577	9000
9200	20.786	185.036	203.199	183.086	2563.558	2563.558	–9.4346	9200
9400	20.786	189.194	203.646	183.519	2567.715	2567.715	–9.1246	9400
9600	20.786	193.351	204.083	183.943	2571.872	2571.872	–8.8271	9600
9800	20.786	197.508	204.512	184.358	2576.030	2576.030	–8.5413	9800
10000	20.786	201.665	204.932	184.765	2580.187	2580.187	–8.2665	10000
10500	20.786	212.058	205.946	185.750	2590.580	2590.580	–7.6235	10500
11000	20.786	222.452	206.913	186.690	2600.973	2600.973	–7.0365	11000
11500	20.786	232.845	207.837	187.590	2611.366	2611.366	–6.4985	11500
12000	20.786	243.238	208.722	188.452	2621.759	2621.759	–6.0033	12000
12500	20.786	253.631	209.570	189.280	2632.152	2632.152	–5.5460	12500
13000	20.786	264.024	210.386	190.076	2642.546	2642.545	–5.1221	13000
13500	20.786	274.417	211.170	190.843	2652.939	2652.938	–4.7281	13500
14000	20.786	284.810	211.926	191.582	2663.332	2663.330	–4.3608	14000
14500	20.786	295.204	212.655	192.297	2673.725	2673.722	–4.0175	14500
15000	20.786	305.597	213.360	192.987	2684.118	2684.113	–3.6958	15000
15500	20.786	315.990	214.042	193.655	2694.511	2694.503	–3.3937	15500
16000	20.786	326.383	214.702	194.303	2704.904	2704.890	–3.1094	16000
16500	20.786	336.776	215.341	194.931	2715.298	2715.275	–2.8413	16500
17000	20.786	347.169	215.962	195.540	2725.691	2725.655	–2.5880	17000
17500	20.786	357.562	216.564	196.132	2736.084	2736.032	–2.3483	17500
18000	20.786	367.956	217.150	196.708	2746.477	2746.415	–2.1210	18000
18500	20.786	378.349	217.719	197.268	2756.870	2756.791	–1.9052	18500
19000	20.786	388.742	218.274	197.814	2767.263	2767.152	–1.7000	19000
19500	20.786	399.135	218.814	198.345	2777.656	2777.505	–1.5046	19500
20000	20.786	409.528	219.340	198.864	2788.050	2787.844	–1.3183	20000

TABLE A59.—THERMODYNAMIC PROPERTIES FOR Hg

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	55.183	64.526	----------	0
100	20.786	–4.119	152.265	193.453	57.261	64.898	–27.8893	100
200	20.786	–2.040	166.673	176.873	59.340	64.392	–10.9851	200
*298.15	20.786	0.000	174.972	174.972	61.380	61.380	–5.5851	298.15
300	20.786	0.038	175.101	174.973	61.418	61.366	–5.5187	300
400	20.786	2.117	181.081	175.788	63.497	60.680	–2.8614	400
500	20.786	4.196	185.719	177.327	65.576	60.031	–1.2844	500
600	20.786	6.274	189.509	179.051	67.654	59.395	–0.2445	600
700	20.786	8.353	192.713	180.780	69.733	58.754	0.4905	700
800	20.786	10.432	195.489	182.449	71.812	58.090	1.0355	800
900	20.786	12.510	197.937	184.037	73.890	57.394	1.4546	900
1000	20.786	14.589	200.127	185.538	75.969	56.668	1.7856	1000
1100	20.786	16.667	202.108	186.956	78.047	55.909	2.0530	1100
1200	20.786	18.746	203.917	188.295	80.126	55.120	2.2727	1200
1300	20.786	20.825	205.580	189.561	82.205	54.300	2.4559	1300
1400	20.786	22.903	207.121	190.761	84.283	53.447	2.6106	1400
1500	20.786	24.982	208.555	191.900	86.362	52.564	2.7425	1500
1600	20.786	27.061	209.896	192.984	88.441	51.649	2.8559	1600
1700	20.786	29.139	211.157	194.016	90.519	50.703	2.9542	1700
1800	20.786	31.218	212.345	195.001	92.598	49.725	3.0399	1800
1900	20.786	33.296	213.469	195.944	94.676	48.717	3.1151	1900
2000	20.786	35.375	214.535	196.847	96.755	47.676	3.1814	2000
2100	20.786	37.454	215.549	197.714	98.834			2100
2200	20.786	39.532	216.516	198.547	100.912			2200
2300	20.786	41.611	217.440	199.348	102.991			2300
2400	20.786	43.690	218.325	200.121	105.070			2400
2500	20.786	45.768	219.173	200.866	107.148			2500
2600	20.786	47.847	219.988	201.586	109.227			2600
2700	20.786	49.926	220.773	202.282	111.306			2700
2800	20.786	52.004	221.529	202.956	113.384			2800
2900	20.786	54.083	222.258	203.609	115.463			2900
3000	20.786	56.161	222.963	204.242	117.541			3000
3100	20.786	58.240	223.644	204.857	119.620			3100
3200	20.787	60.319	224.304	205.455	121.699			3200
3300	20.787	62.397	224.944	206.036	123.777			3300
3400	20.787	64.476	225.565	206.601	125.856			3400
3500	20.787	66.555	226.167	207.152	127.935			3500
3600	20.788	68.634	226.753	207.688	130.014			3600
3700	20.789	70.712	227.322	208.211	132.092			3700
3800	20.790	72.791	227.877	208.721	134.171			3800
3900	20.791	74.870	228.417	209.219	136.250			3900
4000	20.793	76.950	228.943	209.706	138.330			4000
4100	20.796	79.029	229.457	210.181	140.409			4100
4200	20.799	81.109	229.958	210.646	142.489			4200
4300	20.803	83.189	230.447	211.101	144.569			4300
4400	20.807	85.269	230.926	211.546	146.649			4400
4500	20.813	87.350	231.393	211.982	148.730			4500

TABLE A59.—THERMODYNAMIC PROPERTIES FOR Hg (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.821	89.432	231.851	212.409	150.812			4600
4700	20.829	91.514	232.299	212.828	152.894			4700
4800	20.840	93.598	232.737	213.238	154.978			4800
4900	20.852	95.682	233.167	213.640	157.062			4900
5000	20.866	97.768	233.589	214.035	159.148			5000
5100	20.883	99.856	234.002	214.422	161.236			5100
5200	20.902	101.945	234.408	214.803	163.325			5200
5300	20.924	104.036	234.806	215.176	165.416			5300
5400	20.949	106.130	235.197	215.544	167.510			5400
5500	20.978	108.226	235.582	215.904	169.606			5500
5600	21.010	110.326	235.960	216.259	171.706			5600
5700	21.046	112.428	236.332	216.608	173.808			5700
5800	21.087	114.535	236.699	216.951	175.915			5800
5900	21.132	116.646	237.060	217.289	178.026			5900
6000	21.182	118.762	237.415	217.622	180.142			6000
6200	21.335	123.052	238.119	218.272	184.432			6200
6400	21.452	127.331	238.798	218.903	188.711			6400
6600	21.589	131.634	239.460	219.516	193.014			6600
6800	21.751	135.968	240.107	220.112	197.348			6800
7000	21.942	140.337	240.740	220.692	201.717			7000
7200	22.168	144.747	241.362	221.258	206.127			7200
7400	22.432	149.206	241.972	221.809	210.586			7400
7600	22.738	153.723	242.575	222.348	215.103			7600
7800	23.088	158.304	243.170	222.874	219.684			7800
8000	23.484	162.961	243.759	223.389	224.341			8000
8500	24.686	174.991	245.217	224.630	236.371			8500
9000	26.186	187.696	246.669	225.814	249.076			9000
9500	27.968	201.224	248.132	226.950	262.604			9500
10000	29.997	215.706	249.617	228.046	277.086			10000
10500	32.224	231.254	251.134	229.110	292.634			10500
11000	34.593	247.953	252.687	230.146	309.333			11000
11500	37.043	265.860	254.279	231.160	327.240			11500
12000	39.509	284.998	255.907	232.157	346.378			12000
12500	41.928	305.362	257.569	233.141	366.742			12500
13000	44.236	326.908	259.259	234.113	388.288			13000
13500	46.377	349.569	260.970	235.076	410.949			13500
14000	48.296	373.248	262.692	236.031	434.628			14000
14500	49.947	397.821	264.416	236.980	459.201			14500
15000	51.292	423.144	266.133	237.923	484.524			15000
15500	52.298	449.056	267.832	238.861	510.436			15500
16000	52.944	475.382	269.504	239.792	536.762			16000
16500	53.218	501.938	271.138	240.718	563.318			16500
17000	53.118	528.538	272.726	241.636	589.918			17000
17500	52.652	554.995	274.260	242.546	616.375			17500
18000	51.840	581.133	275.733	243.448	642.513			18000
18500	50.711	606.783	277.138	244.339	668.163			18500
19000	49.309	631.798	278.473	245.220	693.178			19000
19500	47.687	656.054	279.733	246.089	717.434			19500
20000	45.911	679.459	280.918	246.945	740.839			20000

***Assigned reference element phase change at 234.29 K**

TABLE A60.—THERMODYNAMIC PROPERTIES FOR Hg^+

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K^\circ$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1068.446	1071.591	----------	0
*298.15	20.786	0.000	180.735	180.735	1074.643	1074.643	–181.7032	298.15
300	20.786	0.038	180.864	180.736	1074.682	1074.668	–180.5422	300
400	20.786	2.117	186.844	181.551	1076.760	1076.060	–133.7372	400
500	20.786	4.196	191.482	183.091	1078.839	1077.490	–105.6168	500
600	20.786	6.274	195.272	184.815	1080.917	1078.933	–86.8447	600
700	20.786	8.353	198.476	186.543	1082.996	1080.370	–73.4181	700
800	20.786	10.432	201.252	188.212	1085.075	1081.784	–63.3348	800
900	20.786	12.510	203.700	189.800	1087.153	1083.168	–55.4819	900
1000	20.786	14.589	205.890	191.301	1089.232	1084.520	–49.1918	1000
1100	20.786	16.667	207.871	192.719	1091.311	1085.840	–44.0389	1100
1200	20.786	18.746	209.680	194.058	1093.389	1087.129	–39.7396	1200
1300	20.786	20.825	211.344	195.325	1095.468	1088.388	–36.0976	1300
1400	20.786	22.903	212.884	196.524	1097.546	1089.614	–32.9722	1400
1500	20.786	24.982	214.318	197.663	1099.625	1090.809	–30.2605	1500
1600	20.786	27.061	215.660	198.747	1101.704	1091.972	–27.8853	1600
1700	20.786	29.139	216.920	199.779	1103.782	1093.106	–25.7873	1700
1800	20.786	31.218	218.108	200.765	1105.861	1094.206	–23.9204	1800
1900	20.786	33.296	219.232	201.707	1107.940	1095.276	–22.2485	1900
2000	20.786	35.375	220.298	202.610	1110.018	1096.314	–20.7422	2000
2100	20.786	37.454	221.312	203.477	1112.097			2100
2200	20.786	39.532	222.279	204.310	1114.176			2200
2300	20.786	41.611	223.203	205.111	1116.254			2300
2400	20.786	43.690	224.088	205.884	1118.333			2400
2500	20.786	45.768	224.936	206.629	1120.411			2500
2600	20.786	47.847	225.752	207.349	1122.490			2600
2700	20.786	49.926	226.536	208.045	1124.569			2700
2800	20.786	52.004	227.292	208.719	1126.647			2800
2900	20.786	54.083	228.021	209.372	1128.726			2900
3000	20.787	56.161	228.726	210.006	1130.805			3000
3100	20.787	58.240	229.408	210.621	1132.883			3100
3200	20.787	60.319	230.068	211.218	1134.962			3200
3300	20.787	62.398	230.707	211.799	1137.041			3300
3400	20.788	64.476	231.328	212.364	1139.119			3400
3500	20.789	66.555	231.930	212.915	1141.198			3500
3600	20.790	68.634	232.516	213.451	1143.277			3600
3700	20.791	70.713	233.086	213.974	1145.356			3700
3800	20.793	72.792	233.640	214.484	1147.435			3800
3900	20.795	74.872	234.180	214.982	1149.515			3900
4000	20.798	76.951	234.707	215.469	1151.594			4000
4100	20.801	79.031	235.220	215.945	1153.674			4100
4200	20.806	81.112	235.722	216.409	1155.755			4200
4300	20.811	83.192	236.211	216.864	1157.836			4300
4400	20.817	85.274	236.690	217.309	1159.917			4400
4500	20.825	87.356	237.158	217.745	1161.999			4500
4600	20.833	89.439	237.616	218.172	1164.082			4600
4700	20.843	91.523	238.064	218.591	1166.166			4700
4800	20.855	93.608	238.503	219.001	1168.251			4800
4900	20.868	95.694	238.933	219.404	1170.337			4900
5000	20.884	97.781	239.355	219.798	1172.424			5000

TABLE A60.—THERMODYNAMIC PROPERTIES FOR Hg^+ (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.901	99.870	239.768	220.186	1174.514			5100
5200	20.920	101.962	240.174	220.566	1176.605			5200
5300	20.942	104.055	240.573	220.940	1178.698			5300
5400	20.966	106.150	240.965	221.307	1180.793			5400
5500	20.993	108.248	241.350	221.668	1182.891			5500
5600	21.022	110.349	241.728	222.023	1184.992			5600
5700	21.054	112.452	242.101	222.372	1187.096			5700
5800	21.089	114.560	242.467	222.715	1189.203			5800
5900	21.127	116.670	242.828	223.053	1191.314			5900
6000	21.169	118.785	243.183	223.386	1193.428			6000
6200	21.261	123.028	243.879	224.036	1197.671			6200
6400	21.367	127.290	244.556	224.666	1201.934			6400
6600	21.487	131.576	245.215	225.279	1206.219			6600
6800	21.621	135.886	245.858	225.875	1210.529			6800
7000	21.771	140.225	246.487	226.455	1214.868			7000
7200	21.935	144.595	247.103	227.020	1219.238			7200
7400	22.115	149.000	247.706	227.571	1223.643			7400
7600	22.311	153.442	248.298	228.109	1228.086			7600
7800	22.521	157.925	248.881	228.634	1232.569			7800
8000	22.747	162.452	249.454	229.147	1237.095			8000
8500	23.375	173.979	250.851	230.383	1248.622			8500
9000	24.090	185.841	252.207	231.558	1260.484			9000
9500	24.886	198.082	253.530	232.680	1272.725			9500
10000	25.755	210.739	254.829	233.755	1285.383			10000
10500	26.691	223.848	256.108	234.789	1298.492			10500
11000	27.689	237.441	257.372	235.787	1312.084			11000
11500	28.742	251.546	258.626	236.752	1326.189			11500
12000	29.848	266.191	259.872	237.690	1340.834			12000
12500	31.003	281.401	261.114	238.602	1356.044			12500
13000	32.204	297.199	262.353	239.492	1371.842			13000
13500	33.449	313.606	263.591	240.361	1388.249			13500
14000	34.742	330.651	264.831	241.213	1405.294			14000
14500	36.073	348.348	266.073	242.049	1422.991			14500
15000	37.444	366.721	267.318	242.870	1441.364			15000
15500	38.848	385.786	268.568	243.679	1460.429			15500
16000	40.263	405.536	269.822	244.476	1480.179			16000
16500	41.688	425.987	271.081	245.263	1500.630			16500
17000	43.085	447.097	272.340	246.041	1521.740			17000
17500	44.509	468.965	273.608	246.810	1543.608			17500
18000	45.776	491.288	274.864	247.570	1565.931			18000
18500	47.131	514.495	276.136	248.325	1589.138			18500
19000	48.456	538.394	277.410	249.074	1613.037			19000
19500	49.727	562.942	278.686	249.817	1637.585			19500
20000	50.932	588.110	279.960	250.554	1662.753			20000

*Assigned reference element phase change at 234.29 K

TABLE A61.—THERMODYNAMIC PROPERTIES FOR I

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	100.563	107.161	----------	0
100	20.786	–4.119	158.081	199.269	102.641	107.714	–49.5986	100
200	20.786	–2.040	172.489	182.690	104.720	107.327	–21.5007	200
298.15	20.786	0.000	180.789	180.789	106.760	106.760	–12.2934	298.15
300	20.786	0.038	180.917	180.789	106.798	106.748	–12.1781	300
*400	20.786	2.117	186.897	181.604	108.877	97.974	–7.5816	400
500	20.786	4.196	191.535	183.144	110.956	96.074	–5.0458	500
600	20.786	6.274	195.325	184.868	113.034	94.175	–3.3886	600
700	20.786	8.353	198.529	186.597	115.113	92.276	–2.2286	700
800	20.787	10.432	201.305	188.265	117.192	90.377	–1.3763	800
900	20.790	12.510	203.754	189.853	119.270	88.478	–0.7273	900
1000	20.795	14.590	205.944	191.355	121.350	86.580	–0.2191	1000
1100	20.806	16.670	207.927	192.772	123.430	84.682	0.1877	1100
1200	20.824	18.751	209.738	194.112	125.511	82.786	0.5191	1200
1300	20.851	20.835	211.406	195.379	127.595	80.892	0.7932	1300
1400	20.889	22.922	212.952	196.579	129.682	79.001	1.0227	1400
1500	20.937	25.013	214.395	197.720	131.773	77.114	1.2169	1500
1600	20.995	27.109	215.748	198.804	133.869	75.233	1.3827	1600
1700	21.062	29.212	217.023	199.839	135.972	73.358	1.5255	1700
1800	21.138	31.322	218.229	200.827	138.082	71.490	1.6491	1800
1900	21.220	33.440	219.374	201.774	140.200	69.630	1.7569	1900
2000	21.308	35.566	220.464	202.681	142.326	67.779	1.8514	2000
2100	21.400	37.702	221.506	203.553	144.462	65.936	1.9345	2100
2200	21.493	39.846	222.504	204.392	146.606	64.103	2.0080	2200
2300	21.588	42.000	223.461	205.200	148.760	62.280	2.0733	2300
2400	21.682	44.164	224.382	205.980	150.924	60.465	2.1314	2400
2500	21.775	46.337	225.269	206.734	153.097	58.660	2.1832	2500
2600	21.866	48.519	226.125	207.464	155.279	56.865	2.2297	2600
2700	21.953	50.710	226.952	208.170	157.470	55.078	2.2713	2700
2800	22.037	52.909	227.752	208.855	159.669	53.300	2.3088	2800
2900	22.116	55.117	228.526	209.520	161.877	51.530	2.3425	2900
3000	22.191	57.332	229.277	210.167	164.092	49.767	2.3729	3000
3100	22.262	59.555	230.006	210.795	166.315	48.012	2.4004	3100
3200	22.327	61.785	230.714	211.406	168.545	46.264	2.4252	3200
3300	22.388	64.020	231.402	212.002	170.780	44.522	2.4477	3300
3400	22.443	66.262	232.071	212.582	173.022	42.786	2.4680	3400
3500	22.494	68.509	232.723	213.149	175.269	41.055	2.4864	3500
3600	22.540	70.761	233.357	213.701	177.521	39.329	2.5030	3600
3700	22.581	73.017	233.975	214.241	179.777	37.607	2.5181	3700
3800	22.618	75.277	234.578	214.768	182.037	35.890	2.5318	3800
3900	22.651	77.540	235.166	215.284	184.300	34.175	2.5441	3900
4000	22.680	79.807	235.739	215.788	186.567	32.464	2.5553	4000
4100	22.704	82.076	236.300	216.281	188.836	30.756	2.5654	4100
4200	22.725	84.347	236.847	216.764	191.107	29.049	2.5744	4200
4300	22.743	86.621	237.382	217.238	193.381	27.345	2.5826	4300
4400	22.758	88.896	237.905	217.702	195.656	25.642	2.5899	4400
4500	22.769	91.172	238.417	218.156	197.932	23.941	2.5965	4500

TABLE A61.—THERMODYNAMIC PROPERTIES FOR I (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	22.778	93.450	238.917	218.602	200.210	22.241	2.6023	4600
4700	22.784	95.728	239.407	219.040	202.488	20.541	2.6075	4700
4800	22.787	98.006	239.887	219.469	204.766	18.842	2.6120	4800
4900	22.789	100.285	240.357	219.890	207.045	17.143	2.6160	4900
5000	22.788	102.564	240.817	220.304	209.324	15.444	2.6195	5000
5100	22.786	104.843	241.268	220.711	211.603	13.745	2.6225	5100
5200	22.782	107.121	241.711	221.111	213.881	12.046	2.6250	5200
5300	22.777	109.399	242.145	221.503	216.159	10.346	2.6271	5300
5400	22.770	111.677	242.570	221.890	218.437	8.645	2.6289	5400
5500	22.762	113.953	242.988	222.269	220.713	6.944	2.6302	5500
5600	22.753	116.229	243.398	222.643	222.989	5.242	2.6313	5600
5700	22.743	118.504	243.801	223.011	225.264	3.539	2.6320	5700
5800	22.733	120.778	244.196	223.373	227.538	1.835	2.6324	5800
5900	22.722	123.050	244.585	223.729	229.810	0.130	2.6326	5900
6000	22.711	125.322	244.967	224.080	232.082	–1.576	2.6325	6000
6200	22.688	129.862	245.711	224.766	236.622			6200
6400	22.665	134.397	246.431	225.431	241.157			6400
6600	22.644	138.928	247.128	226.078	245.688			6600
6800	22.627	143.455	247.804	226.707	250.215			6800
7000	22.615	147.979	248.459	227.320	254.739			7000
7200	22.609	152.501	249.096	227.916	259.261			7200
7400	22.610	157.022	249.716	228.497	263.782			7400
7600	22.620	161.544	250.319	229.063	268.304			7600
7800	22.638	166.068	250.906	229.615	272.828			7800
8000	22.671	170.597	251.480	230.155	277.357			8000
8500	22.820	181.962	252.857	231.450	288.722			8500
9000	23.101	193.436	254.169	232.676	300.196			9000
9500	23.553	204.989	255.420	233.842	311.749			9500
10000	24.214	216.925	256.644	234.951	323.685			10000
10500	25.016	229.226	257.845	236.014	335.986			10500
11000	25.935	241.960	259.029	237.033	348.720			11000
11500	26.951	255.178	260.204	238.015	361.938			11500
12000	28.040	268.923	261.374	238.964	375.683			12000
12500	29.181	283.227	262.541	239.883	389.987			12500
13000	30.352	298.109	263.709	240.777	404.869			13000
13500	31.534	313.580	264.876	241.648	420.340			13500
14000	32.707	329.641	266.044	242.499	436.401			14000
14500	33.855	346.283	267.213	243.331	453.043			14500
15000	34.963	363.489	268.379	244.146	470.249			15000
15500	36.015	381.237	269.542	244.946	487.997			15500
16000	37.000	399.493	270.701	245.733	506.253			16000
16500	37.907	418.224	271.855	246.508	524.984			16500
17000	38.726	437.385	272.999	247.270	544.145			17000
17500	39.449	456.933	274.132	248.021	563.693			17500
18000	40.071	476.818	275.252	248.762	583.578			18000
18500	40.586	496.986	276.357	249.493	603.746			18500
19000	40.990	517.385	277.445	250.214	624.145			19000
19500	41.282	537.958	278.514	250.926	644.718			19500
20000	41.461	558.647	279.561	251.629	665.407			20000

***Assigned reference element phase change at 386.75 K**

TABLE A62.—THERMODYNAMIC PROPERTIES FOR I^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1115.154	1115.554	----------	0
298.15	20.786	0.000	182.644	182.644	1121.351	1121.351	–188.8483	298.15
300	20.786	0.038	182.772	182.644	1121.389	1121.377	–187.6369	300
*400	20.786	2.117	188.752	183.460	1123.468	1114.682	–138.8349	400
500	20.786	4.196	193.391	184.999	1125.547	1114.861	–109.7210	500
600	20.786	6.274	197.180	186.723	1127.625	1115.041	–90.3085	600
700	20.787	8.353	200.385	188.452	1129.704	1115.220	–76.4403	700
800	20.791	10.432	203.161	190.121	1131.783	1115.400	–66.0374	800
900	20.800	12.511	205.610	191.708	1133.862	1115.580	–57.9450	900
1000	20.819	14.592	207.802	193.210	1135.943	1115.762	–51.4700	1000
1100	20.852	16.676	209.788	194.628	1138.027	1115.946	–46.1714	1100
1200	20.904	18.763	211.604	195.968	1140.114	1116.135	–41.7551	1200
1300	20.974	20.857	213.280	197.236	1142.208	1116.329	–38.0177	1300
1400	21.066	22.959	214.838	198.439	1144.310	1116.532	–34.8136	1400
1500	21.177	25.071	216.295	199.581	1146.422	1116.745	–32.0361	1500
1600	21.306	27.195	217.666	200.669	1148.546	1116.970	–29.6054	1600
1700	21.450	29.332	218.962	201.707	1150.683	1117.208	–27.4602	1700
1800	21.608	31.485	220.192	202.700	1152.836	1117.462	–25.5530	1800
1900	21.776	33.654	221.365	203.652	1155.005	1117.732	–23.8461	1900
2000	21.953	35.841	222.486	204.566	1157.192	1118.019	–22.3095	2000
2100	22.135	38.045	223.562	205.445	1159.396	1118.325	–20.9189	2100
2200	22.320	40.268	224.596	206.292	1161.619	1118.648	–19.6544	2200
2300	22.507	42.509	225.592	207.110	1163.860	1118.990	–18.4994	2300
2400	22.694	44.769	226.554	207.900	1166.120	1119.351	–17.4404	2400
2500	22.879	47.048	227.484	208.665	1168.399	1119.731	–16.4658	2500
2600	23.062	49.345	228.385	209.406	1170.696	1120.129	–15.5658	2600
2700	23.242	51.660	229.259	210.125	1173.011	1120.545	–14.7322	2700
2800	23.417	53.993	230.107	210.824	1175.344	1120.979	–13.9579	2800
2900	23.587	56.343	230.932	211.503	1177.694	1121.430	–13.2367	2900
3000	23.752	58.710	231.734	212.164	1180.061	1121.898	–12.5632	3000
3100	23.910	61.093	232.516	212.808	1182.444	1122.382	–11.9330	3100
3200	24.062	63.492	233.277	213.436	1184.843	1122.881	–11.3419	3200
3300	24.208	65.906	234.020	214.048	1187.257	1123.396	–10.7863	3300
3400	24.347	68.334	234.744	214.646	1189.685	1123.924	–10.2632	3400
3500	24.478	70.775	235.452	215.231	1192.126	1124.467	–9.7698	3500
3600	24.603	73.229	236.144	215.802	1194.580	1125.022	–9.3035	3600
3700	24.720	75.695	236.819	216.361	1197.046	1125.589	–8.8622	3700
3800	24.831	78.173	237.480	216.908	1199.524	1126.167	–8.4440	3800
3900	24.934	80.661	238.126	217.444	1202.012	1126.756	–8.0470	3900
4000	25.030	83.159	238.759	217.969	1204.510	1127.355	–7.6696	4000
4100	25.119	85.667	239.378	218.484	1207.018	1127.964	–7.3104	4100
4200	25.201	88.183	239.984	218.988	1209.534	1128.581	–6.9682	4200
4300	25.276	90.707	240.578	219.484	1212.058	1129.205	–6.6417	4300
4400	25.345	93.238	241.160	219.970	1214.589	1129.837	–6.3299	4400
4500	25.408	95.775	241.730	220.447	1217.126	1130.476	–6.0317	4500
4600	25.464	98.319	242.289	220.916	1219.670	1131.120	–5.7464	4600
4700	25.514	100.868	242.838	221.376	1222.219	1131.770	–5.4730	4700
4800	25.559	103.422	243.375	221.829	1224.773	1132.425	–5.2109	4800
4900	25.598	105.980	243.903	222.274	1227.331	1133.084	–4.9594	4900
5000	25.632	108.541	244.420	222.712	1229.892	1133.746	–4.7177	5000

TABLE A62.—THERMODYNAMIC PROPERTIES FOR I^+ (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K^\circ$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	25.661	111.106	244.928	223.142	1232.457	1134.412	–4.4854	5100
5200	25.686	113.673	245.427	223.566	1235.024	1135.080	–4.2619	5200
5300	25.705	116.243	245.916	223.983	1237.594	1135.750	–4.0467	5300
5400	25.721	118.814	246.397	224.394	1240.165	1136.423	–3.8394	5400
5500	25.732	121.387	246.869	224.798	1242.738	1137.096	–3.6395	5500
5600	25.739	123.961	247.332	225.197	1245.312	1137.771	–3.4466	5600
5700	25.743	126.535	247.788	225.589	1247.886	1138.446	–3.2603	5700
5800	25.744	129.109	248.236	225.976	1250.460	1139.121	–3.0804	5800
5900	25.741	131.683	248.676	226.357	1253.034	1139.796	–2.9065	5900
6000	25.735	134.257	249.108	226.732	1255.608	1140.471	–2.7382	6000
6200	25.715	139.402	249.952	227.468	1260.753			6200
6400	25.685	144.542	250.768	228.183	1265.893			6400
6600	25.647	149.676	251.558	228.880	1271.027			6600
6800	25.602	154.801	252.323	229.558	1276.152			6800
7000	25.550	159.916	253.064	230.219	1281.267			7000
7200	25.494	165.020	253.783	230.864	1286.371			7200
7400	25.433	170.113	254.481	231.492	1291.464			7400
7600	25.369	175.193	255.158	232.106	1296.544			7600
7800	25.303	180.261	255.816	232.706	1301.612			7800
8000	25.235	185.314	256.456	233.292	1306.665			8000
8500	25.061	197.888	257.981	234.700	1319.239			8500
9000	24.887	210.375	259.408	236.033	1331.726			9000
9500	24.722	222.777	260.749	237.299	1344.128			9500
10000	24.572	235.100	262.013	238.503	1356.451			10000
10500	24.443	247.352	263.209	239.652	1368.703			10500
11000	24.344	259.548	264.344	240.749	1380.899			11000
11500	24.282	271.702	265.424	241.798	1393.053			11500
12000	24.268	283.837	266.457	242.804	1405.188			12000
12500	24.312	295.977	267.448	243.770	1417.328			12500
13000	24.429	308.157	268.404	244.699	1429.508			13000
13500	24.629	320.411	269.329	245.595	1441.762			13500
14000	24.924	332.781	270.228	246.458	1454.132			14000
14500	25.328	345.317	271.108	247.293	1466.668			14500
15000	25.857	358.078	271.973	248.101	1479.429			15000
15500	26.518	371.117	272.828	248.885	1492.468			15500
16000	27.293	384.462	273.675	249.646	1505.813			16000
16500	28.231	398.230	274.521	250.386	1519.581			16500
17000	29.296	412.435	275.369	251.108	1533.786			17000
17500	30.484	427.130	276.219	251.812	1548.481			17500
18000	31.668	442.160	277.063	252.499	1563.511			18000
18500	33.013	457.846	277.920	253.172	1579.197			18500
19000	34.331	473.908	278.773	253.830	1595.259			19000
19500	35.841	490.811	279.648	254.478	1612.162			19500
20000	37.014	507.517	280.486	255.110	1628.868			20000

*Assigned reference element phase change at 386.75 K

TABLE A63.—THERMODYNAMIC PROPERTIES FOR I^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–200.793	–187.998	----------	0
298.15	20.786	0.000	169.262	169.262	–194.596	–194.596	38.8036	298.15
300	20.786	0.038	169.391	169.263	–194.557	–194.646	38.5934	300
*400	20.786	2.117	175.371	170.078	–192.478	–205.499	30.0300	400
500	20.786	4.196	180.009	171.618	–190.400	–209.477	24.6149	500
600	20.786	6.274	183.799	173.342	–188.321	–213.455	20.9352	600
700	20.786	8.353	187.003	175.070	–186.243	–217.432	18.2571	700
800	20.786	10.432	189.779	176.739	–184.164	–221.410	16.2113	800
900	20.786	12.510	192.227	178.327	–182.085	–225.388	14.5912	900
1000	20.786	14.589	194.417	179.828	–180.007	–229.366	13.2719	1000
1100	20.786	16.667	196.398	181.246	–177.928	–233.343	12.1737	1100
1200	20.786	18.746	198.207	182.585	–175.849	–237.321	11.2427	1200
1300	20.786	20.825	199.871	183.852	–173.771	–241.299	10.4416	1300
1400	20.786	22.903	201.411	185.051	–171.692	–245.277	9.7435	1400
1500	20.786	24.982	202.845	186.190	–169.614	–249.254	9.1286	1500
1600	20.786	27.061	204.187	187.274	–167.535	–253.232	8.5819	1600
1700	20.786	29.139	205.447	188.306	–165.456	–257.210	8.0918	1700
1800	20.786	31.218	206.635	189.292	–163.378	–261.188	7.6494	1800
1900	20.786	33.296	207.759	190.234	–161.299	–265.165	7.2475	1900
2000	20.786	35.375	208.825	191.137	–159.220	–269.143	6.8804	2000
2100	20.786	37.454	209.839	192.004	–157.142	–273.121	6.5432	2100
2200	20.786	39.532	210.806	192.837	–155.063	–277.099	6.2322	2200
2300	20.786	41.611	211.730	193.638	–152.985	–281.076	5.9442	2300
2400	20.786	43.690	212.615	194.411	–150.906	–285.054	5.6763	2400
2500	20.786	45.768	213.463	195.156	–148.827	–289.032	5.4265	2500
2600	20.786	47.847	214.278	195.876	–146.749	–293.010	5.1926	2600
2700	20.786	49.926	215.063	196.572	–144.670	–296.987	4.9731	2700
2800	20.786	52.004	215.819	197.246	–142.591	–300.965	4.7666	2800
2900	20.786	54.083	216.548	197.899	–140.513	–304.943	4.5717	2900
3000	20.786	56.161	217.253	198.533	–138.434	–308.921	4.3875	3000
3100	20.786	58.240	217.935	199.148	–136.356	–312.898	4.2129	3100
3200	20.786	60.319	218.595	199.745	–134.277	–316.876	4.0471	3200
3300	20.786	62.397	219.234	200.326	–132.198	–320.854	3.8894	3300
3400	20.786	64.476	219.855	200.891	–130.120	–324.832	3.7391	3400
3500	20.786	66.555	220.457	201.442	–128.041	–328.809	3.5956	3500
3600	20.786	68.633	221.043	201.978	–125.962	–332.787	3.4585	3600
3700	20.786	70.712	221.612	202.501	–123.884	–336.765	3.3272	3700
3800	20.786	72.790	222.167	203.011	–121.805	–340.743	3.2014	3800
3900	20.786	74.869	222.707	203.509	–119.727	–344.720	3.0806	3900
4000	20.786	76.948	223.233	203.996	–117.648	–348.698	2.9645	4000
4100	20.786	79.026	223.746	204.471	–115.569	–352.676	2.8528	4100
4200	20.786	81.105	224.247	204.936	–113.491	–356.654	2.7452	4200
4300	20.786	83.184	224.736	205.391	–111.412	–360.631	2.6415	4300
4400	20.786	85.262	225.214	205.836	–109.333	–364.609	2.5414	4400
4500	20.786	87.341	225.681	206.272	–107.255	–368.587	2.4447	4500
4600	20.786	89.419	226.138	206.699	–105.176	–372.565	2.3512	4600
4700	20.786	91.498	226.585	207.117	–103.098	–376.542	2.2607	4700
4800	20.786	93.577	227.023	207.528	–101.019	–380.520	2.1731	4800
4900	20.786	95.655	227.451	207.930	–98.940	–384.498	2.0881	4900
5000	20.786	97.734	227.871	208.324	–96.862	–388.476	2.0057	5000

TABLE A63.—THERMODYNAMIC PROPERTIES FOR I^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	228.283	208.712	–94.783	–392.453	1.9258	5100
5200	20.786	101.891	228.686	209.092	–92.704	–396.431	1.8481	5200
5300	20.786	103.970	229.082	209.465	–90.626	–400.409	1.7726	5300
5400	20.786	106.048	229.471	209.832	–88.547	–404.387	1.6991	5400
5500	20.786	108.127	229.852	210.193	–86.468	–408.364	1.6277	5500
5600	20.786	110.206	230.227	210.547	–84.390	–412.342	1.5581	5600
5700	20.786	112.284	230.595	210.896	–82.311	–416.320	1.4903	5700
5800	20.786	114.363	230.956	211.239	–80.233	–420.298	1.4242	5800
5900	20.786	116.442	231.312	211.576	–78.154	–424.275	1.3597	5900
6000	20.786	118.520	231.661	211.908	–76.075	–428.253	1.2968	6000
6200	20.786	122.677	232.343	212.556	–71.918			6200
6400	20.786	126.835	233.002	213.185	–67.761			6400
6600	20.786	130.992	233.642	213.795	–63.604			6600
6800	20.786	135.149	234.263	214.388	–59.446			6800
7000	20.786	139.306	234.865	214.964	–55.289			7000
7200	20.786	143.464	235.451	215.525	–51.132			7200
7400	20.786	147.621	236.020	216.071	–46.975			7400
7600	20.786	151.778	236.575	216.604	–42.817			7600
7800	20.786	155.936	237.115	217.123	–38.660			7800
8000	20.786	160.093	237.641	217.629	–34.503			8000
8500	20.786	170.486	238.901	218.844	–24.110			8500
9000	20.786	180.879	240.089	219.991	–13.717			9000
9500	20.786	191.272	241.213	221.079	–3.323			9500
10000	20.786	201.665	242.279	222.113	7.070			10000
10500	20.786	212.058	243.293	223.097	17.463			10500
11000	20.786	222.452	244.260	224.037	27.856			11000
11500	20.786	232.845	245.184	224.937	38.249			11500
12000	20.786	243.238	246.069	225.799	48.642			12000
12500	20.786	253.631	246.917	226.627	59.035			12500
13000	20.786	264.024	247.733	227.423	69.429			13000
13500	20.786	274.417	248.517	228.190	79.822			13500
14000	20.786	284.810	249.273	228.930	90.215			14000
14500	20.786	295.204	250.003	229.644	100.608			14500
15000	20.786	305.597	250.707	230.334	111.001			15000
15500	20.786	315.990	251.389	231.002	121.394			15500
16000	20.786	326.383	252.049	231.650	131.787			16000
16500	20.786	336.776	252.688	232.278	142.181			16500
17000	20.786	347.169	253.309	232.887	152.574			17000
17500	20.786	357.562	253.911	233.479	162.967			17500
18000	20.786	367.956	254.497	234.055	173.360			18000
18500	20.786	378.349	255.067	234.615	183.753			18500
19000	20.786	388.742	255.621	235.161	194.146			19000
19500	20.786	399.135	256.161	235.692	204.539			19500
20000	20.786	409.528	256.687	236.211	214.933			20000

*Assigned reference element phase change at 386.75 K

TABLE A64.—THERMODYNAMIC PROPERTIES FOR K

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	82.803	89.891	----------	0
100	20.786	–4.119	137.634	178.822	84.881	90.236	–41.8033	100
200	20.786	–2.040	152.042	162.243	86.960	89.723	–18.2837	200
298.15	20.786	0.000	160.342	160.342	89.000	89.000	–10.5953	298.15
300	20.786	0.038	160.470	160.342	89.038	88.983	–10.4991	300
*400	20.786	2.117	166.450	161.157	91.117	85.598	–6.7031	400
500	20.786	4.196	171.088	162.697	93.196	84.564	–4.4802	500
600	20.786	6.274	174.878	164.421	95.274	83.599	–3.0158	600
700	20.786	8.353	178.082	166.150	97.353	82.680	–1.9816	700
800	20.786	10.432	180.858	167.819	99.432	81.777	–1.2144	800
900	20.786	12.510	183.306	169.406	101.510	80.859	–0.6243	900
1000	20.786	14.589	185.496	170.908	103.589	79.898	–0.1577	1000
1100	20.787	16.667	187.478	172.325	105.667	78.860	0.2193	1100
1200	20.787	18.746	189.286	173.664	107.746	77.716	0.5292	1200
1300	20.789	20.825	190.950	174.931	109.825	76.433	0.7874	1300
1400	20.793	22.904	192.491	176.131	111.904	74.981	1.0048	1400
1500	20.801	24.984	193.926	177.270	113.984	73.328	1.1893	1500
1600	20.814	27.064	195.269	178.353	116.064	71.442	1.3469	1600
1700	20.836	29.147	196.531	179.386	118.147	69.295	1.4821	1700
1800	20.868	31.232	197.723	180.372	120.232	66.853	1.5985	1800
1900	20.914	33.321	198.852	181.315	122.321	64.087	1.6985	1900
2000	20.976	35.415	199.927	182.219	124.415	60.966	1.7846	2000
2100	21.056	37.517	200.952	183.087	126.517	57.462	1.8583	2100
2200	21.158	39.627	201.934	183.921	128.627	53.543	1.9211	2200
2300	21.282	41.749	202.877	184.725	130.749			2300
2400	21.431	43.884	203.786	185.500	132.884			2400
2500	21.607	46.036	204.664	186.249	135.036			2500
2600	21.811	48.207	205.515	186.974	137.207			2600
2700	22.045	50.399	206.343	187.676	139.399			2700
2800	22.309	52.617	207.149	188.357	141.617			2800
2900	22.606	54.862	207.937	189.019	143.862			2900
3000	22.936	57.139	208.709	189.663	146.139			3000
3100	23.302	59.450	209.467	190.289	148.450			3100
3200	23.704	61.800	210.213	190.900	150.800			3200
3300	24.138	64.190	210.948	191.497	153.190			3300
3400	24.614	66.627	211.676	192.079	155.627			3400
3500	25.122	69.111	212.396	192.649	158.111			3500
3600	25.678	71.651	213.111	193.208	160.651			3600
3700	26.277	74.248	213.822	193.755	163.248			3700
3800	26.917	76.906	214.531	194.293	165.906			3800
3900	27.601	79.630	215.239	194.821	168.630			3900
4000	28.309	82.418	215.945	195.340	171.418			4000
4100	29.062	85.281	216.651	195.851	174.281			4100
4200	29.840	88.252	217.369	196.356	177.252			4200
4300	30.645	91.276	218.080	196.853	180.276			4300
4400	31.475	94.382	218.794	197.344	183.382			4400
4500	32.329	97.572	219.511	197.828	186.572			4500

TABLE A64.—THERMODYNAMIC PROPERTIES FOR K (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	33.201	100.848	220.231	198.308	189.848			4600
4700	34.088	104.213	220.955	198.782	193.213			4700
4800	34.986	107.666	221.682	199.251	196.666			4800
4900	35.888	111.210	222.412	199.717	200.210			4900
5000	36.790	114.844	223.146	200.178	203.844			5000
5100	37.966	118.585	223.887	200.635	207.585			5100
5200	39.016	122.435	224.635	201.090	211.435			5200
5300	39.995	126.386	225.387	201.541	215.386			5300
5400	40.904	130.431	226.144	201.990	219.431			5400
5500	41.744	134.564	226.902	202.436	223.564			5500
5600	42.514	138.778	227.661	202.879	227.778			5600
5700	43.217	143.065	228.420	203.321	232.065			5700
5800	43.855	147.419	229.177	203.760	236.419			5800
5900	44.428	151.834	229.932	204.197	240.834			5900
6000	44.940	156.303	230.683	204.632	245.303			6000
6200	45.786	165.379	232.171	205.497	254.379			6200
6400	46.414	174.603	233.635	206.353	263.603			6400
6600	46.842	183.931	235.070	207.202	272.931			6600
6800	47.089	193.328	236.473	208.042	282.328			6800
7000	47.175	202.756	237.839	208.874	291.756			7000
7200	47.117	212.188	239.168	209.697	301.188			7200
7400	46.934	221.595	240.457	210.511	310.595			7400
7600	46.641	230.954	241.705	211.316	319.954			7600
7800	46.254	240.245	242.911	212.111	329.245			7800
8000	45.786	249.450	244.077	212.895	338.450			8000
8500	44.345	271.997	246.811	214.811	360.997			8500
9000	42.648	293.753	249.298	216.659	382.753			9000
9500	40.828	314.624	251.556	218.437	403.624			9500
10000	38.985	334.576	253.603	220.145	423.576			10000
10500	37.191	353.617	255.461	221.783	442.617			10500
11000	35.499	371.785	257.152	223.353	460.785			11000
11500	33.939	389.138	258.695	224.857	478.138			11500
12000	32.530	405.749	260.109	226.297	494.749			12000
12500	31.278	421.694	261.411	227.675	510.694			12500
13000	30.183	437.054	262.616	228.996	526.054			13000
13500	29.235	451.902	263.737	230.263	540.902			13500
14000	28.422	466.311	264.785	231.477	555.311			14000
14500	27.728	480.345	265.770	232.643	569.345			14500
15000	27.135	494.056	266.700	233.763	583.056			15000
15500	26.625	507.493	267.581	234.839	596.493			15500
16000	26.178	520.691	268.419	235.876	609.691			16000
16500	25.779	533.679	269.218	236.874	622.679			16500
17000	25.411	546.477	269.982	237.837	635.477			17000
17500	25.061	559.094	270.714	238.766	648.094			17500
18000	24.718	571.538	271.415	239.663	660.538			18000
18500	24.375	583.812	272.088	240.530	672.812			18500
19000	24.026	595.913	272.733	241.369	684.913			19000
19500	23.672	607.837	273.353	242.182	696.837			19500
20000	23.316	619.584	273.948	242.968	708.584			20000

***Assigned reference element phase change at 336.86 K**

TABLE A65.—THERMODYNAMIC PROPERTIES FOR K^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	507.810	508.701	----------	0
298.15	20.786	0.000	154.578	154.578	514.008	514.008	–84.2582	298.15
300	20.786	0.038	154.707	154.579	514.046	514.029	–83.7029	300
*400	20.786	2.117	160.687	155.394	516.125	512.723	–61.3646	400
500	20.786	4.196	165.325	156.934	518.203	513.767	–47.9615	500
600	20.786	6.274	169.115	158.658	520.282	514.881	–39.0072	600
700	20.786	8.353	172.319	160.386	522.360	516.040	–32.5971	700
800	20.786	10.432	175.095	162.055	524.439	517.216	–27.7785	800
900	20.786	12.510	177.543	163.643	526.518	518.377	–24.0223	900
1000	20.786	14.589	179.733	165.144	528.596	519.494	–21.0106	1000
1100	20.786	16.667	181.714	166.562	530.675	520.535	–18.5414	1100
1200	20.786	18.746	183.523	167.901	532.754	521.470	–16.4798	1200
1300	20.786	20.825	185.187	169.168	534.832	522.265	–14.7324	1300
1400	20.786	22.903	186.727	170.368	536.911	522.891	–13.2326	1400
1500	20.786	24.982	188.161	171.506	538.990	523.315	–11.9314	1500
1600	20.786	27.061	189.503	172.590	541.068	523.507	–10.7922	1600
1700	20.786	29.139	190.763	173.622	543.147	523.434	–9.7870	1700
1800	20.786	31.218	191.951	174.608	545.225	523.064	–8.8937	1800
1900	20.786	33.296	193.075	175.550	547.304	522.367	–8.0954	1900
2000	20.786	35.375	194.141	176.453	549.383	521.309	–7.3779	2000
2100	20.786	37.454	195.155	177.320	551.461	519.860	–6.7305	2100
2200	20.786	39.532	196.122	178.153	553.540	517.988	–6.1438	2200
2300	20.786	41.611	197.046	178.954	555.619			2300
2400	20.786	43.690	197.931	179.727	557.697			2400
2500	20.786	45.768	198.779	180.472	559.776			2500
2600	20.786	47.847	199.595	181.192	561.854			2600
2700	20.786	49.926	200.379	181.888	563.933			2700
2800	20.786	52.004	201.135	182.562	566.012			2800
2900	20.786	54.083	201.864	183.215	568.090			2900
3000	20.786	56.161	202.569	183.849	570.169			3000
3100	20.786	58.240	203.251	184.464	572.248			3100
3200	20.786	60.319	203.911	185.061	574.326			3200
3300	20.786	62.397	204.550	185.642	576.405			3300
3400	20.786	64.476	205.171	186.207	578.483			3400
3500	20.786	66.555	205.773	186.758	580.562			3500
3600	20.786	68.633	206.359	187.294	582.641			3600
3700	20.786	70.712	206.928	187.817	584.719			3700
3800	20.786	72.790	207.483	188.327	586.798			3800
3900	20.786	74.869	208.023	188.825	588.877			3900
4000	20.786	76.948	208.549	189.312	590.955			4000
4100	20.786	79.026	209.062	189.787	593.034			4100
4200	20.786	81.105	209.563	190.252	595.112			4200
4300	20.786	83.184	210.052	190.707	597.191			4300
4400	20.786	85.262	210.530	191.152	599.270			4400
4500	20.786	87.341	210.997	191.588	601.348			4500
4600	20.786	89.419	211.454	192.015	603.427			4600
4700	20.786	91.498	211.901	192.433	605.506			4700
4800	20.786	93.577	212.339	192.844	607.584			4800
4900	20.786	95.655	212.767	193.246	609.663			4900
5000	20.786	97.734	213.187	193.640	611.741			5000

TABLE A65.—THERMODYNAMIC PROPERTIES FOR K^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	213.599	194.028	613.820			5100
5200	20.786	101.891	214.003	194.408	615.899			5200
5300	20.786	103.970	214.398	194.782	617.977			5300
5400	20.786	106.048	214.787	195.148	620.056			5400
5500	20.786	108.127	215.168	195.509	622.135			5500
5600	20.786	110.206	215.543	195.863	624.213			5600
5700	20.786	112.284	215.911	196.212	626.292			5700
5800	20.786	114.363	216.272	196.555	628.370			5800
5900	20.786	116.442	216.628	196.892	630.449			5900
6000	20.786	118.520	216.977	197.224	632.528			6000
6200	20.786	122.677	217.659	197.872	636.685			6200
6400	20.786	126.835	218.319	198.501	640.842			6400
6600	20.786	130.992	218.958	199.111	645.000			6600
6800	20.786	135.149	219.579	199.704	649.157			6800
7000	20.786	139.306	220.181	200.280	653.314			7000
7200	20.786	143.464	220.767	200.841	657.471			7200
7400	20.786	147.621	221.336	201.388	661.629			7400
7600	20.786	151.778	221.891	201.920	665.786			7600
7800	20.786	155.936	222.431	202.439	669.943			7800
8000	20.786	160.093	222.957	202.945	674.100			8000
8500	20.786	170.486	224.217	204.160	684.493			8500
9000	20.786	180.879	225.405	205.307	694.887			9000
9500	20.786	191.272	226.529	206.395	705.280			9500
10000	20.786	201.665	227.595	207.429	715.673			10000
10500	20.786	212.058	228.609	208.413	726.066			10500
11000	20.786	222.452	229.576	209.353	736.459			11000
11500	20.786	232.845	230.500	210.253	746.852			11500
12000	20.787	243.238	231.385	211.115	757.246			12000
12500	20.787	253.631	232.234	211.943	767.639			12500
13000	20.787	264.025	233.049	212.739	778.032			13000
13500	20.788	274.419	233.833	213.506	788.426			13500
14000	20.790	284.814	234.589	214.246	798.821			14000
14500	20.793	295.209	235.319	214.960	809.217			14500
15000	20.797	305.607	236.024	215.650	819.614			15000
15500	20.804	316.007	236.706	216.319	830.015			15500
16000	20.814	326.411	237.367	216.966	840.419			16000
16500	20.828	336.822	238.007	217.594	850.829			16500
17000	20.848	347.240	238.629	218.204	861.248			17000
17500	20.875	357.671	239.234	218.796	871.678			17500
18000	20.912	368.117	239.823	219.372	882.124			18000
18500	20.960	378.584	240.396	219.932	892.592			18500
19000	21.024	389.080	240.956	220.478	903.087			19000
19500	21.105	399.611	241.503	221.010	913.618			19500
20000	21.208	410.188	242.039	221.529	924.196			20000

*Assigned reference element phase change at 336.86 K

TABLE A66.—THERMODYNAMIC PROPERTIES FOR K^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	28.221	41.506	----------	0
298.15	20.786	0.000	154.579	154.579	34.418	34.418	–2.4299	298.15
300	20.786	0.038	154.707	154.579	34.457	34.363	–2.3927	300
*400	20.786	2.117	160.687	155.394	36.535	28.899	–1.0150	400
500	20.786	4.196	165.325	156.934	38.614	25.786	–0.2981	500
600	20.786	6.274	169.115	158.658	40.692	22.743	0.1260	600
700	20.786	8.353	172.319	160.387	42.771	19.745	0.3911	700
800	20.786	10.432	175.095	162.056	44.850	16.763	0.5620	800
900	20.786	12.510	177.543	163.643	46.928	13.767	0.6732	900
1000	20.786	14.589	179.733	165.145	49.007	10.727	0.7446	1000
1100	20.786	16.667	181.715	166.562	51.086	7.611	0.7884	1100
1200	20.786	18.746	183.523	167.901	53.164	4.388	0.8123	1200
1300	20.786	20.825	185.187	169.168	55.243	1.026	0.8216	1300
1400	20.786	22.903	186.727	170.368	57.321	–2.505	0.8196	1400
1500	20.786	24.982	188.161	171.507	59.400	–6.238	0.8090	1500
1600	20.786	27.061	189.503	172.590	61.479	–10.204	0.7912	1600
1700	20.786	29.139	190.763	173.622	63.557	–14.434	0.7676	1700
1800	20.786	31.218	191.951	174.608	65.636	–18.961	0.7393	1800
1900	20.786	33.296	193.075	175.551	67.715	–23.816	0.7067	1900
2000	20.786	35.375	194.141	176.454	69.793	–29.031	0.6705	2000
2100	20.786	37.454	195.156	177.320	71.872	–34.637	0.6310	2100
2200	20.786	39.532	196.122	178.153	73.951	–40.666	0.5885	2200
2300	20.786	41.611	197.046	178.955	76.029			2300
2400	20.786	43.690	197.931	179.727	78.108			2400
2500	20.786	45.768	198.780	180.472	80.186			2500
2600	20.786	47.847	199.595	181.192	82.265			2600
2700	20.786	49.926	200.379	181.888	84.344			2700
2800	20.786	52.004	201.135	182.562	86.422			2800
2900	20.786	54.083	201.865	183.216	88.501			2900
3000	20.786	56.161	202.569	183.849	90.580			3000
3100	20.786	58.240	203.251	184.464	92.658			3100
3200	20.786	60.319	203.911	185.061	94.737			3200
3300	20.786	62.397	204.551	185.642	96.815			3300
3400	20.786	64.476	205.171	186.208	98.894			3400
3500	20.786	66.555	205.774	186.758	100.973			3500
3600	20.786	68.633	206.359	187.294	103.051			3600
3700	20.786	70.712	206.929	187.817	105.130			3700
3800	20.786	72.790	207.483	188.328	107.209			3800
3900	20.786	74.869	208.023	188.826	109.287			3900
4000	20.786	76.948	208.549	189.312	111.366			4000
4100	20.786	79.026	209.063	189.788	113.444			4100
4200	20.786	81.105	209.563	190.253	115.523			4200
4300	20.786	83.184	210.053	190.708	117.602			4300
4400	20.786	85.262	210.530	191.153	119.680			4400
4500	20.786	87.341	210.998	191.588	121.759			4500

TABLE A66.—THERMODYNAMIC PROPERTIES FOR K^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.786	89.419	211.454	192.015	123.838			4600
4700	20.786	91.498	211.901	192.434	125.916			4700
4800	20.786	93.577	212.339	192.844	127.995			4800
4900	20.786	95.655	212.768	193.246	130.073			4900
5000	20.786	97.734	213.188	193.641	132.152			5000
5100	20.786	99.813	213.599	194.028	134.231			5100
5200	20.786	101.891	214.003	194.408	136.309			5200
5300	20.786	103.970	214.399	194.782	138.388			5300
5400	20.786	106.048	214.787	195.149	140.467			5400
5500	20.786	108.127	215.169	195.509	142.545			5500
5600	20.786	110.206	215.543	195.864	144.624			5600
5700	20.786	112.284	215.911	196.212	146.702			5700
5800	20.786	114.363	216.273	196.555	148.781			5800
5900	20.786	116.442	216.628	196.892	150.860			5900
6000	20.786	118.520	216.977	197.224	152.938			6000
6200	20.786	122.677	217.659	197.872	157.096			6200
6400	20.786	126.835	218.319	198.501	161.253			6400
6600	20.786	130.992	218.959	199.111	165.410			6600
6800	20.786	135.149	219.579	199.704	169.567			6800
7000	20.786	139.306	220.182	200.281	173.725			7000
7200	20.786	143.464	220.767	200.842	177.882			7200
7400	20.786	147.621	221.337	201.388	182.039			7400
7600	20.786	151.778	221.891	201.920	186.196			7600
7800	20.786	155.936	222.431	202.439	190.354			7800
8000	20.786	160.093	222.957	202.946	194.511			8000
8500	20.786	170.486	224.217	204.160	204.904			8500
9000	20.786	180.879	225.406	205.308	215.297			9000
9500	20.786	191.272	226.529	206.395	225.690			9500
10000	20.786	201.665	227.596	207.429	236.083			10000
10500	20.786	212.058	228.610	208.414	246.477			10500
11000	20.786	222.452	229.577	209.354	256.870			11000
11500	20.786	232.845	230.501	210.253	267.263			11500
12000	20.786	243.238	231.385	211.116	277.656			12000
12500	20.786	253.631	232.234	211.943	288.049			12500
13000	20.786	264.024	233.049	212.740	298.442			13000
13500	20.786	274.417	233.834	213.506	308.835			13500
14000	20.786	284.810	234.590	214.246	319.229			14000
14500	20.786	295.204	235.319	214.960	329.622			14500
15000	20.786	305.597	236.024	215.651	340.015			15000
15500	20.786	315.990	236.705	216.319	350.408			15500
16000	20.786	326.383	237.365	216.966	360.801			16000
16500	20.786	336.776	238.005	217.594	371.194			16500
17000	20.786	347.169	238.625	218.204	381.587			17000
17500	20.786	357.562	239.228	218.796	391.981			17500
18000	20.786	367.956	239.813	219.371	402.374			18000
18500	20.786	378.349	240.383	219.932	412.767			18500
19000	20.786	388.742	240.937	220.477	423.160			19000
19500	20.786	399.135	241.477	221.009	433.553			19500
20000	20.786	409.528	242.004	221.527	443.946			20000

***Assigned reference element phase change at 336.86 K**

TABLE A67.—THERMODYNAMIC PROPERTIES FOR Kr

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–6.197	0	----------	0
100	20.786	–4.119	141.379	182.567	–4.119	0	0	100
200	20.786	–2.040	155.787	165.988	–2.040	0	0	200
298.15	20.786	0.000	164.086	164.086	0.000	0	0	298.15
300	20.786	0.038	164.215	164.087	0.038	0	0	300
400	20.786	2.117	170.195	164.902	2.117	0	0	400
500	20.786	4.196	174.833	166.442	4.196	0	0	500
600	20.786	6.274	178.623	168.166	6.274	0	0	600
700	20.786	8.353	181.827	169.894	8.353	0	0	700
800	20.786	10.432	184.603	171.563	10.432	0	0	800
900	20.786	12.510	187.051	173.151	12.510	0	0	900
1000	20.786	14.589	189.241	174.652	14.589	0	0	1000
1100	20.786	16.667	191.222	176.070	16.667	0	0	1100
1200	20.786	18.746	193.031	177.409	18.746	0	0	1200
1300	20.786	20.825	194.695	178.676	20.825	0	0	1300
1400	20.786	22.903	196.235	179.876	22.903	0	0	1400
1500	20.786	24.982	197.669	181.015	24.982	0	0	1500
1600	20.786	27.061	199.011	182.098	27.061	0	0	1600
1700	20.786	29.139	200.271	183.130	29.139	0	0	1700
1800	20.786	31.218	201.459	184.116	31.218	0	0	1800
1900	20.786	33.296	202.583	185.058	33.296	0	0	1900
2000	20.786	35.375	203.649	185.962	35.375	0	0	2000
2100	20.786	37.454	204.663	186.828	37.454	0	0	2100
2200	20.786	39.532	205.630	187.661	39.532	0	0	2200
2300	20.786	41.611	206.554	188.462	41.611	0	0	2300
2400	20.786	43.690	207.439	189.235	43.690	0	0	2400
2500	20.786	45.768	208.287	189.980	45.768	0	0	2500
2600	20.786	47.847	209.103	190.700	47.847	0	0	2600
2700	20.786	49.926	209.887	191.396	49.926	0	0	2700
2800	20.786	52.004	210.643	192.070	52.004	0	0	2800
2900	20.786	54.083	211.372	192.723	54.083	0	0	2900
3000	20.786	56.161	212.077	193.357	56.161	0	0	3000
3100	20.786	58.240	212.759	193.972	58.240	0	0	3100
3200	20.786	60.319	213.419	194.569	60.319	0	0	3200
3300	20.786	62.397	214.058	195.150	62.397	0	0	3300
3400	20.786	64.476	214.679	195.715	64.476	0	0	3400
3500	20.786	66.555	215.281	196.266	66.555	0	0	3500
3600	20.786	68.633	215.867	196.802	68.633	0	0	3600
3700	20.786	70.712	216.436	197.325	70.712	0	0	3700
3800	20.786	72.790	216.991	197.835	72.790	0	0	3800
3900	20.786	74.869	217.531	198.334	74.869	0	0	3900
4000	20.786	76.948	218.057	198.820	76.948	0	0	4000
4100	20.786	79.026	218.570	199.296	79.026	0	0	4100
4200	20.786	81.105	219.071	199.760	81.105	0	0	4200
4300	20.786	83.184	219.560	200.215	83.184	0	0	4300
4400	20.786	85.262	220.038	200.660	85.262	0	0	4400
4500	20.786	87.341	220.505	201.096	87.341	0	0	4500

TABLE A67.—THERMODYNAMIC PROPERTIES FOR Kr (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.786	89.419	220.962	201.523	89.419	0	0	4600
4700	20.786	91.498	221.409	201.942	91.498	0	0	4700
4800	20.786	93.577	221.847	202.352	93.577	0	0	4800
4900	20.786	95.655	222.275	202.754	95.655	0	0	4900
5000	20.786	97.734	222.695	203.149	97.734	0	0	5000
5100	20.786	99.813	223.107	203.536	99.813	0	0	5100
5200	20.786	101.891	223.511	203.916	101.891	0	0	5200
5300	20.786	103.970	223.907	204.290	103.970	0	0	5300
5400	20.786	106.048	224.295	204.656	106.048	0	0	5400
5500	20.786	108.127	224.676	205.017	108.127	0	0	5500
5600	20.786	110.206	225.051	205.371	110.206	0	0	5600
5700	20.786	112.284	225.419	205.720	112.284	0	0	5700
5800	20.786	114.363	225.780	206.063	114.363	0	0	5800
5900	20.786	116.442	226.136	206.400	116.442	0	0	5900
6000	20.786	118.520	226.485	206.732	118.520	0	0	6000
6200	20.787	122.678	227.167	207.380	122.678	0	0	6200
6400	20.787	126.835	227.827	208.009	126.835	0	0	6400
6600	20.787	130.992	228.466	208.619	130.992	0	0	6600
6800	20.788	135.150	229.087	209.212	135.150	0	0	6800
7000	20.789	139.307	229.689	209.788	139.307	0	0	7000
7200	20.790	143.465	230.275	210.349	143.465	0	0	7200
7400	20.792	147.624	230.845	210.896	147.624	0	0	7400
7600	20.795	151.782	231.399	211.428	151.782	0	0	7600
7800	20.799	155.942	231.940	211.947	155.942	0	0	7800
8000	20.805	160.102	232.466	212.453	160.102	0	0	8000
8500	20.829	170.510	233.728	213.668	170.510	0	0	8500
9000	20.892	180.930	234.920	214.817	180.930	0	0	9000
9500	20.998	191.402	236.053	215.905	191.402	0	0	9500
10000	21.128	201.931	237.133	216.940	201.931	0	0	10000
10500	21.296	212.535	238.168	217.926	212.535	0	0	10500
11000	21.523	223.237	239.163	218.869	223.237	0	0	11000
11500	21.838	234.073	240.127	219.772	234.073	0	0	11500
12000	22.272	245.095	241.065	220.640	245.095	0	0	12000
12500	22.857	256.371	241.985	221.476	256.371	0	0	12500
13000	23.623	267.982	242.896	222.282	267.982	0	0	13000
13500	24.598	280.028	243.805	223.062	280.028	0	0	13500
14000	25.801	292.618	244.721	223.819	292.618	0	0	14000
14500	27.245	305.870	245.651	224.556	305.870	0	0	14500
15000	28.932	319.903	246.602	225.275	319.903	0	0	15000
15500	30.857	334.840	247.581	225.979	334.840	0	0	15500
16000	32.998	350.796	248.594	226.670	350.796	0	0	16000
16500	35.324	367.870	249.645	227.350	367.870	0	0	16500
17000	37.789	386.143	250.736	228.021	386.143	0	0	17000
17500	40.331	405.672	251.868	228.686	405.672	0	0	17500
18000	42.876	426.475	253.040	229.347	426.475	0	0	18000
18500	45.333	448.533	254.248	230.003	448.533	0	0	18500
19000	47.593	471.775	255.488	230.657	471.775	0	0	19000
19500	49.533	496.073	256.750	231.310	496.073	0	0	19500
20000	51.013	521.232	258.024	231.962	521.232	0	0	20000

TABLE A68.—THERMODYNAMIC PROPERTIES FOR Kr^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1350.756	1350.756	----------	0
298.15	20.786	0.000	175.613	175.613	1356.954	1356.954	–236.0288	298.15
300	20.786	0.038	175.741	175.613	1356.992	1356.992	–234.5628	300
400	20.786	2.117	181.721	176.428	1359.071	1359.071	–175.4551	400
500	20.786	4.196	186.359	177.968	1361.150	1361.150	–139.9355	500
600	20.788	6.274	190.149	179.692	1363.228	1363.228	–116.2194	600
700	20.794	8.353	193.354	181.421	1365.307	1365.307	–99.2534	700
800	20.811	10.434	196.132	183.090	1367.388	1367.388	–86.5093	800
900	20.844	12.516	198.585	184.678	1369.470	1369.470	–76.5822	900
1000	20.896	14.603	200.783	186.180	1371.557	1371.557	–68.6284	1000
1100	20.969	16.696	202.778	187.600	1373.650	1373.650	–62.1107	1100
1200	21.061	18.797	204.607	188.942	1375.751	1375.751	–56.6711	1200
1300	21.170	20.909	206.297	190.213	1377.863	1377.863	–52.0612	1300
1400	21.292	23.032	207.870	191.419	1379.986	1379.986	–48.1038	1400
1500	21.422	25.168	209.343	192.565	1382.121	1382.121	–44.6688	1500
1600	21.555	27.316	210.730	193.657	1384.270	1384.270	–41.6585	1600
1700	21.689	29.479	212.041	194.700	1386.433	1386.433	–38.9982	1700
1800	21.819	31.654	213.284	195.699	1388.608	1388.608	–36.6298	1800
1900	21.944	33.842	214.467	196.656	1390.796	1390.796	–34.5073	1900
2000	22.062	36.043	215.596	197.575	1392.997	1392.997	–32.5941	2000
2100	22.172	38.254	216.675	198.459	1395.208	1395.208	–30.8603	2100
2200	22.272	40.477	217.709	199.310	1397.431	1397.431	–29.2817	2200
2300	22.362	42.708	218.701	200.132	1399.662	1399.662	–27.8380	2300
2400	22.442	44.949	219.654	200.926	1401.903	1401.903	–26.5125	2400
2500	22.513	47.197	220.572	201.693	1404.150	1404.150	–25.2911	2500
2600	22.574	49.451	221.456	202.437	1406.405	1406.405	–24.1619	2600
2700	22.626	51.711	222.309	203.157	1408.665	1408.665	–23.1146	2700
2800	22.670	53.976	223.133	203.856	1410.930	1410.930	–22.1406	2800
2900	22.706	56.245	223.929	204.534	1413.199	1413.199	–21.2322	2900
3000	22.734	58.517	224.699	205.194	1415.471	1415.471	–20.3831	3000
3100	22.756	60.791	225.445	205.835	1417.745	1417.745	–19.5875	3100
3200	22.772	63.068	226.168	206.459	1420.022	1420.022	–18.8404	3200
3300	22.782	65.345	226.869	207.067	1422.299	1422.299	–18.1374	3300
3400	22.787	67.624	227.549	207.659	1424.578	1424.578	–17.4748	3400
3500	22.788	69.903	228.209	208.237	1426.857	1426.857	–16.8490	3500
3600	22.785	72.181	228.851	208.801	1429.135	1429.135	–16.2570	3600
3700	22.778	74.460	229.475	209.351	1431.414	1431.414	–15.6961	3700
3800	22.768	76.737	230.083	209.889	1433.691	1433.691	–15.1639	3800
3900	22.756	79.013	230.674	210.414	1435.967	1435.967	–14.6582	3900
4000	22.741	81.288	231.250	210.928	1438.242	1438.242	–14.1771	4000
4100	22.724	83.561	231.811	211.431	1440.515	1440.515	–13.7186	4100
4200	22.705	85.833	232.359	211.922	1442.787	1442.787	–13.2813	4200
4300	22.684	88.102	232.893	212.404	1445.056	1445.056	–12.8637	4300
4400	22.662	90.369	233.414	212.875	1447.323	1447.323	–12.4645	4400
4500	22.640	92.635	233.923	213.338	1449.588	1449.588	–12.0824	4500
4600	22.616	94.897	234.420	213.790	1451.851	1451.851	–11.7163	4600
4700	22.591	97.158	234.906	214.235	1454.112	1454.112	–11.3653	4700
4800	22.566	99.416	235.382	214.670	1456.370	1456.370	–11.0283	4800
4900	22.541	101.671	235.847	215.098	1458.625	1458.625	–10.7047	4900
5000	22.515	103.924	236.302	215.517	1460.878	1460.878	–10.3934	5000

TABLE A68.—THERMODYNAMIC PROPERTIES FOR Kr^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	22.489	106.174	236.748	215.929	1463.128	1463.128	–10.0940	5100
5200	22.463	108.422	237.184	216.334	1465.375	1465.375	–9.8056	5200
5300	22.436	110.666	237.612	216.731	1467.620	1467.620	–9.5276	5300
5400	22.410	112.909	238.031	217.122	1469.863	1469.863	–9.2596	5400
5500	22.384	115.148	238.442	217.506	1472.102	1472.102	–9.0009	5500
5600	22.357	117.385	238.845	217.883	1474.339	1474.339	–8.7510	5600
5700	22.332	119.620	239.240	218.254	1476.574	1476.574	–8.5096	5700
5800	22.306	121.852	239.628	218.620	1478.806	1478.806	–8.2761	5800
5900	22.280	124.081	240.010	218.979	1481.035	1481.035	–8.0502	5900
6000	22.255	126.308	240.384	219.332	1483.262	1483.262	–7.8315	6000
6200	22.206	130.754	241.113	220.023	1487.708	1487.708	–7.4144	6200
6400	22.157	135.190	241.817	220.693	1492.144	1492.144	–7.0221	6400
6600	22.111	139.617	242.498	221.344	1496.571	1496.571	–6.6526	6600
6800	22.066	144.035	243.157	221.976	1500.988	1500.988	–6.3037	6800
7000	22.022	148.443	243.796	222.590	1505.397	1505.396	–5.9738	7000
7200	21.980	152.843	244.416	223.188	1509.797	1509.796	–5.6613	7200
7400	21.940	157.235	245.018	223.770	1514.189	1514.187	–5.3649	7400
7600	21.901	161.620	245.603	224.337	1518.573	1518.569	–5.0832	7600
7800	21.864	165.996	246.171	224.889	1522.950	1522.944	–4.8152	7800
8000	21.828	170.365	246.724	225.428	1527.319	1527.310	–4.5599	8000
8200	21.794	174.727	247.263	225.954	1531.681	1531.668	–4.3163	8200
8400	21.761	179.083	247.787	226.468	1536.037	1536.017	–4.0837	8400
8600	21.730	183.432	248.299	226.970	1540.386	1540.358	–3.8613	8600
8800	21.699	187.775	248.798	227.460	1544.729	1544.689	–3.6483	8800
9000	21.671	192.112	249.286	227.940	1549.066	1549.010	–3.4443	9000
9200	21.643	196.443	249.762	228.409	1553.397	1553.321	–3.2486	9200
9400	21.617	200.769	250.227	228.868	1557.723	1557.621	–3.0607	9400
9600	21.591	205.090	250.682	229.318	1562.044	1561.907	–2.8801	9600
9800	21.567	209.406	251.127	229.759	1566.360	1566.178	–2.7065	9800
10000	21.544	213.717	251.562	230.190	1570.671	1570.447	–2.5393	10000
10500	21.491	224.475	252.612	231.233	1581.429	1581.019	–2.1474	10500
11000	21.445	235.209	253.610	232.228	1592.163	1591.436	–1.7887	11000
11500	21.405	245.921	254.563	233.178	1602.875	1601.699	–1.4591	11500
12000	21.372	256.615	255.473	234.089	1613.569	1611.754	–1.1550	12000
12500	21.347	267.294	256.345	234.961	1624.248	1621.432	–0.8735	12500
13000	21.332	277.963	257.182	235.800	1634.917	1630.701	–0.6122	13000
13500	21.328	288.628	257.987	236.607	1645.582	1639.648	–0.3688	13500
14000	21.337	299.293	258.763	237.385	1656.247	1648.371	–0.1415	14000
14500	21.362	309.967	259.512	238.135	1666.921	1656.707	0.0713	14500
15000	21.408	320.659	260.237	238.859	1677.613	1663.848	0.2707	15000
15500	21.477	331.379	260.940	239.560	1688.333	1670.146	0.4579	15500
16000	21.573	342.140	261.623	240.239	1699.094	1675.497	0.6341	16000
16500	21.703	352.957	262.289	240.897	1709.911	1679.802	0.8001	16500
17000	21.870	363.848	262.939	241.536	1720.802	1682.976	0.9566	17000
17500	22.081	374.833	263.576	242.157	1731.787	1684.946	1.1045	17500
18000	22.334	385.927	264.201	242.760	1742.880	1685.651	1.2442	18000
18500	22.642	397.163	264.816	243.348	1754.117	1685.070	1.3764	18500
19000	23.014	408.574	265.425	243.921	1765.528	1684.804	1.5022	19000
19500	23.437	420.163	266.027	244.480	1777.117	1687.101	1.6229	19500
20000	23.941	432.003	266.626	245.026	1788.957	1689.429	1.7380	20000

TABLE A69.—THERMODYNAMIC PROPERTIES FOR Li

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	153.103	157.735	----------	0
100	20.786	–4.119	116.075	157.263	155.181	159.319	–77.5376	100
200	20.786	–2.040	130.483	140.684	157.260	159.554	–35.8915	200
298.15	20.786	0.000	138.783	138.783	159.300	159.300	–22.1800	298.15
300	20.786	0.038	138.911	138.783	159.338	159.292	–22.0079	300
400	20.786	2.117	144.891	139.598	161.417	158.769	–15.0835	400
*500	20.786	4.196	149.529	141.138	163.496	154.910	–10.9788	500
600	20.786	6.274	153.319	142.862	165.574	154.007	–8.2891	600
700	20.786	8.353	156.523	144.591	167.653	153.145	–6.3789	700
800	20.786	10.432	159.299	146.259	169.732	152.311	–4.9542	800
900	20.786	12.510	161.747	147.847	171.810	151.496	–3.8520	900
1000	20.786	14.589	163.937	149.348	173.889	150.692	–2.9751	1000
1100	20.786	16.667	165.918	150.766	175.967	149.892	–2.2613	1100
1200	20.786	18.746	167.727	152.105	178.046	149.090	–1.6697	1200
1300	20.787	20.825	169.391	153.372	180.125	148.281	–1.1719	1300
1400	20.788	22.903	170.931	154.572	182.203	147.457	–0.7475	1400
1500	20.789	24.982	172.366	155.711	184.282	146.614	–0.3817	1500
1600	20.793	27.061	173.707	156.794	186.361	145.746	–0.0635	1600
1700	20.799	29.141	174.968	157.826	188.441	144.849	0.2155	1700
1800	20.810	31.221	176.157	158.812	190.521	143.916	0.4620	1800
1900	20.826	33.303	177.283	159.755	192.603	142.943	0.6811	1900
2000	20.850	35.387	178.352	160.658	194.687	141.926	0.8769	2000
2100	20.882	37.473	179.370	161.525	196.773	140.860	1.0527	2100
2200	20.925	39.564	180.342	162.359	198.864	139.740	1.2114	2200
2300	20.980	41.659	181.273	163.161	200.959	138.562	1.3550	2300
2400	21.049	43.760	182.168	163.934	203.060	137.323	1.4856	2400
2500	21.132	45.869	183.029	164.681	205.169	136.018	1.6046	2500
2600	21.231	47.987	183.859	165.403	207.287	134.644	1.7133	2600
2700	21.347	50.116	184.663	166.101	209.416	133.196	1.8130	2700
2800	21.479	52.257	185.441	166.778	211.557	131.672	1.9045	2800
2900	21.628	54.412	186.198	167.435	213.712	130.068	1.9887	2900
3000	21.794	56.583	186.934	168.073	215.883	128.380	2.0663	3000
3100	21.976	58.771	187.651	168.693	218.071			3100
3200	22.175	60.979	188.352	169.296	220.279			3200
3300	22.389	63.207	189.037	169.884	222.507			3300
3400	22.619	65.457	189.709	170.457	224.757			3400
3500	22.864	67.731	190.368	171.017	227.031			3500
3600	23.123	70.030	191.016	171.563	229.330			3600
3700	23.396	72.356	191.653	172.098	231.656			3700
3800	23.682	74.710	192.281	172.620	234.010			3800
3900	23.982	77.093	192.900	173.133	236.393			3900
4000	24.294	79.506	193.511	173.634	238.806			4000
4100	24.618	81.952	194.115	174.127	241.252			4100
4200	24.955	84.430	194.712	174.610	243.730			4200
4300	25.304	86.943	195.303	175.084	246.243			4300
4400	25.652	89.486	195.888	175.550	248.786			4400
4500	26.013	92.066	196.468	176.008	251.366			4500

TABLE A69.—THERMODYNAMIC PROPERTIES FOR Li (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	26.393	94.686	197.043	176.459	253.986			4600
4700	26.785	97.345	197.615	176.904	256.645			4700
4800	27.188	100.043	198.183	177.341	259.343			4800
4900	27.602	102.781	198.748	177.772	262.081			4900
5000	28.027	105.561	199.309	178.197	264.861			5000
5100	28.450	108.378	199.867	178.616	267.678			5100
5200	28.899	111.245	200.424	179.030	270.545			5200
5300	29.354	114.155	200.978	179.439	273.455			5300
5400	29.818	117.111	201.530	179.843	276.411			5400
5500	30.292	120.112	202.081	180.242	279.412			5500
5600	30.769	123.194	202.637	180.638	282.494			5600
5700	31.261	126.295	203.186	181.029	285.595			5700
5800	31.764	129.446	203.734	181.415	288.746			5800
5900	32.278	132.648	204.281	181.798	291.948			5900
6000	32.803	135.902	204.828	182.177	295.202			6000
6200	33.691	142.550	205.918	182.926	301.850			6200
6400	34.624	149.381	207.002	183.661	308.681			6400
6600	35.550	156.399	208.082	184.385	315.699			6600
6800	36.432	163.598	209.156	185.098	322.898			6800
7000	37.246	170.968	210.224	185.800	330.268			7000
7200	37.974	178.491	211.284	186.493	337.791			7200
7400	38.609	186.151	212.333	187.178	345.451			7400
7600	39.145	193.927	213.370	187.853	353.227			7600
7800	39.583	201.802	214.393	188.521	361.102			7800
8000	39.926	209.755	215.400	189.180	369.055			8000
8500	40.393	229.856	217.837	190.795	389.156			8500
9000	40.384	250.068	220.147	192.362	409.368			9000
9500	40.008	270.179	222.322	193.882	429.479			9500
10000	39.371	290.033	224.359	195.356	449.333			10000
10500	38.564	309.522	226.261	196.782	468.822			10500
11000	37.663	328.581	228.034	198.163	487.881			11000
11500	36.726	347.179	229.688	199.498	506.479			11500
12000	35.794	365.308	231.231	200.789	524.608			12000
12500	34.895	382.978	232.674	202.036	542.278			12500
13000	34.047	400.211	234.026	203.240	559.511			13000
13500	33.254	417.035	235.296	204.404	576.335			13500
14000	32.516	433.475	236.492	205.529	592.775			14000
14500	31.828	449.558	237.620	206.616	608.858			14500
15000	31.178	465.309	238.688	207.668	624.609			15000
15500	30.555	480.741	239.701	208.685	640.041			15500
16000	29.947	495.867	240.661	209.669	655.167			16000
16500	29.340	510.688	241.573	210.622	669.988			16500
17000	28.725	525.205	242.440	211.546	684.505			17000
17500	28.093	539.412	243.264	212.440	698.712			17500
18000	27.441	553.296	244.046	213.307	712.596			18000
18500	26.766	566.849	244.789	214.148	726.149			18500
19000	26.075	580.060	245.493	214.964	739.360			19000
19500	25.377	592.923	246.162	215.755	752.223			19500
20000	24.686	605.438	246.795	216.523	764.738			20000

***Assigned reference element phase change at 453.69 K**

TABLE A70.—THERMODYNAMIC PROPERTIES FOR Li^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	679.522	677.957	----------	0
298.15	20.786	0.000	133.018	133.018	685.719	685.719	–113.6094	298.15
300	20.786	0.038	133.147	133.019	685.758	685.750	–112.8686	300
400	20.786	2.117	139.127	133.834	687.837	687.305	–82.9878	400
*500	20.786	4.196	143.765	135.374	689.915	685.525	–65.0543	500
600	20.786	6.274	147.555	137.098	691.994	686.701	–53.1090	600
700	20.786	8.353	150.759	138.826	694.072	687.918	–44.5617	700
800	20.786	10.432	153.535	140.495	696.151	689.162	–38.1397	800
900	20.786	12.510	155.983	142.083	698.230	690.426	–33.1357	900
1000	20.786	14.589	158.173	143.584	700.308	691.700	–29.1251	1000
1100	20.786	16.667	160.154	145.002	702.387	692.979	–25.8376	1100
1200	20.786	18.746	161.963	146.341	704.466	694.256	–23.0930	1200
1300	20.786	20.825	163.627	147.608	706.544	695.525	–20.7664	1300
1400	20.786	22.903	165.167	148.808	708.623	696.780	–18.7685	1400
1500	20.786	24.982	166.601	149.947	710.701	698.015	–17.0339	1500
1600	20.786	27.061	167.943	151.030	712.780	699.226	–15.5134	1600
1700	20.786	29.139	169.203	152.062	714.859	700.406	–14.1695	1700
1800	20.786	31.218	170.391	153.048	716.937	701.550	–12.9730	1800
1900	20.786	33.296	171.515	153.990	719.016	702.653	–11.9007	1900
2000	20.786	35.375	172.581	154.894	721.095	703.709	–10.9342	2000
2100	20.786	37.454	173.595	155.760	723.173	704.713	–10.0584	2100
2200	20.786	39.532	174.562	156.593	725.252	705.660	–9.2611	2200
2300	20.786	41.611	175.486	157.394	727.330	706.545	–8.5322	2300
2400	20.786	43.690	176.371	158.167	729.409	707.362	–7.8632	2400
2500	20.786	45.768	177.219	158.912	731.488	708.105	–7.2471	2500
2600	20.786	47.847	178.035	159.632	733.566	708.770	–6.6778	2600
2700	20.786	49.926	178.819	160.328	735.645	709.351	–6.1502	2700
2800	20.786	52.004	179.575	161.002	737.724	709.843	–5.6600	2800
2900	20.786	54.083	180.304	161.655	739.802	710.241	–5.2032	2900
3000	20.786	56.161	181.009	162.289	741.881	710.539	–4.7767	3000
3100	20.786	58.240	181.691	162.904	743.959			3100
3200	20.786	60.319	182.351	163.501	746.038			3200
3300	20.786	62.397	182.990	164.082	748.117			3300
3400	20.786	64.476	183.611	164.647	750.195			3400
3500	20.786	66.555	184.213	165.198	752.274			3500
3600	20.786	68.633	184.799	165.734	754.353			3600
3700	20.786	70.712	185.368	166.257	756.431			3700
3800	20.786	72.790	185.923	166.767	758.510			3800
3900	20.786	74.869	186.463	167.266	760.588			3900
4000	20.786	76.948	186.989	167.752	762.667			4000
4100	20.786	79.026	187.502	168.228	764.746			4100
4200	20.786	81.105	188.003	168.692	766.824			4200
4300	20.786	83.184	188.492	169.147	768.903			4300
4400	20.786	85.262	188.970	169.592	770.982			4400
4500	20.786	87.341	189.437	170.028	773.060			4500
4600	20.786	89.419	189.894	170.455	775.139			4600
4700	20.786	91.498	190.341	170.874	777.217			4700
4800	20.786	93.577	190.779	171.284	779.296			4800
4900	20.786	95.655	191.207	171.686	781.375			4900
5000	20.786	97.734	191.627	172.081	783.453			5000

TABLE A70.—THERMODYNAMIC PROPERTIES FOR Li^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	192.039	172.468	785.532			5100
5200	20.786	101.891	192.443	172.848	787.611			5200
5300	20.786	103.970	192.839	173.222	789.689			5300
5400	20.786	106.048	193.227	173.588	791.768			5400
5500	20.786	108.127	193.608	173.949	793.847			5500
5600	20.786	110.206	193.983	174.303	795.925			5600
5700	20.786	112.284	194.351	174.652	798.004			5700
5800	20.786	114.363	194.712	174.995	800.082			5800
5900	20.786	116.442	195.068	175.332	802.161			5900
6000	20.786	118.520	195.417	175.664	804.240			6000
6200	20.786	122.677	196.099	176.312	808.397			6200
6400	20.786	126.835	196.759	176.941	812.554			6400
6600	20.786	130.992	197.398	177.551	816.711			6600
6800	20.786	135.149	198.019	178.144	820.869			6800
7000	20.786	139.306	198.621	178.720	825.026			7000
7200	20.786	143.464	199.207	179.281	829.183			7200
7400	20.786	147.621	199.776	179.828	833.340			7400
7600	20.786	151.778	200.331	180.360	837.498			7600
7800	20.786	155.936	200.871	180.879	841.655			7800
8000	20.786	160.093	201.397	181.385	845.812			8000
8500	20.786	170.486	202.657	182.600	856.205			8500
9000	20.786	180.879	203.845	183.748	866.598			9000
9500	20.786	191.272	204.969	184.835	876.992			9500
10000	20.786	201.665	206.035	185.869	887.385			10000
10500	20.786	212.058	207.049	186.853	897.778			10500
11000	20.786	222.452	208.016	187.794	908.171			11000
11500	20.786	232.845	208.940	188.693	918.564			11500
12000	20.786	243.238	209.825	189.555	928.957			12000
12500	20.786	253.631	210.674	190.383	939.350			12500
13000	20.786	264.024	211.489	191.179	949.744			13000
13500	20.786	274.417	212.273	191.946	960.137			13500
14000	20.786	284.810	213.029	192.686	970.530			14000
14500	20.786	295.204	213.759	193.400	980.923			14500
15000	20.786	305.597	214.463	194.090	991.316			15000
15500	20.786	315.990	215.145	194.759	1001.709			15500
16000	20.786	326.383	215.805	195.406	1012.102			16000
16500	20.786	336.776	216.445	196.034	1022.496			16500
17000	20.786	347.169	217.065	196.643	1032.889			17000
17500	20.786	357.562	217.668	197.235	1043.282			17500
18000	20.786	367.956	218.253	197.811	1053.675			18000
18500	20.786	378.349	218.823	198.371	1064.068			18500
19000	20.786	388.742	219.377	198.917	1074.461			19000
19500	20.786	399.135	219.917	199.449	1084.854			19500
20000	20.786	409.528	220.443	199.967	1095.247			20000

*Assigned reference element phase change at 453.69 K

TABLE A71.—THERMODYNAMIC PROPERTIES FOR Li^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	87.277	98.107	----------	0
298.15	20.786	0.000	133.020	133.020	93.475	93.475	–12.0447	298.15
300	20.786	0.038	133.149	133.021	93.513	93.429	–11.9438	300
400	20.786	2.117	139.129	133.836	95.592	90.826	–7.9272	400
*500	20.786	4.196	143.767	135.376	97.670	84.889	–5.6220	500
600	20.786	6.274	147.557	137.100	99.749	81.908	–4.1685	600
700	20.786	8.353	150.761	138.828	101.828	78.967	–3.1672	700
800	20.786	10.432	153.537	140.497	103.906	76.055	–2.4436	800
900	20.786	12.510	155.985	142.085	105.985	73.161	–1.9020	900
1000	20.786	14.589	158.175	143.586	108.064	70.278	–1.4855	1000
1100	20.786	16.667	160.156	145.004	110.142	67.400	–1.1584	1100
1200	20.786	18.746	161.965	146.343	112.221	64.519	–0.8972	1200
1300	20.786	20.825	163.629	147.610	114.299	61.631	–0.6859	1300
1400	20.786	22.903	165.169	148.810	116.378	58.728	–0.5130	1400
1500	20.786	24.982	166.603	149.949	118.457	55.806	–0.3705	1500
1600	20.786	27.061	167.945	151.032	120.535	52.860	–0.2522	1600
1700	20.786	29.139	169.205	152.064	122.614	49.882	–0.1535	1700
1800	20.786	31.218	170.393	153.050	124.693	46.869	–0.0709	1800
1900	20.786	33.296	171.517	153.992	126.771	43.815	–0.0016	1900
2000	20.786	35.375	172.583	154.895	128.850	40.714	0.0566	2000
2100	20.786	37.454	173.597	155.762	130.928	37.561	0.1053	2100
2200	20.786	39.532	174.564	156.595	133.007	34.351	0.1460	2200
2300	20.786	41.611	175.488	157.396	135.086	31.078	0.1798	2300
2400	20.786	43.690	176.373	158.169	137.164	27.738	0.2076	2400
2500	20.786	45.768	177.221	158.914	139.243	24.324	0.2303	2500
2600	20.786	47.847	178.037	159.634	141.322	20.831	0.2485	2600
2700	20.786	49.926	178.821	160.330	143.400	17.255	0.2627	2700
2800	20.786	52.004	179.577	161.004	145.479	13.590	0.2734	2800
2900	20.786	54.083	180.306	161.657	147.557	9.831	0.2809	2900
3000	20.786	56.161	181.011	162.291	149.636	5.971	0.2857	3000
3100	20.786	58.240	181.693	162.906	151.715			3100
3200	20.786	60.319	182.353	163.503	153.793			3200
3300	20.786	62.397	182.992	164.084	155.872			3300
3400	20.786	64.476	183.613	164.649	157.951			3400
3500	20.786	66.555	184.215	165.200	160.029			3500
3600	20.786	68.633	184.801	165.736	162.108			3600
3700	20.786	70.712	185.370	166.259	164.187			3700
3800	20.786	72.790	185.925	166.769	166.265			3800
3900	20.786	74.869	186.465	167.268	168.344			3900
4000	20.786	76.948	186.991	167.754	170.422			4000
4100	20.786	79.026	187.504	168.230	172.501			4100
4200	20.786	81.105	188.005	168.694	174.580			4200
4300	20.786	83.184	188.494	169.149	176.658			4300
4400	20.786	85.262	188.972	169.594	178.737			4400
4500	20.786	87.341	189.439	170.030	180.816			4500
4600	20.786	89.419	189.896	170.457	182.894			4600
4700	20.786	91.498	190.343	170.875	184.973			4700
4800	20.786	93.577	190.781	171.286	187.051			4800
4900	20.786	95.655	191.209	171.688	189.130			4900
5000	20.786	97.734	191.629	172.083	191.209			5000

TABLE A71.—THERMODYNAMIC PROPERTIES FOR Li^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	192.041	172.470	193.287			5100
5200	20.786	101.891	192.445	172.850	195.366			5200
5300	20.786	103.970	192.841	173.224	197.445			5300
5400	20.786	106.048	193.229	173.590	199.523			5400
5500	20.786	108.127	193.610	173.951	201.602			5500
5600	20.786	110.206	193.985	174.305	203.680			5600
5700	20.786	112.284	194.353	174.654	205.759			5700
5800	20.786	114.363	194.714	174.997	207.838			5800
5900	20.786	116.442	195.070	175.334	209.916			5900
6000	20.786	118.520	195.419	175.666	211.995			6000
6200	20.786	122.677	196.101	176.314	216.152			6200
6400	20.786	126.835	196.761	176.943	220.309			6400
6600	20.786	130.992	197.400	177.553	224.467			6600
6800	20.786	135.149	198.021	178.146	228.624			6800
7000	20.786	139.306	198.623	178.722	232.781			7000
7200	20.786	143.464	199.209	179.283	236.938			7200
7400	20.786	147.621	199.778	179.830	241.096			7400
7600	20.786	151.778	200.333	180.362	245.253			7600
7800	20.786	155.936	200.873	180.881	249.410			7800
8000	20.786	160.093	201.399	181.387	253.567			8000
8500	20.786	170.486	202.659	182.602	263.961			8500
9000	20.786	180.879	203.847	183.750	274.354			9000
9500	20.786	191.272	204.971	184.837	284.747			9500
10000	20.786	201.665	206.037	185.871	295.140			10000
10500	20.786	212.058	207.051	186.855	305.533			10500
11000	20.786	222.452	208.018	187.796	315.926			11000
11500	20.786	232.845	208.942	188.695	326.319			11500
12000	20.786	243.238	209.827	189.557	336.713			12000
12500	20.786	253.631	210.676	190.385	347.106			12500
13000	20.786	264.024	211.491	191.181	357.499			13000
13500	20.786	274.417	212.275	191.948	367.892			13500
14000	20.786	284.810	213.031	192.688	378.285			14000
14500	20.786	295.204	213.761	193.402	388.678			14500
15000	20.786	305.597	214.465	194.092	399.071			15000
15500	20.786	315.990	215.147	194.761	409.465			15500
16000	20.786	326.383	215.807	195.408	419.858			16000
16500	20.786	336.776	216.447	196.036	430.251			16500
17000	20.786	347.169	217.067	196.645	440.644			17000
17500	20.786	357.562	217.670	197.237	451.037			17500
18000	20.786	367.956	218.255	197.813	461.430			18000
18500	20.786	378.349	218.825	198.373	471.823			18500
19000	20.786	388.742	219.379	198.919	482.217			19000
19500	20.786	399.135	219.919	199.450	492.610			19500
20000	20.786	409.528	220.445	199.969	503.003			20000

*Assigned reference element phase change at 453.69 K

TABLE A72.—THERMODYNAMIC PROPERTIES FOR Mg

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	140.903	145.882	----------	0
100	20.786	–4.119	125.942	167.130	142.981	147.321	–70.8662	100
200	20.786	–2.040	140.350	150.551	145.060	147.400	–32.3686	200
298.15	20.786	0.000	148.649	148.649	147.100	147.100	–19.7056	298.15
300	20.786	0.038	148.778	148.650	147.138	147.092	–19.5467	300
400	20.786	2.117	154.758	149.465	149.217	146.610	–13.1531	400
500	20.786	4.196	159.396	151.005	151.296	146.015	–9.3311	500
600	20.786	6.274	163.186	152.729	153.374	145.324	–6.7943	600
700	20.786	8.353	166.390	154.457	155.453	144.530	–4.9916	700
800	20.786	10.432	169.166	156.126	157.532	143.618	–3.6475	800
900	20.786	12.510	171.614	157.714	159.610	142.571	–2.6091	900*
*1000	20.786	14.589	173.804	159.215	161.689	132.868	–1.8218	1000
1100	20.786	16.667	175.785	160.633	163.767	131.517	–1.1940	1100
1200	20.786	18.746	177.594	161.972	165.846	130.165	–0.6762	1200
1300	20.786	20.825	179.258	163.239	167.925	128.814	–0.2426	1300
1400	20.786	22.903	180.798	164.439	170.003	127.463	0.1252	1400
1500	20.786	24.982	182.232	165.578	172.082	126.111	0.4406	1500
1600	20.786	27.061	183.574	166.661	174.161	124.760	0.7137	1600
1700	20.787	29.139	184.834	167.693	176.239	123.408	0.9520	1700
1800	20.787	31.218	186.022	168.679	178.318	122.057	1.1615	1800
1900	20.788	33.297	187.146	169.621	180.397	120.706	1.3469	1900
2000	20.789	35.375	188.212	170.525	182.475	119.355	1.5119	2000
2100	20.791	37.454	189.227	171.391	184.554	118.004	1.6595	2100
2200	20.796	39.534	190.194	172.224	186.634	116.653	1.7922	2200
2300	20.802	41.614	191.118	173.026	188.714	115.303	1.9119	2300
2400	20.812	43.694	192.004	173.798	190.794	113.954	2.0204	2400
2500	20.826	45.776	192.854	174.543	192.876	112.605	2.1190	2500
2600	20.847	47.860	193.671	175.263	194.960	111.259	2.2089	2600
2700	20.874	49.946	194.458	175.960	197.046	109.915	2.2912	2700
2800	20.910	52.035	195.218	176.634	199.135	108.574	2.3667	2800
2900	20.956	54.128	195.953	177.288	201.228	107.237	2.4361	2900
3000	21.014	56.226	196.664	177.922	203.326	105.906	2.5001	3000
3100	21.086	58.331	197.354	178.538	205.431	104.581	2.5592	3100
3200	21.172	60.444	198.025	179.136	207.544	103.263	2.6140	3200
3300	21.275	62.566	198.678	179.718	209.666	101.955	2.6647	3300
3400	21.397	64.700	199.315	180.286	211.800	100.659	2.7119	3400
3500	21.537	66.846	199.937	180.838	213.946	99.375	2.7558	3500
3600	21.698	69.008	200.546	181.377	216.108	98.107	2.7967	3600
3700	21.879	71.186	201.143	181.903	218.286	96.856	2.8350	3700
3800	22.083	73.384	201.729	182.417	220.484	95.624	2.8707	3800
3900	22.310	75.604	202.306	182.920	222.704	94.413	2.9042	3900
4000	22.559	77.847	202.873	183.412	224.947	93.226	2.9356	4000
4100	22.832	80.117	203.434	183.893	227.217	92.066	2.9651	4100
4200	23.127	82.414	203.988	184.365	229.514	90.933	2.9929	4200
4300	23.446	84.743	204.535	184.828	231.843	89.832	3.0190	4300
4400	23.788	87.104	205.078	185.282	234.204	88.763	3.0437	4400
4500	24.151	89.501	205.617	185.728	236.601	87.730	3.0670	4500

TABLE A72.—THERMODYNAMIC PROPERTIES FOR Mg (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	24.537	91.935	206.152	186.166	239.035	86.734	3.0890	4600
4700	24.943	94.409	206.684	186.597	241.509	85.778	3.1098	4700
4800	25.371	96.924	207.213	187.021	244.024	84.864	3.1296	4800
4900	25.818	99.484	207.741	187.438	246.584	83.993	3.1483	4900
5000	26.284	102.089	208.267	187.850	249.189	83.168	3.1661	5000
5100	26.768	104.741	208.793	188.255	251.841	82.390	3.1831	5100
5200	27.270	107.443	209.317	188.655	254.543	81.662	3.1992	5200
5300	27.786	110.195	209.841	189.050	257.295	80.984	3.2146	5300
5400	28.319	113.000	210.366	189.440	260.100	80.359	3.2294	5400
5500	28.863	115.858	210.890	189.825	262.958	79.787	3.2435	5500
5600	29.420	118.771	211.415	190.206	265.871	79.270	3.2569	5600
5700	29.992	121.741	211.941	190.583	268.841	78.811	3.2699	5700
5800	30.575	124.769	212.467	190.955	271.869	78.409	3.2823	5800
5900	31.170	127.857	212.995	191.324	274.957	78.066	3.2942	5900
6000	31.774	131.003	213.524	191.690	278.103	77.782	3.3057	6000
6200	33.009	137.480	214.586	192.411	284.580			6200
6400	34.276	144.207	215.653	193.121	291.307			6400
6600	35.439	151.118	216.716	193.819	298.218			6600
6800	36.573	158.249	217.779	194.507	305.349			6800
7000	37.815	165.688	218.857	195.188	312.788			7000
7200	39.054	173.375	219.940	195.860	320.475			7200
7400	40.284	181.309	221.027	196.526	328.409			7400
7600	41.501	189.488	222.117	197.185	336.588			7600
7800	42.597	197.825	223.199	197.837	344.925			7800
8000	43.726	206.439	224.289	198.484	353.539			8000
8500	46.654	229.391	227.079	200.092	376.491			8500
9000	48.533	253.222	229.803	201.667	400.322			9000
9500	49.639	277.795	232.460	203.218	424.895			9500
10000	50.063	302.746	235.019	204.745	449.846			10000
10500	49.939	327.767	237.461	206.245	474.867			10500
11000	49.408	352.618	239.773	207.717	499.718			11000
11500	48.598	377.129	241.952	209.158	524.229			11500
12000	47.617	401.187	244.000	210.568	548.287			12000
12500	46.550	424.731	245.923	211.944	571.831			12500
13000	45.459	447.734	247.727	213.286	594.834			13000
13500	44.385	470.193	249.422	214.593	617.293			13500
14000	43.351	492.126	251.018	215.866	639.226			14000
14500	42.364	513.552	252.522	217.104	660.652			14500
15000	41.422	534.497	253.942	218.309	681.597			15000
15500	40.513	554.979	255.285	219.480	702.079			15500
16000	39.618	575.012	256.557	220.619	722.112			16000
16500	38.718	594.598	257.763	221.727	741.698			16500
17000	37.793	613.726	258.905	222.803	760.826			17000
17500	36.824	632.383	259.987	223.850	779.483			17500
18000	35.798	650.541	261.010	224.869	797.641			18000
18500	34.707	668.170	261.976	225.859	815.270			18500
19000	33.549	685.237	262.886	226.821	832.337			19000
19500	32.334	701.709	263.742	227.757	848.809			19500
20000	31.081	717.564	264.545	228.667	864.664			20000

***Assigned reference element phase change at 923 K**

TABLE A73.—THERMODYNAMIC PROPERTIES FOR Mg^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	884.850	883.631	----------	0
298.15	20.786	0.000	154.412	154.412	891.047	891.047	–148.6419	298.15
300	20.786	0.038	154.541	154.413	891.085	891.078	–147.6793	300
400	20.786	2.117	160.521	155.228	893.164	892.674	–108.8607	400
500	20.786	4.196	165.159	156.768	895.243	894.158	–85.5289	500
600	20.786	6.274	168.949	158.492	897.321	895.545	–69.9492	600
700	20.786	8.353	172.153	160.220	899.400	896.830	–58.8040	700
800	20.786	10.432	174.929	161.889	901.479	897.997	–50.4336	800
900	20.786	12.510	177.377	163.477	903.557	899.028	–43.9153	900*
*1000	20.786	14.589	179.567	164.978	905.636	891.404	–38.7320	1000
1100	20.786	16.667	181.548	166.396	907.714	892.131	–34.4975	1100
1200	20.786	18.746	183.357	167.735	909.793	892.858	–30.9658	1200
1300	20.786	20.825	185.021	169.002	911.872	893.586	–27.9751	1300
1400	20.786	22.903	186.561	170.202	913.950	894.313	–25.4095	1400
1500	20.786	24.982	187.995	171.341	916.029	895.040	–23.1842	1500
1600	20.786	27.061	189.337	172.424	918.108	895.767	–21.2355	1600
1700	20.786	29.139	190.597	173.456	920.186	896.495	–19.5146	1700
1800	20.786	31.218	191.785	174.442	922.265	897.222	–17.9837	1800
1900	20.786	33.296	192.909	175.384	924.343	897.949	–16.6129	1900
2000	20.786	35.375	193.975	176.287	926.422	898.676	–15.3781	2000
2100	20.786	37.454	194.989	177.154	928.501	899.404	–14.2600	2100
2200	20.786	39.532	195.956	177.987	930.579	900.131	–13.2427	2200
2300	20.786	41.611	196.880	178.788	932.658	900.858	–12.3132	2300
2400	20.786	43.690	197.765	179.561	934.737	901.585	–11.4604	2400
2500	20.786	45.768	198.613	180.306	936.815	902.313	–10.6752	2500
2600	20.786	47.847	199.429	181.026	938.894	903.040	–9.9498	2600
2700	20.786	49.926	200.213	181.722	940.973	903.767	–9.2777	2700
2800	20.786	52.004	200.969	182.396	943.051	904.494	–8.6530	2800
2900	20.786	54.083	201.698	183.049	945.130	905.222	–8.0709	2900
3000	20.787	56.161	202.403	183.683	947.208	905.949	–7.5272	3000
3100	20.787	58.240	203.085	184.298	949.287	906.676	–7.0182	3100
3200	20.787	60.319	203.745	184.895	951.366	907.404	–6.5406	3200
3300	20.787	62.397	204.384	185.476	953.444	908.131	–6.0916	3300
3400	20.788	64.476	205.005	186.041	955.523	908.858	–5.6686	3400
3500	20.789	66.555	205.608	186.592	957.602	909.586	–5.2696	3500
3600	20.789	68.634	206.193	187.128	959.681	910.313	–4.8923	3600
3700	20.791	70.713	206.763	187.651	961.760	911.041	–4.5352	3700
3800	20.792	72.792	207.317	188.161	963.839	911.769	–4.1966	3800
3900	20.794	74.871	207.857	188.660	965.918	912.497	–3.8752	3900
4000	20.797	76.951	208.384	189.146	967.998	913.225	–3.5695	4000
4100	20.800	79.031	208.897	189.622	970.078	913.953	–3.2785	4100
4200	20.804	81.111	209.399	190.087	972.158	914.682	–3.0012	4200
4300	20.809	83.192	209.888	190.541	974.239	915.412	–2.7365	4300
4400	20.815	85.273	210.367	190.987	976.320	916.141	–2.4837	4400
4500	20.822	87.355	210.835	191.422	978.402	916.872	–2.2419	4500
4600	20.830	89.437	211.292	191.849	980.484	917.603	–2.0105	4600
4700	20.839	91.521	211.740	192.268	982.568	918.335	–1.7887	4700
4800	20.850	93.605	212.179	192.678	984.652	919.068	–1.5760	4800
4900	20.863	95.691	212.609	193.081	986.738	919.802	–1.3718	4900
5000	20.877	97.778	213.031	193.475	988.825	920.538	–1.1756	5000

TABLE A73.—THERMODYNAMIC PROPERTIES FOR Mg^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.893	99.866	213.444	193.863	990.913	921.275	–0.9870	5100
5200	20.910	101.956	213.850	194.243	993.003	922.014	–0.8055	5200
5300	20.930	104.048	214.249	194.617	995.095	922.754	–0.6307	5300
5400	20.952	106.143	214.640	194.984	997.190	923.497	–0.4622	5400
5500	20.976	108.239	215.025	195.345	999.286	924.242	–0.2997	5500
5600	21.003	110.338	215.403	195.700	1001.385	924.990	–0.1429	5600
5700	21.032	112.440	215.775	196.049	1003.487	925.740	0.0085	5700
5800	21.064	114.544	216.141	196.392	1005.591	926.494	0.1548	5800
5900	21.098	116.652	216.502	196.730	1007.699	927.250	0.2963	5900
6000	21.135	118.764	216.856	197.062	1009.811	928.010	0.4332	6000
6200	21.216	122.999	217.551	197.712	1014.046			6200
6400	21.310	127.251	218.226	198.343	1018.298			6400
6600	21.414	131.524	218.883	198.955	1022.571			6600
6800	21.530	135.818	219.524	199.551	1026.865			6800
7000	21.658	140.136	220.150	200.131	1031.183			7000
7200	21.797	144.482	220.762	200.695	1035.529			7200
7400	21.948	148.856	221.361	201.246	1039.903			7400
7600	22.110	153.262	221.949	201.783	1044.309			7600
7800	22.283	157.701	222.525	202.307	1048.748			7800
8000	22.466	162.176	223.092	202.820	1053.223			8000
8500	22.966	173.531	224.468	204.053	1064.578			8500
9000	23.524	185.151	225.797	205.224	1076.198			9000
9500	24.133	197.063	227.085	206.341	1088.110			9500
10000	24.785	209.289	228.339	207.410	1100.336			10000
10500	25.484	221.854	229.565	208.436	1112.901			10500
11000	26.228	234.779	230.767	209.423	1125.826			11000
11500	27.021	248.089	231.950	210.377	1139.136			11500
12000	27.860	261.803	233.117	211.300	1152.850			12000
12500	28.760	275.954	234.273	212.196	1167.001			12500
13000	29.601	290.438	235.408	213.067	1181.485			13000
13500	30.543	305.434	236.539	213.915	1196.481			13500
14000	31.570	320.960	237.669	214.743	1212.007			14000
14500	32.657	337.014	238.795	215.553	1228.061			14500
15000	33.803	353.627	239.922	216.346	1244.674			15000
15500	35.007	370.827	241.049	217.125	1261.874			15500
16000	36.130	389.169	242.220	217.897	1280.216			16000
16500	37.123	407.484	243.348	218.652	1298.531			16500
17000	38.075	426.285	244.470	219.394	1317.332			17000
17500	38.988	445.553	245.587	220.127	1336.600			17500
18000	39.865	465.267	246.698	220.850	1356.314			18000
18500	40.709	485.412	247.802	221.563	1376.459			18500
19000	41.523	505.971	248.898	222.268	1397.018			19000
19500	42.310	526.931	249.987	222.965	1417.978			19500
20000	43.071	548.277	251.068	223.654	1439.324			20000

*Assigned reference element phase change at 923 K

TABLE A74.—THERMODYNAMIC PROPERTIES FOR Mn

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	276.203	281.197	----------	0
100	20.786	–4.119	151.011	192.199	278.281	282.681	–140.2296	100
200	20.786	–2.040	165.419	175.619	280.360	282.798	–66.3731	200
298.15	20.786	0.000	173.718	173.718	282.400	282.400	–42.0722	298.15
300	20.786	0.038	173.847	173.719	282.438	282.389	–41.7670	300
400	20.786	2.117	179.827	174.534	284.517	281.719	–29.4877	400
500	20.786	4.196	184.465	176.073	286.596	280.824	–22.1406	500
600	20.786	6.274	188.255	177.797	288.674	279.792	–17.2593	600
700	20.786	8.353	191.459	179.526	290.753	278.604	–13.7866	700
800	20.786	10.432	194.234	181.195	292.832	277.266	–11.1938	800
900	20.786	12.510	196.683	182.783	294.910	275.779	–9.1874	900
*1000	20.786	14.589	198.873	184.284	296.989	271.922	–7.5937	1000
1100	20.786	16.667	200.854	185.702	299.067	270.209	–6.3064	1100
1200	20.786	18.746	202.663	187.041	301.146	268.456	–5.2406	1200
1300	20.786	20.825	204.326	188.307	303.225	266.660	–4.3446	1300
*1400	20.787	22.903	205.867	189.507	305.303	262.546	–3.5842	1400
*1500	20.787	24.982	207.301	190.646	307.382	258.209	–2.9382	1500
*1600	20.789	27.061	208.643	191.730	309.461	243.627	–2.3999	1600
1700	20.791	29.140	209.903	192.762	311.540	241.103	–1.9345	1700
1800	20.797	31.219	211.092	193.747	313.619	238.580	–1.5250	1800
1900	20.806	33.299	212.216	194.690	315.699	236.058	–1.1625	1900
2000	20.822	35.381	213.284	195.593	317.781	233.537	–0.8398	2000
2100	20.846	37.464	214.300	196.460	319.864	231.018	–0.5509	2100
2200	20.881	39.550	215.271	197.293	321.950	228.502	–0.2911	2200
2300	20.930	41.641	216.200	198.095	324.041	225.990	–0.0565	2300
2400	20.997	43.737	217.092	198.868	326.137	223.484	0.1562	2400
2500	21.085	45.841	217.951	199.615	328.241	220.985	0.3497	2500
2600	21.199	47.955	218.780	200.336	330.355	218.497	0.5263	2600
2700	21.341	50.081	219.583	201.034	332.481	216.021	0.6879	2700
2800	21.516	52.224	220.362	201.710	334.624	213.561	0.8364	2800
2900	21.727	54.386	221.120	202.367	336.786	211.121	0.9730	2900
3000	21.977	56.571	221.861	203.004	338.971	208.703	1.0990	3000
3100	22.269	58.783	222.586	203.624	341.183	206.313	1.2155	3100
3200	22.606	61.026	223.298	204.228	343.426	203.954	1.3236	3200
3300	22.991	63.305	224.000	204.816	345.705	201.631	1.4239	3300
3400	23.424	65.626	224.693	205.391	348.026	199.348	1.5172	3400
3500	23.908	67.992	225.378	205.952	350.392	197.112	1.6042	3500
3600	24.443	70.409	226.059	206.501	352.809	194.927	1.6855	3600
3700	25.030	72.882	226.737	207.039	355.282	192.798	1.7615	3700
3800	25.669	75.417	227.413	207.566	357.817	190.730	1.8328	3800
3900	26.359	78.018	228.088	208.084	360.418	188.728	1.8996	3900
4000	27.100	80.690	228.765	208.592	363.090	186.798	1.9625	4000
4100	27.889	83.439	229.444	209.093	365.839	184.945	2.0217	4100
4200	28.725	86.269	230.126	209.585	368.669	183.173	2.0775	4200
4300	29.606	89.185	230.812	210.071	371.585	181.486	2.1303	4300
4400	30.528	92.191	231.503	210.550	374.591	179.890	2.1801	4400
4500	31.491	95.292	232.199	211.024	377.692	178.388	2.2274	4500

TABLE A74.—THERMODYNAMIC PROPERTIES FOR Mn (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	32.489	98.490	232.902	211.491	380.890	176.984	2.2722	4600
4700	33.519	101.790	233.612	211.955	384.190	175.682	2.3148	4700
4800	34.578	105.195	234.329	212.413	387.595	174.484	2.3554	4800
4900	35.660	108.707	235.053	212.868	391.107	173.394	2.3940	4900
5000	36.763	112.328	235.784	213.319	394.728	172.412	2.4309	5000
5100	37.881	116.060	236.523	213.767	398.460	171.542	2.4661	5100
5200	39.009	119.904	237.270	214.211	402.304	170.784	2.4998	5200
5300	40.145	123.862	238.024	214.654	406.262	170.139	2.5321	5300
5400	41.282	127.933	238.785	215.093	410.333	169.608	2.5631	5400
5500	42.414	132.117	239.552	215.531	414.517	169.190	2.5929	5500
5600	43.541	136.415	240.327	215.967	418.815	168.885	2.6216	5600
5700	44.654	140.824	241.107	216.401	423.224	168.692	2.6492	5700
5800	45.751	145.344	241.893	216.834	427.744	168.609	2.6758	5800
5900	46.828	149.972	242.684	217.265	432.372	168.635	2.7016	5900
6000	47.883	154.708	243.480	217.696	437.108	168.769	2.7265	6000
6200	49.896	164.483	245.083	218.553	446.883			6200
6400	51.783	174.653	246.697	219.407	457.053			6400
6600	53.409	185.121	248.306	220.258	467.521			6600
6800	54.920	195.945	249.922	221.106	478.345			6800
7000	56.245	207.054	251.532	221.953	489.454			7000
7200	57.451	218.385	253.126	222.794	500.785			7200
7400	58.429	229.976	254.714	223.636	512.376			7400
7600	59.196	241.742	256.282	224.474	524.142			7600
7800	59.758	253.641	257.828	225.310	536.041			7800
8000	60.122	265.632	259.346	226.142	548.032			8000
8500	60.257	295.771	263.000	228.203	578.171			8500
9000	59.465	325.735	266.426	230.233	608.135			9000
9500	57.978	355.120	269.604	232.223	637.520			9500
10000	56.014	383.633	272.529	234.166	666.033			10000
10500	53.756	411.085	275.208	236.057	693.485			10500
11000	51.357	437.366	277.654	237.893	719.766			11000
11500	48.933	462.438	279.883	239.671	744.838			11500
12000	46.572	486.310	281.916	241.390	768.710			12000
12500	44.334	509.030	283.771	243.048	791.430			12500
13000	42.257	530.670	285.469	244.648	813.070			13000
13500	40.360	551.317	287.027	246.189	833.717			13500
14000	38.648	571.061	288.464	247.673	853.461			14000
14500	37.115	589.994	289.793	249.103	872.394			14500
15000	35.748	608.204	291.027	250.480	890.604			15000
15500	34.527	625.768	292.179	251.807	908.168			15500
16000	33.432	642.752	293.258	253.086	925.152			16000
16500	32.439	659.217	294.271	254.319	941.617			16500
17000	31.530	675.205	295.226	255.508	957.605			17000
17500	30.685	690.756	296.128	256.656	973.156			17500
18000	29.893	705.899	296.981	257.764	988.299			18000
18500	29.146	720.658	297.789	258.835	1003.058			18500
19000	28.444	735.053	298.557	259.870	1017.453			19000
19500	27.795	749.110	299.288	260.872	1031.510			19500
20000	27.214	762.860	299.984	261.841	1045.260			20000

***Assigned reference element phase change at 980 K, 1361 K, 1412 K, and 1519 K**

TABLE A75.—THERMODYNAMIC PROPERTIES FOR Mn^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	999.674	998.470	----------	0
298.15	20.786	0.000	175.000	175.000	1005.871	1005.871	–167.6554	298.15
300	20.786	0.038	175.128	175.000	1005.910	1005.899	–166.5686	300
400	20.786	2.117	181.108	175.815	1007.988	1007.307	–122.7556	400
500	20.786	4.196	185.746	177.355	1010.067	1008.491	–96.4334	500
600	20.786	6.274	189.536	179.079	1012.146	1009.538	–78.8657	600
700	20.786	8.353	192.740	180.808	1014.224	1010.428	–66.3052	700
800	20.786	10.432	195.516	182.477	1016.303	1011.169	–56.8771	800
900	20.787	12.510	197.964	184.064	1018.382	1011.761	–49.5393	900
*1000	20.788	14.589	200.154	185.566	1020.460	1009.982	–43.6684	1000
1100	20.790	16.668	202.136	186.983	1022.539	1010.349	–38.8717	1100
1200	20.795	18.747	203.945	188.322	1024.618	1010.674	–34.8730	1200
1300	20.805	20.827	205.610	189.589	1026.698	1010.958	–31.4885	1300
*1400	20.822	22.908	207.152	190.789	1028.780	1008.926	–28.5891	1400
*1500	20.847	24.992	208.590	191.929	1030.863	1006.672	–26.0841	1500
*1600	20.883	27.078	209.936	193.012	1032.949	994.176	–23.9146	1600
1700	20.932	29.169	211.204	194.046	1035.040	993.743	–22.0059	1700
1800	20.997	31.265	212.402	195.032	1037.136	993.315	–20.3100	1800
1900	21.079	33.369	213.539	195.977	1039.240	992.895	–18.7932	1900
2000	21.180	35.481	214.623	196.882	1041.353	992.484	–17.4287	2000
2100	21.301	37.605	215.659	197.752	1043.477	992.084	–16.1946	2100
2200	21.445	39.742	216.653	198.588	1045.614	991.698	–15.0732	2200
2300	21.611	41.895	217.610	199.395	1047.766	991.327	–14.0497	2300
2400	21.800	44.065	218.534	200.173	1049.937	990.973	–13.1118	2400
2500	22.012	46.256	219.428	200.926	1052.127	990.640	–12.2492	2500
2600	22.246	48.468	220.296	201.654	1054.340	990.329	–11.4533	2600
2700	22.503	50.706	221.140	202.360	1056.577	990.042	–10.7165	2700
2800	22.781	52.970	221.963	203.046	1058.841	989.782	–10.0326	2800
2900	23.080	55.263	222.768	203.712	1061.134	989.552	–9.3960	2900
3000	23.397	57.586	223.556	204.360	1063.458	989.352	–8.8019	3000
3100	23.733	59.943	224.328	204.992	1065.814	989.184	–8.2463	3100
3200	24.085	62.334	225.087	205.608	1068.205	989.051	–7.7255	3200
3300	24.453	64.760	225.834	206.210	1070.632	988.954	–7.2363	3300
3400	24.835	67.225	226.570	206.798	1073.096	988.895	–6.7759	3400
3500	25.230	69.728	227.295	207.373	1075.599	988.874	–6.3419	3500
3600	25.637	72.271	228.012	207.936	1078.142	988.893	–5.9319	3600
3700	26.055	74.855	228.720	208.489	1080.727	988.954	–5.5441	3700
3800	26.483	77.482	229.420	209.030	1083.354	989.057	–5.1767	3800
3900	26.921	80.152	230.114	209.562	1086.024	989.204	–4.8281	3900
4000	27.369	82.867	230.801	210.084	1088.738	989.394	–4.4968	4000
4100	27.825	85.626	231.482	210.598	1091.498	989.630	–4.1817	4100
4200	28.290	88.432	232.158	211.103	1094.303	989.912	–3.8815	4200
4300	28.763	91.285	232.830	211.601	1097.156	990.241	–3.5951	4300
4400	29.244	94.185	233.496	212.091	1100.056	990.617	–3.3217	4400
4500	29.733	97.134	234.159	212.574	1103.005	991.042	–3.0603	4500
4600	30.231	100.132	234.818	213.050	1106.003	991.517	–2.8102	4600
4700	30.736	103.180	235.474	213.520	1109.051	992.041	–2.5706	4700
4800	31.249	106.279	236.126	213.984	1112.151	992.617	–2.3408	4800
4900	31.770	109.430	236.776	214.443	1115.302	993.244	–2.1203	4900
5000	32.299	112.634	237.423	214.896	1118.505	993.923	–1.9085	5000

TABLE A75.—THERMODYNAMIC PROPERTIES FOR Mn^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	32.836	115.890	238.068	215.344	1121.762	994.656	–1.7048	5100
5200	33.379	119.201	238.711	215.787	1125.072	995.443	–1.5088	5200
5300	33.930	122.566	239.352	216.226	1128.438	996.285	–1.3201	5300
5400	34.488	125.987	239.991	216.660	1131.859	997.182	–1.1382	5400
5500	35.051	129.464	240.629	217.090	1135.336	998.135	–0.9627	5500
5600	35.621	132.998	241.266	217.516	1138.869	999.145	–0.7934	5600
5700	36.195	136.589	241.901	217.938	1142.460	1000.212	–0.6298	5700
5800	36.773	140.237	242.536	218.357	1146.108	1001.336	–0.4717	5800
5900	37.355	143.943	243.169	218.772	1149.815	1002.519	–0.3187	5900
6000	37.940	147.708	243.802	219.184	1153.579	1003.760	–0.1707	6000
6200	39.113	155.413	245.065	219.999	1161.285			6200
6400	40.283	163.353	246.325	220.802	1169.224			6400
6600	41.442	171.526	247.583	221.594	1177.397			6600
6800	42.580	179.928	248.837	222.377	1185.800			6800
7000	43.688	188.556	250.087	223.151	1194.427			7000
7200	44.755	197.401	251.333	223.916	1203.272			7200
7400	45.774	206.455	252.573	224.674	1212.326			7400
7600	46.736	215.707	253.807	225.425	1221.578			7600
7800	47.635	225.145	255.033	226.168	1231.016			7800
8000	48.464	234.756	256.249	226.905	1240.627			8000
8500	50.207	259.444	259.242	228.719	1265.315			8500
9000	51.458	284.880	262.150	230.496	1290.751			9000
9500	52.228	310.818	264.954	232.237	1316.689			9500
10000	52.565	337.029	267.643	233.940	1342.900			10000
10500	52.544	363.314	270.208	235.607	1369.186			10500
11000	52.233	389.505	272.645	237.235	1395.376			11000
11500	51.713	415.478	274.954	238.825	1421.350			11500
12000	51.033	441.126	277.137	240.376	1446.998			12000
12500	50.263	466.402	279.200	241.888	1472.273			12500
13000	49.426	491.241	281.148	243.360	1497.112			13000
13500	48.625	515.718	282.995	244.794	1521.590			13500
14000	47.839	539.782	284.745	246.190	1545.654			14000
14500	47.024	563.351	286.398	247.547	1569.222			14500
15000	46.278	586.572	287.972	248.867	1592.443			15000
15500	45.475	609.227	289.456	250.151	1615.098			15500
16000	44.762	631.596	290.875	251.400	1637.467			16000
16500	43.928	653.249	292.203	252.613	1659.120			16500
17000	43.196	674.665	293.479	253.793	1680.536			17000
17500	42.450	695.601	294.689	254.941	1701.472			17500
18000	41.748	716.210	295.847	256.058	1722.081			18000
18500	41.194	736.842	296.977	257.147	1742.713			18500
19000	40.663	757.185	298.061	258.209	1763.056			19000
19500	40.182	777.351	299.108	259.244	1783.222			19500
20000	39.667	797.074	300.105	260.251	1802.946			20000

*Assigned reference element phase change at 980 K, 1361 K, 1412 K, and 1519 K

TABLE A76.—THERMODYNAMIC PROPERTIES FOR Mo

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	652.303	656.888	----------	0
100	20.786	–4.119	159.246	200.434	654.381	658.475	–335.9925	100
200	20.786	–2.040	173.653	183.854	656.460	658.711	–163.9802	200
298.15	20.786	0.000	181.953	181.953	658.500	658.500	–107.3537	298.15
300	20.786	0.038	182.082	181.953	658.538	658.494	–106.6423	300
400	20.786	2.117	188.061	182.769	660.617	658.117	–77.9865	400
500	20.786	4.196	192.700	184.308	662.696	657.647	–60.8042	500
600	20.786	6.274	196.490	186.032	664.774	657.109	–49.3582	600
700	20.786	8.353	199.694	187.761	666.853	656.515	–41.1895	700
800	20.786	10.432	202.469	189.430	668.932	655.873	–35.0687	800
900	20.786	12.510	204.918	191.017	671.010	655.185	–30.3130	900
1000	20.787	14.589	207.108	192.519	673.089	654.451	–26.5125	1000
1100	20.789	16.668	209.089	193.937	675.168	653.667	–23.4066	1100
1200	20.793	18.747	210.898	195.276	677.247	652.828	–20.8216	1200
1300	20.804	20.827	212.563	196.542	679.327	651.927	–18.6372	1300
1400	20.823	22.908	214.105	197.742	681.408	650.958	–16.7676	1400
1500	20.857	24.992	215.543	198.882	683.492	649.917	–15.1497	1500
1600	20.910	27.080	216.890	199.966	685.580	648.798	–13.7364	1600
1700	20.989	29.174	218.160	200.999	687.674	647.596	–12.4916	1700
1800	21.101	31.279	219.363	201.986	689.779	646.310	–11.3872	1800
1900	21.250	33.396	220.508	202.931	691.896	644.932	–10.4011	1900
2000	21.444	35.530	221.602	203.837	694.030	643.460	–9.5156	2000
2100	21.687	37.686	222.654	204.709	696.186	641.889	–8.7163	2100
2200	21.985	39.869	223.670	205.547	698.369	640.217	–7.9915	2200
2300	22.342	42.085	224.655	206.357	700.585	638.438	–7.3316	2300
2400	22.762	44.340	225.614	207.139	702.840	636.550	–6.7283	2400
2500	23.248	46.640	226.553	207.897	705.140	634.546	–6.1750	2500
2600	23.804	48.992	227.476	208.633	707.492	632.413	–5.6659	2600
2700	24.430	51.403	228.385	209.347	709.903	630.117	–5.1962	2700
2800	25.128	53.880	229.286	210.043	712.380	627.603	–4.7617	2800
*2900	25.900	56.431	230.181	210.722	714.931	588.913	–4.3597	2900
3000	26.745	59.063	231.073	211.386	717.563	587.779	–4.0065	3000
3100	27.662	61.783	231.965	212.035	720.283	586.733	–3.6767	3100
3200	28.651	64.598	232.859	212.672	723.098	585.783	–3.3680	3200
3300	29.707	67.515	233.756	213.297	726.015	584.935	–3.0784	3300
3400	30.830	70.541	234.660	213.912	729.041	584.195	–2.8063	3400
3500	32.014	73.683	235.570	214.518	732.183	583.571	–2.5500	3500
3600	33.255	76.946	236.490	215.116	735.446	583.069	–2.3082	3600
3700	34.547	80.336	237.418	215.706	738.836	582.693	–2.0796	3700
3800	35.884	83.857	238.357	216.290	742.357	582.448	–1.8632	3800
3900	37.260	87.514	239.307	216.868	746.014	582.340	–1.6580	3900
4000	38.668	91.310	240.268	217.441	749.810	582.370	–1.4630	4000
4100	40.098	95.248	241.240	218.009	753.748	582.543	–1.2775	4100
4200	41.545	99.330	242.224	218.574	757.830	582.859	–1.1007	4200
4300	42.999	103.557	243.218	219.136	762.057	583.321	–0.9321	4300
4400	44.453	107.929	244.224	219.694	766.429	583.928	–0.7710	4400
4500	45.900	112.447	245.239	220.251	770.947	584.680	–0.6168	4500

TABLE A76.—THERMODYNAMIC PROPERTIES FOR Mo (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	47.329	117.108	246.263	220.805	775.608	585.575	–0.4692	4600
4700	48.737	121.911	247.296	221.358	780.411	586.613	–0.3276	4700
4800	50.112	126.853	248.336	221.909	785.353	587.788	–0.1916	4800
4900	51.457	131.931	249.384	222.459	790.431	589.102	–0.0610	4900
5000	52.753	137.139	250.436	223.008	795.639	590.544	0.0648	5000
5100	54.013	142.478	251.493	223.556	800.978	592.117	0.1859	5100
5200	55.242	147.907	252.537	224.094	806.407	593.780	0.3022	5200
5300	56.421	153.490	253.601	224.640	811.990	595.598	0.4149	5300
5400	57.538	159.189	254.666	225.186	817.689	597.531	0.5238	5400
5500	58.588	164.996	255.731	225.732	823.496	599.573	0.6290	5500
5600	59.563	170.904	256.796	226.277	829.404	601.715	0.7309	5600
5700	60.458	176.906	257.858	226.822	835.406	603.951	0.8295	5700
5800	61.265	182.993	258.917	227.366	841.493	606.272	0.9251	5800
5900	61.980	189.156	259.970	227.910	847.656	608.670	1.0178	5900
6000	62.594	195.385	261.017	228.453	853.885	611.134	1.1078	6000
6200	63.649	208.010	263.087	229.537	866.510			6200
6400	64.651	220.841	265.124	230.617	879.341			6400
6600	65.517	233.861	267.127	231.693	892.361			6600
6800	66.192	247.035	269.093	232.765	905.535			6800
7000	66.646	260.323	271.019	233.830	918.823			7000
7200	66.867	273.678	272.900	234.889	932.178			7200
7400	66.853	287.054	274.733	235.942	945.554			7400
7600	66.612	300.404	276.513	236.986	958.904			7600
7800	66.159	313.685	278.238	238.022	972.185			7800
8000	65.510	326.855	279.905	239.048	985.355			8000
8500	63.172	359.064	283.811	241.568	1017.564			8500
9000	60.081	389.901	287.337	244.015	1048.401			9000
9500	56.556	419.072	290.492	246.379	1077.572			9500
10000	52.870	446.430	293.300	248.657	1104.930			10000
10500	49.236	471.951	295.791	250.843	1130.451			10500
11000	45.811	495.702	298.001	252.937	1154.202			11000
11500	42.697	517.815	299.968	254.940	1176.315			11500
12000	39.950	538.461	301.725	256.854	1196.961			12000
12500	37.592	557.830	303.307	258.681	1216.330			12500
13000	35.611	576.116	304.742	260.425	1234.616			13000
13500	33.979	593.500	306.054	262.091	1252.000			13500
14000	32.649	610.146	307.265	263.683	1268.646			14000
14500	31.568	626.190	308.391	265.206	1284.690			14500
15000	30.678	641.746	309.446	266.663	1300.246			15000
15500	29.924	656.891	310.439	268.059	1315.391			15500
16000	29.256	671.684	311.378	269.398	1330.184			16000
16500	28.631	686.154	312.269	270.684	1344.654			16500
17000	28.023	700.318	313.115	271.920	1358.818			17000
17500	27.415	714.176	313.918	273.108	1372.676			17500
18000	26.812	727.734	314.682	274.253	1386.234			18000
18500	26.236	740.994	315.409	275.355	1399.494			18500
19000	25.730	753.982	316.102	276.418	1412.482			19000
19500	25.361	766.747	316.765	277.444	1425.247			19500
20000	25.218	779.381	317.405	278.435	1437.881			20000

***Assigned reference element phase change at 2896 K**

TABLE A77.—THERMODYNAMIC PROPERTIES FOR Mo^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1342.816	1341.203	----------	0
298.15	20.786	0.000	180.671	180.671	1349.013	1349.013	–227.2968	298.15
300	20.786	0.038	180.800	180.672	1349.051	1349.046	–225.8394	300
400	20.786	2.117	186.780	181.487	1351.130	1350.747	–167.0845	400
500	20.786	4.196	191.418	183.027	1353.209	1352.355	–131.7879	500
600	20.786	6.274	195.208	184.751	1355.287	1353.897	–108.2292	600
700	20.786	8.353	198.412	186.479	1357.366	1355.381	–91.3826	700
800	20.786	10.432	201.188	188.148	1359.445	1356.817	–78.7341	800
900	20.786	12.510	203.636	189.736	1361.523	1358.208	–68.8860	900
1000	20.786	14.589	205.826	191.237	1363.602	1359.553	–60.9995	1000
1100	20.787	16.668	207.807	192.655	1365.680	1360.847	–54.5407	1100
1200	20.789	18.746	209.616	193.994	1367.759	1362.086	–49.1534	1200
1300	20.794	20.825	211.280	195.261	1369.838	1363.263	–44.5908	1300
1400	20.804	22.905	212.821	196.461	1371.918	1364.372	–40.6767	1400
1500	20.825	24.987	214.257	197.600	1374.000	1365.407	–37.2818	1500
1600	20.860	27.071	215.602	198.683	1376.084	1366.362	–34.3091	1600
1700	20.917	29.159	216.869	199.716	1378.172	1367.233	–31.6844	1700
1800	21.004	31.255	218.067	200.703	1380.268	1368.017	–29.3499	1800
1900	21.129	33.361	219.205	201.647	1382.374	1368.707	–27.2600	1900
2000	21.300	35.482	220.293	202.552	1384.495	1369.300	–25.3783	2000
2100	21.527	37.623	221.338	203.422	1386.636	1369.793	–23.6750	2100
2200	21.817	39.790	222.345	204.259	1388.803	1370.183	–22.1261	2200
2300	22.177	41.989	223.323	205.067	1391.002	1370.466	–20.7116	2300
2400	22.614	44.228	224.276	205.848	1393.241	1370.640	–19.4147	2400
2500	23.131	46.514	225.209	206.603	1395.527	1370.701	–18.2214	2500
2600	23.734	48.857	226.128	207.337	1397.870	1370.638	–17.1199	2600
2700	24.422	51.264	227.036	208.050	1400.277	1370.416	–16.1002	2700
2800	25.197	53.744	227.938	208.744	1402.757	1369.984	–15.1534	2800
*2900	26.057	56.306	228.837	209.421	1405.319	1333.384	–14.2733	2900
3000	26.998	58.958	229.736	210.083	1407.971	1334.349	–13.4724	3000
3100	28.017	61.708	230.638	210.732	1410.721	1335.412	–12.7227	3100
3200	29.108	64.564	231.544	211.368	1413.577	1336.581	–12.0193	3200
3300	30.263	67.532	232.457	211.993	1416.545	1337.862	–11.3578	3300
3400	31.475	70.619	233.379	212.609	1419.632	1339.262	–10.7347	3400
3500	32.735	73.829	234.309	213.215	1422.842	1340.785	–10.1465	3500
3600	34.033	77.167	235.250	213.814	1426.180	1342.436	–9.5904	3600
3700	35.358	80.636	236.200	214.406	1429.649	1344.218	–9.0636	3700
3800	36.701	84.239	237.161	214.993	1433.252	1346.134	–8.5639	3800
3900	38.050	87.977	238.132	215.573	1436.990	1348.185	–8.0891	3900
4000	39.395	91.849	239.112	216.150	1440.862	1350.370	–7.6373	4000
4100	40.726	95.855	240.101	216.722	1444.868	1352.689	–7.2068	4100
4200	42.032	99.993	241.098	217.290	1449.006	1355.140	–6.7962	4200
4300	43.304	104.260	242.102	217.856	1453.273	1357.721	–6.4039	4300
4400	44.535	108.653	243.112	218.418	1457.666	1360.426	–6.0287	4400
4500	45.715	113.166	244.126	218.978	1462.179	1363.252	–5.6694	4500
4600	46.838	117.794	245.143	219.536	1466.807	1366.193	–5.3251	4600
4700	47.899	122.531	246.162	220.092	1471.544	1369.244	–4.9946	4700
4800	48.893	127.372	247.181	220.645	1476.384	1372.397	–4.6772	4800
4900	49.816	132.308	248.199	221.197	1481.321	1375.646	–4.3721	4900
5000	50.665	137.332	249.214	221.747	1486.345	1378.984	–4.0785	5000

TABLE A77.—THERMODYNAMIC PROPERTIES FOR Mo^+ (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	51.439	142.438	250.225	222.296	1491.451	1382.403	–3.7956	5100
5200	52.199	147.645	251.236	222.843	1496.658	1385.922	–3.5230	5200
5300	52.833	152.897	252.237	223.388	1501.910	1389.487	–3.2600	5300
5400	53.395	158.209	253.230	223.932	1507.222	1393.112	–3.0061	5400
5500	53.886	163.574	254.214	224.473	1512.587	1396.790	–2.7608	5500
5600	54.307	168.984	255.189	225.013	1517.997	1400.513	–2.5236	5600
5700	54.663	174.433	256.153	225.551	1523.446	1404.276	–2.2941	5700
5800	54.957	179.914	257.107	226.087	1528.927	1408.070	–2.0719	5800
5900	55.191	185.422	258.048	226.621	1534.435	1411.891	–1.8567	5900
6000	55.371	190.951	258.977	227.152	1539.964	1415.733	–1.6481	6000
6200	55.581	202.049	260.797	228.208	1551.062			6200
6400	55.621	213.172	262.563	229.254	1562.185			6400
6600	55.521	224.288	264.273	230.290	1573.301			6600
6800	55.313	235.373	265.927	231.314	1584.386			6800
7000	55.023	246.408	267.527	232.326	1595.421			7000
7200	54.676	257.379	269.072	233.325	1606.392			7200
7400	54.291	268.276	270.565	234.312	1617.289			7400
7600	53.886	279.094	272.008	235.285	1628.107			7600
7800	53.473	289.830	273.402	236.244	1638.843			7800
8000	53.064	300.483	274.751	237.190	1649.496			8000
8500	52.101	326.770	277.938	239.495	1675.783			8500
9000	51.271	352.607	280.892	241.713	1701.620			9000
9500	50.588	378.066	283.645	243.849	1727.079			9500
10000	50.037	403.217	286.225	245.904	1752.230			10000
10500	49.590	428.120	288.656	247.882	1777.133			10500
11000	49.218	452.819	290.954	249.788	1801.832			11000
11500	48.892	477.345	293.134	251.626	1826.358			11500
12000	48.591	501.716	295.209	253.399	1850.729			12000
12500	48.290	525.931	297.186	255.111	1874.944			12500
13000	47.987	550.001	299.074	256.766	1899.014			13000
13500	47.664	573.909	300.878	258.367	1922.922			13500
14000	47.326	597.657	302.606	259.916	1946.670			14000
14500	46.966	621.231	304.260	261.417	1970.244			14500
15000	46.562	644.578	305.843	262.871	1993.591			15000
15500	46.155	667.759	307.363	264.282	2016.771			15500
16000	45.714	690.697	308.819	265.651	2039.710			16000
16500	45.269	713.443	310.219	266.980	2062.456			16500
17000	44.810	735.963	311.564	268.272	2084.976			17000
17500	44.284	758.102	312.846	269.526	2107.115			17500
18000	43.798	780.123	314.087	270.747	2129.136			18000
18500	43.274	801.798	315.274	271.934	2150.811			18500
19000	42.775	823.311	316.422	273.089	2172.323			19000
19500	42.275	844.573	317.526	274.215	2193.586			19500
20000	41.680	865.221	318.569	275.308	2214.234			20000

*Assigned reference element phase change at 2896 K

TABLE A78.—THERMODYNAMIC PROPERTIES FOR Mo^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	574.127	584.910	----------	0
298.15	20.786	0.000	180.671	180.671	580.325	580.325	–94.8208	298.15
300	20.786	0.038	180.800	180.672	580.363	580.281	–94.1939	300
400	20.786	2.117	186.780	181.487	582.442	577.825	–68.9835	400
500	20.786	4.196	191.418	183.027	584.520	575.276	–53.9232	500
600	20.786	6.274	195.208	184.751	586.599	572.660	–43.9284	600
700	20.786	8.353	198.412	186.479	588.678	569.987	–36.8222	700
800	20.786	10.432	201.188	188.148	590.756	567.266	–31.5178	800
900	20.786	12.510	203.636	189.736	592.835	564.500	–27.4121	900
1000	20.786	14.589	205.826	191.237	594.913	561.687	–24.1438	1000
1100	20.786	16.667	207.807	192.655	596.992	558.824	–21.4832	1100
1200	20.786	18.746	209.616	193.994	599.071	555.906	–19.2775	1200
1300	20.786	20.825	211.280	195.261	601.149	552.925	–17.4210	1300
1400	20.786	22.903	212.820	196.461	603.228	549.875	–15.8384	1400
1500	20.786	24.982	214.254	197.600	605.307	546.750	–14.4744	1500
1600	20.786	27.061	215.596	198.683	607.385	543.543	–13.2879	1600
1700	20.786	29.139	216.856	199.715	609.464	540.247	–12.2472	1700
1800	20.786	31.218	218.044	200.701	611.542	536.856	–11.3278	1800
1900	20.786	33.296	219.168	201.643	613.621	533.361	–10.5105	1900
2000	20.786	35.375	220.234	202.546	615.700	529.755	–9.7798	2000
2100	20.786	37.454	221.248	203.413	617.778	526.028	–9.1232	2100
2200	20.786	39.532	222.215	204.246	619.857	522.173	–8.5306	2200
2300	20.786	41.611	223.139	205.047	621.936	518.178	–7.9936	2300
2400	20.786	43.690	224.024	205.820	624.014	514.035	–7.5052	2400
2500	20.786	45.768	224.872	206.565	626.093	509.731	–7.0595	2500
2600	20.786	47.847	225.688	207.285	628.172	505.246	–6.6517	2600
2700	20.786	49.926	226.472	207.981	630.250	500.539	–6.2775	2700
2800	20.786	52.004	227.228	208.655	632.329	495.548	–5.9333	2800
*2900	20.786	54.083	227.957	209.308	634.407	454.307	–5.6171	2900
3000	20.786	56.161	228.662	209.942	636.486	450.541	–5.3455	3000
3100	20.786	58.240	229.344	210.557	638.565	446.775	–5.0935	3100
3200	20.786	60.319	230.004	211.154	640.643	443.010	–4.8592	3200
3300	20.786	62.397	230.643	211.735	642.722	439.244	–4.6410	3300
3400	20.786	64.476	231.264	212.300	644.801	435.479	–4.4374	3400
3500	20.786	66.555	231.866	212.851	646.879	431.713	–4.2471	3500
3600	20.786	68.633	232.452	213.387	648.958	427.947	–4.0689	3600
3700	20.786	70.712	233.021	213.910	651.036	424.182	–3.9018	3700
3800	20.786	72.790	233.576	214.420	653.115	420.416	–3.7449	3800
3900	20.786	74.869	234.116	214.919	655.194	416.651	–3.5974	3900
4000	20.786	76.948	234.642	215.405	657.272	412.885	–3.4585	4000
4100	20.786	79.026	235.155	215.881	659.351	409.119	–3.3276	4100
4200	20.786	81.105	235.656	216.345	661.430	405.354	–3.2041	4200
4300	20.786	83.184	236.145	216.800	663.508	401.588	–3.0874	4300
4400	20.786	85.262	236.623	217.245	665.587	397.823	–2.9770	4400
4500	20.786	87.341	237.090	217.681	667.665	394.057	–2.8726	4500
4600	20.786	89.419	237.547	218.108	669.744	390.292	–2.7736	4600
4700	20.786	91.498	237.994	218.526	671.823	386.526	–2.6798	4700
4800	20.786	93.577	238.432	218.937	673.901	382.760	–2.5907	4800
4900	20.786	95.655	238.860	219.339	675.980	378.995	–2.5061	4900
5000	20.786	97.734	239.280	219.734	678.059	375.229	–2.4257	5000

TABLE A78.—THERMODYNAMIC PROPERTIES FOR Mo^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	239.692	220.121	680.137	371.463	–2.3492	5100
5200	20.786	101.891	240.096	220.501	682.216	367.698	–2.2764	5200
5300	20.786	103.970	240.492	220.875	684.294	363.932	–2.2071	5300
5400	20.786	106.048	240.880	221.241	686.373	360.167	–2.1410	5400
5500	20.786	108.127	241.261	221.602	688.452	356.401	–2.0780	5500
5600	20.786	110.206	241.636	221.956	690.530	352.635	–2.0179	5600
5700	20.786	112.284	242.004	222.305	692.609	348.870	–1.9605	5700
5800	20.786	114.363	242.365	222.648	694.688	345.104	–1.9057	5800
5900	20.786	116.442	242.721	222.985	696.766	341.339	–1.8533	5900
6000	20.786	118.520	243.070	223.317	698.845	337.573	–1.8032	6000
6200	20.786	122.677	243.752	223.965	703.002			6200
6400	20.786	126.835	244.412	224.594	707.159			6400
6600	20.786	130.992	245.051	225.204	711.317			6600
6800	20.786	135.149	245.672	225.797	715.474			6800
7000	20.786	139.306	246.274	226.373	719.631			7000
7200	20.786	143.464	246.860	226.934	723.788			7200
7400	20.786	147.621	247.429	227.481	727.946			7400
7600	20.786	151.778	247.984	228.013	732.103			7600
7800	20.786	155.936	248.524	228.532	736.260			7800
8000	20.786	160.093	249.050	229.038	740.417			8000
8500	20.786	170.486	250.310	230.253	750.811			8500
9000	20.786	180.879	251.498	231.401	761.204			9000
9500	20.786	191.272	252.622	232.488	771.597			9500
10000	20.786	201.665	253.688	233.522	781.990			10000
10500	20.786	212.058	254.702	234.506	792.383			10500
11000	20.786	222.452	255.669	235.447	802.776			11000
11500	20.786	232.845	256.593	236.346	813.169			11500
12000	20.786	243.238	257.478	237.208	823.563			12000
12500	20.786	253.631	258.327	238.036	833.956			12500
13000	20.786	264.024	259.142	238.832	844.349			13000
13500	20.786	274.417	259.926	239.599	854.742			13500
14000	20.786	284.810	260.682	240.339	865.135			14000
14500	20.786	295.204	261.412	241.053	875.528			14500
15000	20.786	305.597	262.116	241.743	885.921			15000
15500	20.786	315.990	262.798	242.412	896.314			15500
16000	20.786	326.383	263.458	243.059	906.708			16000
16500	20.786	336.776	264.098	243.687	917.101			16500
17000	20.786	347.169	264.718	244.296	927.494			17000
17500	20.786	357.562	265.321	244.888	937.887			17500
18000	20.786	367.956	265.906	245.464	948.280			18000
18500	20.786	378.349	266.476	246.024	958.673			18500
19000	20.786	388.742	267.030	246.570	969.066			19000
19500	20.786	399.135	267.570	247.101	979.460			19500
20000	20.786	409.528	268.096	247.620	989.853			20000

*Assigned reference element phase change at 2896 K

TABLE A79.—THERMODYNAMIC PROPERTIES FOR N

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	466.483	470.818	----------	0
100	20.786	–4.119	130.595	171.783	468.561	471.445	–243.6039	100
200	20.786	–2.040	145.003	155.203	470.640	472.068	–120.4151	200
298.15	20.786	0.000	153.302	153.302	472.680	472.680	–79.8062	298.15
300	20.786	0.038	153.431	153.303	472.718	472.691	–79.2955	300
400	20.786	2.117	159.411	154.118	474.797	473.312	–58.7081	400
500	20.786	4.196	164.049	155.657	476.876	473.920	–46.3394	500
600	20.786	6.274	167.839	157.381	478.954	474.507	–38.0831	600
700	20.786	8.353	171.043	159.110	481.033	475.064	–32.1785	700
800	20.786	10.432	173.818	160.779	483.112	475.588	–27.7451	800
900	20.786	12.510	176.267	162.367	485.190	476.079	–24.2931	900
1000	20.786	14.589	178.457	163.868	487.269	476.538	–21.5288	1000
1100	20.786	16.667	180.438	165.286	489.347	476.967	–19.2650	1100
1200	20.786	18.746	182.247	166.625	491.426	477.372	–17.3768	1200
1300	20.786	20.825	183.910	167.891	493.505	477.754	–15.7778	1300
1400	20.786	22.903	185.451	169.091	495.583	478.115	–14.4061	1400
1500	20.786	24.982	186.885	170.230	497.662	478.460	–13.2165	1500
1600	20.786	27.061	188.226	171.314	499.741	478.789	–12.1748	1600
1700	20.787	29.139	189.487	172.346	501.819	479.105	–11.2551	1700
1800	20.787	31.218	190.675	173.331	503.898	479.409	–10.4370	1800
1900	20.788	33.297	191.799	174.274	505.977	479.703	–9.7046	1900
2000	20.790	35.376	192.865	175.177	508.056	479.987	–9.0450	2000
2100	20.793	37.455	193.879	176.044	510.135	480.264	–8.4479	2100
2200	20.798	39.534	194.847	176.877	512.214	480.534	–7.9048	2200
2300	20.804	41.614	195.772	177.678	514.294	480.798	–7.4086	2300
2400	20.814	43.695	196.657	178.451	516.375	481.055	–6.9535	2400
2500	20.826	45.777	197.507	179.196	518.457	481.309	–6.5347	2500
2600	20.843	47.861	198.324	179.916	520.541	481.560	–6.1478	2600
2700	20.864	49.946	199.111	180.613	522.626	481.807	–5.7894	2700
2800	20.891	52.034	199.870	181.287	524.714	482.053	–5.4564	2800
2900	20.924	54.124	200.604	181.940	526.804	482.297	–5.1462	2900
3000	20.963	56.219	201.314	182.574	528.899	482.542	–4.8566	3000
3100	21.010	58.317	202.002	183.190	530.997	482.788	–4.5855	3100
3200	21.064	60.421	202.670	183.788	533.101	483.035	–4.3312	3200
3300	21.127	62.530	203.319	184.371	535.210	483.285	–4.0922	3300
3400	21.198	64.647	203.951	184.937	537.327	483.539	–3.8672	3400
3500	21.277	66.770	204.566	185.489	539.450	483.799	–3.6549	3500
3600	21.366	68.902	205.167	186.028	541.582	484.063	–3.4543	3600
3700	21.463	71.044	205.754	186.553	543.724	484.335	–3.2644	3700
3800	21.570	73.195	206.328	187.066	545.875	484.615	–3.0844	3800
3900	21.685	75.358	206.889	187.567	548.038	484.903	–2.9136	3900
4000	21.809	77.533	207.440	188.057	550.213	485.201	–2.7512	4000
4100	21.942	79.720	207.980	188.536	552.400	485.510	–2.5966	4100
4200	22.083	81.921	208.510	189.005	554.601	485.831	–2.4493	4200
4300	22.232	84.137	209.032	189.465	556.817	486.165	–2.3087	4300
4400	22.388	86.368	209.545	189.916	559.048	486.511	–2.1744	4400
4500	22.552	88.615	210.050	190.357	561.295	486.872	–2.0461	4500

TABLE A79.—THERMODYNAMIC PROPERTIES FOR N (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	22.722	90.878	210.547	190.791	563.558	487.247	–1.9232	4600
4700	22.899	93.159	211.038	191.217	565.839	487.638	–1.8054	4700
4800	23.081	95.458	211.522	191.635	568.138	488.045	–1.6924	4800
4900	23.269	97.776	212.000	192.045	570.456	488.469	–1.5840	4900
5000	23.461	100.112	212.472	192.449	572.792	488.910	–1.4798	5000
5100	23.658	102.468	212.938	192.846	575.148	489.369	–1.3796	5100
5200	23.858	104.844	213.399	193.237	577.524	489.844	–1.2832	5200
5300	24.061	107.240	213.856	193.622	579.920	490.339	–1.1903	5300
5400	24.267	109.656	214.307	194.001	582.336	490.852	–1.1008	5400
5500	24.474	112.093	214.755	194.374	584.773	491.383	–1.0144	5500
5600	24.683	114.551	215.197	194.742	587.231	491.933	–0.9310	5600
5700	24.893	117.030	215.636	195.105	589.710	492.500	–0.8505	5700
5800	25.102	119.530	216.071	195.462	592.210	493.087	–0.7726	5800
5900	25.312	122.050	216.502	195.815	594.730	493.692	–0.6973	5900
6000	25.521	124.592	216.929	196.164	597.272	494.315	–0.6244	6000
6200	25.936	129.738	217.773	196.847	602.418	495.614	–0.4854	6200
6400	26.342	134.966	218.603	197.514	607.646	496.981	–0.3548	6400
6600	26.737	140.274	219.419	198.166	612.954	498.413	–0.2317	6600
6800	27.119	145.660	220.223	198.803	618.340	499.905	–0.1155	6800
7000	27.484	151.120	221.014	199.426	623.800	501.451	–0.0056	7000
7200	27.831	156.652	221.794	200.036	629.332	503.046	0.0985	7200
7400	28.159	162.252	222.561	200.635	634.932	504.683	0.1973	7400
7600	28.466	167.915	223.316	201.222	640.595	506.355	0.2912	7600
7800	28.752	173.637	224.059	201.798	646.317	508.054	0.3806	7800
8000	29.016	179.414	224.790	202.364	652.094	509.771	0.4658	8000
8500	29.573	194.082	226.568	203.735	666.762	514.110	0.6623	8500
9000	29.963	208.970	228.270	205.051	681.650	518.359	0.8386	9000
9500	30.236	224.024	229.897	206.316	696.704	522.402	0.9975	9500
10000	30.416	239.191	231.454	207.534	711.871	526.123	1.1416	10000
10500	30.528	254.430	232.940	208.709	727.110	529.427	1.2729	10500
11000	30.592	269.712	234.362	209.843	742.392	532.241	1.3929	11000
11500	30.622	285.015	235.722	210.938	757.695	534.514	1.5030	11500
12000	30.631	300.330	237.026	211.998	773.010	536.221	1.6044	12000
12500	30.631	315.646	238.276	213.025	788.326	537.362	1.6978	12500
13000	30.626	330.960	239.478	214.019	803.640	537.958	1.7843	13000
13500	30.623	346.273	240.634	214.984	818.953	538.052	1.8643	13500
14000	30.624	361.584	241.747	215.919	834.264	537.706	1.9386	14000
14500	30.629	376.896	242.822	216.829	849.576	536.991	2.0078	14500
15000	30.640	392.214	243.860	217.713	864.894	535.993	2.0722	15000
15500	30.655	407.537	244.866	218.573	880.217	534.796	2.1324	15500
16000	30.674	422.869	245.839	219.410	895.549	533.488	2.1887	16000
16500	30.696	438.211	246.783	220.225	910.891	532.155	2.2413	16500
17000	30.721	453.567	247.700	221.020	926.247	530.874	2.2908	17000
17500	30.747	468.933	248.591	221.794	941.613	529.714	2.3374	17500
18000	30.776	484.314	249.458	222.551	956.994	528.739	2.3813	18000
18500	30.807	499.710	250.301	223.289	972.390	528.001	2.4227	18500
19000	30.844	515.122	251.123	224.011	987.802	527.543	2.4619	19000
19500	30.886	530.553	251.925	224.717	1003.233	527.402	2.4991	19500
20000	30.939	546.009	252.707	225.407	1018.689	527.607	2.5344	20000

TABLE A80.—THERMODYNAMIC PROPERTIES FOR N^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.117	----------	----------	1875.011	1873.149	----------	0
298.15	21.285	0.000	159.799	159.799	1882.128	1882.128	–325.2942	298.15
300	21.278	0.039	159.931	159.799	1882.167	1882.178	–323.2608	300
400	21.060	2.155	166.018	160.631	1884.282	1884.914	–241.2799	400
500	20.960	4.255	170.705	162.195	1886.383	1887.623	–192.0194	500
600	20.906	6.348	174.521	163.941	1888.476	1890.303	–159.1318	600
700	20.874	8.437	177.742	165.688	1890.565	1892.949	–135.6074	700
800	20.853	10.523	180.527	167.373	1892.651	1895.560	–117.9395	800
900	20.839	12.608	182.983	168.974	1894.736	1898.135	–104.1789	900
1000	20.829	14.691	185.178	170.486	1896.819	1900.677	–93.1556	1000
1100	20.821	16.774	187.163	171.914	1898.901	1903.189	–84.1244	1100
1200	20.816	18.856	188.974	173.261	1900.983	1905.675	–76.5886	1200
1300	20.811	20.937	190.640	174.535	1903.065	1908.138	–70.2038	1300
1400	20.808	23.018	192.182	175.741	1905.146	1910.581	–64.7241	1400
1500	20.805	25.099	193.618	176.885	1907.226	1913.006	–59.9690	1500
1600	20.804	27.179	194.960	177.973	1909.307	1915.416	–55.8030	1600
1700	20.803	29.259	196.222	179.010	1911.387	1917.812	–52.1225	1700
1800	20.803	31.340	197.411	180.000	1913.467	1920.196	–48.8468	1800
1900	20.804	33.420	198.535	180.946	1915.548	1922.570	–45.9123	1900
2000	20.806	35.501	199.603	181.852	1917.628	1924.935	–43.2680	2000
2100	20.811	37.581	200.618	182.722	1919.709	1927.292	–40.8726	2100
2200	20.817	39.663	201.586	183.557	1921.790	1929.642	–38.6924	2200
2300	20.825	41.745	202.511	184.362	1923.872	1931.986	–36.6992	2300
2400	20.835	43.828	203.398	185.136	1925.955	1934.325	–34.8700	2400
2500	20.848	45.912	204.249	185.884	1928.040	1936.660	–33.1851	2500
2600	20.864	47.997	205.067	186.606	1930.125	1938.991	–31.6279	2600
2700	20.883	50.085	205.855	187.305	1932.212	1941.319	–30.1843	2700
2800	20.905	52.174	206.614	187.981	1934.302	1943.645	–28.8422	2800
2900	20.929	54.266	207.348	188.636	1936.393	1945.969	–27.5911	2900
3000	20.957	56.360	208.058	189.272	1938.488	1948.293	–26.4221	3000
3100	20.987	58.457	208.746	189.889	1940.585	1950.615	–25.3272	3100
3200	21.020	60.558	209.413	190.489	1942.685	1952.938	–24.2995	3200
3300	21.056	62.661	210.060	191.072	1944.789	1955.261	–23.3330	3300
3400	21.095	64.769	210.689	191.640	1946.897	1957.585	–22.4222	3400
3500	21.135	66.880	211.301	192.193	1949.008	1959.911	–21.5624	3500
3600	21.178	68.996	211.897	192.732	1951.124	1962.238	–20.7495	3600
3700	21.223	71.116	212.478	193.258	1953.244	1964.567	–19.9796	3700
3800	21.269	73.241	213.045	193.771	1955.368	1966.898	–19.2493	3800
3900	21.317	75.370	213.598	194.272	1957.498	1969.232	–18.5556	3900
4000	21.367	77.504	214.138	194.762	1959.632	1971.568	–17.8959	4000
4100	21.417	79.643	214.667	195.241	1961.771	1973.907	–17.2676	4100
4200	21.468	81.788	215.183	195.710	1963.915	1976.250	–16.6685	4200
4300	21.520	83.937	215.689	196.169	1966.065	1978.596	–16.0966	4300
4400	21.573	86.092	216.184	196.618	1968.219	1980.945	–15.5500	4400
4500	21.626	88.252	216.670	197.058	1970.379	1983.297	–15.0271	4500
4600	21.679	90.417	217.146	197.490	1972.545	1985.653	–14.5264	4600
4700	21.732	92.587	217.612	197.913	1974.715	1988.012	–14.0464	4700
4800	21.785	94.763	218.071	198.328	1976.891	1990.375	–13.5858	4800
4900	21.837	96.944	218.520	198.736	1979.072	1992.741	–13.1435	4900
5000	21.890	99.131	218.962	199.136	1981.258	1995.110	–12.7184	5000

TABLE A80.—THERMODYNAMIC PROPERTIES FOR N^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.941	101.322	219.396	199.529	1983.450	1997.483	–12.3095	5100
5200	21.992	103.519	219.822	199.915	1985.647	1999.858	–11.9159	5200
5300	22.043	105.721	220.242	200.295	1987.848	2002.237	–11.5366	5300
5400	22.092	107.927	220.654	200.668	1990.055	2004.619	–11.1710	5400
5500	22.141	110.139	221.060	201.035	1992.267	2007.003	–10.8182	5500
5600	22.189	112.356	221.460	201.396	1994.483	2009.390	–10.4777	5600
5700	22.236	114.577	221.853	201.752	1996.705	2011.779	–10.1486	5700
5800	22.282	116.803	222.240	202.101	1998.930	2014.171	–9.8306	5800
5900	22.327	119.033	222.621	202.446	2001.161	2016.564	–9.5230	5900
6000	22.371	121.268	222.997	202.785	2003.396	2018.959	–9.2252	6000
6200	22.455	125.751	223.732	203.449	2007.878	2023.752	–8.6576	6200
6400	22.535	130.250	224.446	204.094	2012.377	2028.547	–8.1242	6400
6600	22.611	134.764	225.140	204.722	2016.892	2033.343	–7.6219	6600
6800	22.682	139.294	225.817	205.332	2021.421	2038.136	–7.1480	6800
7000	22.749	143.837	226.475	205.927	2025.965	2042.922	–6.7002	7000
7200	22.812	148.393	227.117	206.507	2030.521	2047.698	–6.2763	7200
7400	22.871	152.962	227.743	207.072	2035.089	2052.462	–5.8743	7400
7600	22.927	157.541	228.353	207.624	2039.669	2057.208	–5.4927	7600
7800	22.979	162.132	228.949	208.163	2044.260	2061.932	–5.1297	7800
8000	23.027	166.733	229.532	208.690	2048.860	2066.630	–4.7841	8000
8500	23.136	178.274	230.931	209.958	2060.402	2078.236	–3.9882	8500
9000	23.229	189.866	232.256	211.160	2071.993	2089.581	–3.2768	9000
9500	23.309	201.501	233.514	212.304	2083.628	2100.598	–2.6369	9500
10000	23.378	213.173	234.712	213.395	2095.300	2111.218	–2.0579	10000
10500	23.440	224.878	235.854	214.437	2107.005	2121.381	–1.5316	10500
11000	23.496	236.612	236.946	215.436	2118.740	2131.041	–1.0508	11000
11500	23.547	248.373	237.991	216.394	2130.501	2140.164	–0.6099	11500
12000	23.596	260.159	238.995	217.315	2142.286	2148.736	–0.2040	12000
12500	23.642	271.968	239.959	218.201	2154.096	2156.763	0.1708	12500
13000	23.687	283.801	240.887	219.056	2165.928	2164.270	0.5180	13000
13500	23.732	295.655	241.782	219.881	2177.783	2171.300	0.8406	13500
14000	23.778	307.533	242.646	220.679	2189.661	2177.913	1.1411	14000
14500	23.825	319.434	243.481	221.451	2201.561	2184.180	1.4217	14500
15000	23.874	331.359	244.289	222.199	2213.486	2190.182	1.6843	15000
15500	23.925	343.308	245.073	222.924	2225.436	2196.005	1.9307	15500
16000	23.979	355.284	245.833	223.628	2237.412	2201.735	2.1622	16000
16500	24.037	367.288	246.572	224.312	2249.416	2207.456	2.3803	16500
17000	24.098	379.322	247.291	224.978	2261.449	2213.246	2.5861	17000
17500	24.163	391.387	247.990	225.625	2273.514	2219.178	2.7807	17500
18000	24.232	403.486	248.672	226.256	2285.613	2225.314	2.9649	18000
18500	24.307	415.620	249.337	226.871	2297.748	2231.707	3.1397	18500
19000	24.386	427.793	249.986	227.471	2309.920	2238.403	3.3058	19000
19500	24.470	440.007	250.620	228.056	2322.134	2245.438	3.4638	19500
20000	24.560	452.264	251.241	228.628	2334.392	2252.838	3.6144	20000

TABLE A81.—THERMODYNAMIC PROPERTIES FOR N^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.498	----------	----------	467.039	477.572	----------	0
298.15	21.009	0.000	159.930	159.930	473.538	473.538	–80.7061	298.15
300	21.007	0.039	160.060	159.930	473.576	473.511	–80.1945	300
400	20.914	2.134	166.088	160.753	475.672	472.069	–59.6120	400
500	20.869	4.223	170.750	162.303	477.761	470.609	–47.3007	500
600	20.844	6.309	174.552	164.038	479.846	469.125	–39.1189	600
700	20.829	8.392	177.764	165.775	481.930	467.608	–33.2935	700
800	20.819	10.475	180.545	167.451	484.012	466.058	–28.9389	800
900	20.812	12.556	182.997	169.045	486.094	464.473	–25.5633	900
1000	20.808	14.637	185.189	170.552	488.175	462.855	–22.8722	1000
1100	20.804	16.718	187.172	171.974	490.255	461.208	–20.6781	1100
1200	20.801	18.798	188.982	173.317	492.336	459.535	–18.8563	1200
1300	20.799	20.878	190.647	174.587	494.416	457.840	–17.3204	1300
1400	20.797	22.958	192.188	175.790	496.495	456.124	–16.0088	1400
1500	20.796	25.038	193.623	176.931	498.575	454.391	–14.8764	1500
1600	20.795	27.117	194.965	178.017	500.655	452.642	–13.8893	1600
1700	20.794	29.196	196.226	179.051	502.734	450.880	–13.0217	1700
1800	20.793	31.276	197.414	180.039	504.813	449.107	–12.2536	1800
1900	20.792	33.355	198.539	180.983	506.893	447.322	–11.5690	1900
2000	20.792	35.434	199.605	181.888	508.972	445.528	–10.9553	2000
2100	20.791	37.513	200.619	182.756	511.051	443.726	–10.4023	2100
2200	20.791	39.592	201.587	183.590	513.130	441.917	–9.9017	2200
2300	20.790	41.672	202.511	184.393	515.209	440.101	–9.4464	2300
2400	20.790	43.751	203.396	185.166	517.288	438.279	–9.0308	2400
2500	20.790	45.830	204.244	185.913	519.367	436.451	–8.6501	2500
2600	20.789	47.908	205.060	186.633	521.446	434.618	–8.3001	2600
2700	20.789	49.987	205.844	187.330	523.525	432.780	–7.9773	2700
2800	20.789	52.066	206.600	188.005	525.604	430.939	–7.6790	2800
2900	20.789	54.145	207.330	188.659	527.683	429.093	–7.4023	2900
3000	20.789	56.224	208.035	189.293	529.762	427.244	–7.1453	3000
3100	20.789	58.303	208.716	189.909	531.841	425.391	–6.9058	3100
3200	20.788	60.382	209.376	190.507	533.919	423.535	–6.6823	3200
3300	20.788	62.461	210.016	191.089	535.998	421.676	–6.4733	3300
3400	20.788	64.539	210.637	191.654	538.077	419.814	–6.2774	3400
3500	20.788	66.618	211.239	192.205	540.156	417.950	–6.0935	3500
3600	20.788	68.697	211.825	192.742	542.235	416.082	–5.9206	3600
3700	20.788	70.776	212.394	193.266	544.313	414.213	–5.7579	3700
3800	20.788	72.855	212.949	193.776	546.392	412.341	–5.6043	3800
3900	20.788	74.933	213.489	194.275	548.471	410.467	–5.4593	3900
4000	20.788	77.012	214.015	194.762	550.550	408.591	–5.3222	4000
4100	20.788	79.091	214.528	195.238	552.628	406.712	–5.1924	4100
4200	20.788	81.170	215.029	195.703	554.707	404.832	–5.0693	4200
4300	20.787	83.248	215.518	196.158	556.786	402.950	–4.9525	4300
4400	20.787	85.327	215.996	196.604	558.865	401.066	–4.8415	4400
4500	20.787	87.406	216.463	197.040	560.943	399.180	–4.7359	4500
4600	20.787	89.485	216.920	197.467	563.022	397.292	–4.6354	4600
4700	20.787	91.563	217.367	197.886	565.101	395.402	–4.5397	4700
4800	20.787	93.642	217.805	198.296	567.180	393.510	–4.4483	4800
4900	20.787	95.721	218.234	198.699	569.258	391.617	–4.3611	4900
5000	20.787	97.800	218.654	199.094	571.337	389.721	–4.2779	5000

TABLE A81.—THERMODYNAMIC PROPERTIES FOR N^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.787	99.878	219.065	199.481	573.416	387.824	–4.1982	5100
5200	20.787	101.957	219.469	199.862	575.495	385.924	–4.1220	5200
5300	20.787	104.036	219.865	200.235	577.573	384.022	–4.0491	5300
5400	20.787	106.114	220.253	200.603	579.652	382.119	–3.9791	5400
5500	20.787	108.193	220.635	200.963	581.731	380.213	–3.9121	5500
5600	20.787	110.272	221.009	201.318	583.809	378.305	–3.8478	5600
5700	20.787	112.350	221.377	201.667	585.888	376.394	–3.7860	5700
5800	20.787	114.429	221.739	202.010	587.967	374.481	–3.7267	5800
5900	20.787	116.508	222.094	202.347	590.045	372.565	–3.6697	5900
6000	20.787	118.587	222.443	202.679	592.124	370.647	–3.6149	6000
6200	20.787	122.744	223.125	203.328	596.281	366.800	–3.5113	6200
6400	20.787	126.901	223.785	203.957	600.439	362.939	–3.4152	6400
6600	20.787	131.059	224.425	204.567	604.596	359.063	–3.3260	6600
6800	20.787	135.216	225.045	205.161	608.754	355.169	–3.2428	6800
7000	20.787	139.373	225.648	205.737	612.911	351.255	–3.1653	7000
7200	20.787	143.531	226.233	206.299	617.068	347.318	–3.0929	7200
7400	20.787	147.688	226.803	206.845	621.226	343.356	–3.0252	7400
7600	20.787	151.845	227.357	207.378	625.383	339.365	–2.9618	7600
7800	20.787	156.003	227.897	207.897	629.540	335.342	–2.9023	7800
8000	20.787	160.160	228.423	208.403	633.698	331.282	–2.8465	8000
8500	20.787	170.553	229.684	209.619	644.091	320.953	–2.7212	8500
9000	20.787	180.947	230.872	210.767	654.484	310.314	–2.6134	9000
9500	20.787	191.340	231.996	211.855	664.877	299.303	–2.5203	9500
10000	20.786	201.733	233.062	212.889	675.271	287.858	–2.4395	10000
10500	20.786	212.126	234.076	213.874	685.664	275.923	–2.3694	10500
11000	20.786	222.520	235.043	214.814	696.057	263.455	–2.3084	11000
11500	20.786	232.913	235.967	215.714	706.450	250.424	–2.2553	11500
12000	20.786	243.306	236.852	216.576	716.844	236.817	–2.2092	12000
12500	20.786	253.699	237.700	217.404	727.237	222.642	–2.1691	12500
13000	20.786	264.092	238.515	218.201	737.630	207.924	–2.1345	13000
13500	20.786	274.486	239.300	218.968	748.023	192.705	–2.1047	13500
14000	20.786	284.879	240.056	219.707	758.416	177.048	–2.0791	14000
14500	20.786	295.272	240.785	220.422	768.810	161.021	–2.0573	14500
15000	20.786	305.665	241.490	221.112	779.203	144.705	–2.0390	15000
15500	20.786	316.058	242.172	221.781	789.596	128.185	–2.0236	15500
16000	20.786	326.452	242.832	222.428	799.989	111.546	–2.0110	16000
16500	20.786	336.845	243.471	223.056	810.382	94.870	–2.0008	16500
17000	20.786	347.238	244.092	223.666	820.775	78.233	–1.9927	17000
17500	20.786	357.631	244.694	224.258	831.169	61.707	–1.9866	17500
18000	20.786	368.024	245.280	224.834	841.562	45.351	–1.9821	18000
18500	20.786	378.417	245.849	225.394	851.955	29.217	–1.9792	18500
19000	20.786	388.811	246.404	225.940	862.348	13.347	–1.9776	19000
19500	20.786	399.204	246.944	226.472	872.741	–2.225	–1.9772	19500
20000	20.786	409.597	247.470	226.990	883.134	–17.475	–1.9778	20000

TABLE A82.—THERMODYNAMIC PROPERTIES FOR Na

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	101.303	107.763	----------	0
100	20.786	–4.119	131.011	172.199	103.381	108.494	–51.0626	100
200	20.786	–2.040	145.419	155.620	105.460	108.118	–22.7585	200
298.15	20.786	0.000	153.719	153.719	107.500	107.500	–13.4834	298.15
300	20.786	0.038	153.847	153.719	107.538	107.486	–13.3673	300
*400	20.786	2.117	159.827	154.535	109.617	103.947	–8.7322	400
500	20.786	4.196	164.466	156.074	111.696	102.917	–6.0301	500
600	20.786	6.274	168.255	157.798	113.774	101.967	–4.2460	600
700	20.786	8.353	171.460	159.527	115.853	101.084	–2.9832	700
800	20.786	10.432	174.235	161.196	117.932	100.248	–2.0441	800
900	20.786	12.510	176.683	162.783	120.010	99.440	–1.3197	900
1000	20.786	14.589	178.874	164.285	122.089	98.641	–0.7448	1000
1100	20.786	16.667	180.855	165.702	124.167	97.831	–0.2782	1100
1200	20.786	18.746	182.663	167.042	126.246	96.989	0.1073	1200
1300	20.786	20.825	184.327	168.308	128.325	96.096	0.4306	1300
1400	20.786	22.903	185.868	169.508	130.403	95.130	0.7051	1400
1500	20.787	24.982	187.302	170.647	132.482	94.073	0.9404	1500
1600	20.788	27.061	188.643	171.730	134.561	92.903	1.1440	1600
1700	20.789	29.140	189.904	172.763	136.640	91.601	1.3211	1700
1800	20.792	31.219	191.092	173.748	138.719	90.144	1.4763	1800
1900	20.797	33.298	192.216	174.691	140.798	88.514	1.6127	1900
2000	20.805	35.378	193.283	175.594	142.878	86.690	1.7333	2000
2100	20.817	37.459	194.298	176.461	144.959	84.652	1.8398	2100
2200	20.833	39.542	195.267	177.294	147.042	82.381	1.9343	2200
2300	20.856	41.626	196.194	178.095	149.126	79.856	2.0181	2300
2400	20.886	43.713	197.082	178.868	151.213			2400
2500	20.925	45.803	197.935	179.614	153.303			2500
2600	20.973	47.898	198.757	180.334	155.398			2600
2700	21.033	49.998	199.550	181.032	157.498			2700
2800	21.104	52.105	200.316	181.707	159.605			2800
2900	21.189	54.220	201.058	182.361	161.720			2900
3000	21.289	56.344	201.778	182.996	163.844			3000
3100	21.404	58.478	202.478	183.614	165.978			3100
3200	21.535	60.625	203.159	184.214	168.125			3200
3300	21.680	62.785	203.824	184.798	170.285			3300
3400	21.846	64.961	204.473	185.367	172.461			3400
3500	22.030	67.155	205.109	185.922	174.655			3500
3600	22.235	69.368	205.733	186.464	176.868			3600
3700	22.461	71.602	206.345	186.993	179.102			3700
3800	22.709	73.861	206.947	187.510	181.361			3800
3900	22.981	76.145	207.541	188.016	183.645			3900
4000	23.278	78.458	208.126	188.512	185.958			4000
4100	23.602	80.801	208.705	188.997	188.301			4100
4200	23.946	83.176	209.277	189.473	190.676			4200
4300	24.324	85.590	209.845	189.940	193.090			4300
4400	24.612	87.999	210.398	190.398	195.499			4400
4500	24.992	90.470	210.953	190.849	197.970			4500

TABLE A82.—THERMODYNAMIC PROPERTIES FOR Na (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	25.421	92.991	211.507	191.292	200.491			4600
4700	25.877	95.555	212.059	191.728	203.055			4700
4800	26.359	98.167	212.609	192.157	205.667			4800
4900	26.857	100.879	213.169	192.582	208.379			4900
5000	27.370	103.590	213.717	192.999	211.090			5000
5100	27.767	106.346	214.263	193.411	213.846			5100
5200	28.253	109.147	214.807	193.817	216.647			5200
5300	28.808	111.999	215.350	194.218	219.499			5300
5400	29.416	114.910	215.894	194.614	222.410			5400
5500	30.063	117.884	216.440	195.006	225.384			5500
5600	30.735	120.924	216.987	195.394	228.424			5600
5700	31.422	124.031	217.537	195.778	231.531			5700
5800	32.115	127.208	218.090	196.157	234.708			5800
5900	32.808	130.454	218.645	196.534	237.954			5900
6000	33.493	133.769	219.202	196.907	241.269			6000
6200	34.823	140.602	220.322	197.644	248.102			6200
6400	36.071	147.693	221.448	198.371	255.193			6400
6600	37.219	155.024	222.575	199.087	262.524			6600
6800	38.254	162.573	223.702	199.794	270.073			6800
7000	39.169	170.317	224.825	200.493	277.817			7000
7200	39.962	178.232	225.939	201.185	285.732			7200
7400	40.635	186.294	227.044	201.869	293.794			7400
7600	41.192	194.478	228.135	202.546	301.978			7600
7800	41.638	202.763	229.211	203.216	310.263			7800
8000	41.980	211.127	230.270	203.879	318.627			8000
8500	42.423	232.251	232.831	205.507	339.751			8500
9000	42.375	253.468	235.256	207.093	360.968			9000
9500	41.949	274.562	237.537	208.636	382.062			9500
10000	41.248	295.372	239.672	210.135	402.872			10000
10500	40.357	315.779	241.664	211.590	423.279			10500
11000	39.348	335.709	243.518	212.999	443.209			11000
11500	38.276	355.116	245.244	214.364	462.616			11500
12000	37.183	373.981	246.850	215.685	481.481			12000
12500	36.102	392.301	248.346	216.962	499.801			12500
13000	35.052	410.089	249.741	218.196	517.589			13000
13500	34.048	427.361	251.045	219.389	534.861			13500
14000	33.096	444.144	252.266	220.541	551.644			14000
14500	32.199	460.467	253.411	221.655	567.967			14500
15000	31.356	476.353	254.489	222.732	583.853			15000
15500	30.563	491.831	255.504	223.773	599.331			15500
16000	29.814	506.922	256.462	224.780	614.422			16000
16500	29.103	521.650	257.369	225.753	629.150			16500
17000	28.425	536.031	258.227	226.696	643.531			17000
17500	27.774	550.080	259.042	227.609	657.580			17500
18000	27.147	563.810	259.815	228.493	671.310			18000
18500	26.542	577.231	260.551	229.349	684.731			18500
19000	25.958	590.355	261.251	230.179	697.855			19000
19500	25.398	603.192	261.918	230.985	710.692			19500
20000	24.867	615.758	262.554	231.766	723.258			20000

***Assigned reference element phase change at 371.01 K**

TABLE A83.—THERMODYNAMIC PROPERTIES FOR Na^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	603.346	603.608	----------	0
298.15	20.786	0.000	147.955	147.955	609.543	609.543	–100.6423	298.15
300	20.786	0.038	148.084	147.956	609.581	609.568	–99.9838	300
*400	20.786	2.117	154.064	148.771	611.660	608.107	–73.4533	400
500	20.786	4.196	158.702	150.311	613.739	609.155	–57.5590	500
600	20.786	6.274	162.492	152.035	615.817	610.285	–46.9438	600
700	20.786	8.353	165.696	153.763	617.896	611.480	–39.3470	700
800	20.786	10.432	168.472	155.432	619.975	612.722	–33.6380	800
900	20.786	12.510	170.920	157.020	622.053	613.993	–29.1885	900
1000	20.786	14.589	173.110	158.521	624.132	615.273	–25.6215	1000
1100	20.786	16.667	175.091	159.939	626.210	616.542	–22.6970	1100
1200	20.786	18.746	176.900	161.278	628.289	617.778	–20.2549	1200
1300	20.786	20.825	178.564	162.545	630.368	618.963	–18.1844	1300
1400	20.786	22.903	180.104	163.745	632.446	620.077	–16.4064	1400
1500	20.786	24.982	181.538	164.883	634.525	621.098	–14.8629	1500
1600	20.786	27.061	182.880	165.967	636.604	622.006	–13.5101	1600
1700	20.786	29.139	184.140	166.999	638.682	622.782	–12.3149	1700
1800	20.786	31.218	185.328	167.985	640.761	623.404	–11.2513	1800
1900	20.786	33.296	186.452	168.927	642.839	623.852	–10.2988	1900
2000	20.786	35.375	187.518	169.830	644.918	624.105	–9.4411	2000
2100	20.786	37.454	188.532	170.697	646.997	624.143	–8.6649	2100
2200	20.786	39.532	189.499	171.530	649.075	623.947	–7.9593	2200
2300	20.786	41.611	190.423	172.331	651.154	623.495	–7.3154	2300
2400	20.786	43.690	191.308	173.104	653.233			2400
2500	20.786	45.768	192.156	173.849	655.311			2500
2600	20.786	47.847	192.972	174.569	657.390			2600
2700	20.786	49.926	193.756	175.265	659.468			2700
2800	20.786	52.004	194.512	175.939	661.547			2800
2900	20.786	54.083	195.241	176.592	663.626			2900
3000	20.786	56.161	195.946	177.226	665.704			3000
3100	20.786	58.240	196.628	177.841	667.783			3100
3200	20.786	60.319	197.288	178.438	669.862			3200
3300	20.786	62.397	197.927	179.019	671.940			3300
3400	20.786	64.476	198.548	179.584	674.019			3400
3500	20.786	66.555	199.150	180.135	676.097			3500
3600	20.786	68.633	199.736	180.671	678.176			3600
3700	20.786	70.712	200.305	181.194	680.255			3700
3800	20.786	72.790	200.860	181.704	682.333			3800
3900	20.786	74.869	201.400	182.202	684.412			3900
4000	20.786	76.948	201.926	182.689	686.491			4000
4100	20.786	79.026	202.439	183.164	688.569			4100
4200	20.786	81.105	202.940	183.629	690.648			4200
4300	20.786	83.184	203.429	184.084	692.726			4300
4400	20.786	85.262	203.907	184.529	694.805			4400
4500	20.786	87.341	204.374	184.965	696.884			4500
4600	20.786	89.419	204.831	185.392	698.962			4600
4700	20.786	91.498	205.278	185.810	701.041			4700
4800	20.786	93.577	205.716	186.221	703.120			4800
4900	20.786	95.655	206.144	186.623	705.198			4900
5000	20.786	97.734	206.564	187.017	707.277			5000

TABLE A83.—THERMODYNAMIC PROPERTIES FOR Na^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	206.976	187.405	709.356			5100
5200	20.786	101.891	207.380	187.785	711.434			5200
5300	20.786	103.970	207.775	188.159	713.513			5300
5400	20.786	106.048	208.164	188.525	715.591			5400
5500	20.786	108.127	208.545	188.886	717.670			5500
5600	20.786	110.206	208.920	189.240	719.749			5600
5700	20.786	112.284	209.288	189.589	721.827			5700
5800	20.786	114.363	209.649	189.932	723.906			5800
5900	20.786	116.442	210.005	190.269	725.985			5900
6000	20.786	118.520	210.354	190.601	728.063			6000
6200	20.786	122.677	211.036	191.249	732.220			6200
6400	20.786	126.835	211.696	191.878	736.378			6400
6600	20.786	130.992	212.335	192.488	740.535			6600
6800	20.786	135.149	212.956	193.081	744.692			6800
7000	20.786	139.306	213.558	193.657	748.849			7000
7200	20.786	143.464	214.144	194.218	753.007			7200
7400	20.786	147.621	214.713	194.765	757.164			7400
7600	20.786	151.778	215.268	195.297	761.321			7600
7800	20.786	155.936	215.808	195.816	765.478			7800
8000	20.786	160.093	216.334	196.322	769.636			8000
8500	20.786	170.486	217.594	197.537	780.029			8500
9000	20.786	180.879	218.782	198.684	790.422			9000
9500	20.786	191.272	219.906	199.772	800.815			9500
10000	20.786	201.665	220.972	200.806	811.208			10000
10500	20.786	212.058	221.986	201.790	821.601			10500
11000	20.786	222.452	222.953	202.730	831.995			11000
11500	20.786	232.845	223.877	203.630	842.388			11500
12000	20.786	243.238	224.762	204.492	852.781			12000
12500	20.786	253.631	225.611	205.320	863.174			12500
13000	20.786	264.024	226.426	206.116	873.567			13000
13500	20.786	274.417	227.210	206.883	883.960			13500
14000	20.786	284.810	227.966	207.623	894.353			14000
14500	20.786	295.204	228.696	208.337	904.746			14500
15000	20.786	305.597	229.400	209.027	915.140			15000
15500	20.786	315.990	230.082	209.695	925.533			15500
16000	20.786	326.383	230.742	210.343	935.926			16000
16500	20.786	336.776	231.381	210.971	946.319			16500
17000	20.786	347.169	232.002	211.580	956.712			17000
17500	20.786	357.562	232.605	212.172	967.105			17500
18000	20.786	367.956	233.190	212.748	977.498			18000
18500	20.786	378.349	233.760	213.308	987.892			18500
19000	20.786	388.742	234.314	213.854	998.285			19000
19500	20.786	399.135	234.854	214.385	1008.678			19500
20000	20.786	409.528	235.380	214.904	1019.071			20000

*Assigned reference element phase change at 371.01 K

TABLE A84.—THERMODYNAMIC PROPERTIES FOR Na^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	42.256	54.913	----------	0
298.15	20.786	0.000	147.956	147.956	48.453	48.453	–4.5358	298.15
300	20.786	0.038	148.085	147.956	48.492	48.401	–4.4835	300
*400	20.786	2.117	154.064	148.772	50.571	42.783	–2.4612	400
500	20.786	4.196	158.703	150.311	52.649	39.674	–1.3815	500
600	20.786	6.274	162.492	152.035	54.728	36.646	–0.7156	600
700	20.786	8.353	165.697	153.764	56.806	33.684	–0.2774	700
800	20.786	10.432	168.472	155.433	58.885	30.769	0.0238	800
900	20.786	12.510	170.921	157.020	60.964	27.883	0.2369	900
1000	20.786	14.589	173.111	158.522	63.042	25.005	0.3907	1000
1100	20.786	16.667	175.092	159.940	65.121	22.117	0.5028	1100
1200	20.786	18.746	176.900	161.279	67.200	19.196	0.5847	1200
1300	20.786	20.825	178.564	162.545	69.278	16.224	0.6442	1300
1400	20.786	22.903	180.105	163.745	71.357	13.180	0.6865	1400
1500	20.786	24.982	181.539	164.884	73.435	10.044	0.7155	1500
1600	20.786	27.061	182.880	165.967	75.514	6.795	0.7340	1600
1700	20.786	29.139	184.140	167.000	77.593	3.414	0.7438	1700
1800	20.786	31.218	185.329	167.985	79.671	–0.122	0.7468	1800
1900	20.786	33.296	186.452	168.928	81.750	–3.831	0.7438	1900
2000	20.786	35.375	187.519	169.831	83.829	–7.735	0.7359	2000
2100	20.786	37.454	188.533	170.698	85.907	–11.854	0.7238	2100
2200	20.786	39.532	189.500	171.530	87.986	–16.208	0.7080	2200
2300	20.786	41.611	190.424	172.332	90.064	–20.817	0.6889	2300
2400	20.786	43.690	191.308	173.104	92.143			2400
2500	20.786	45.768	192.157	173.850	94.222			2500
2600	20.786	47.847	192.972	174.570	96.300			2600
2700	20.786	49.926	193.757	175.266	98.379			2700
2800	20.786	52.004	194.513	175.940	100.458			2800
2900	20.786	54.083	195.242	176.593	102.536			2900
3000	20.786	56.161	195.947	177.226	104.615			3000
3100	20.786	58.240	196.628	177.841	106.693			3100
3200	20.786	60.319	197.288	178.439	108.772			3200
3300	20.786	62.397	197.928	179.020	110.851			3300
3400	20.786	64.476	198.548	179.585	112.929			3400
3500	20.786	66.555	199.151	180.135	115.008			3500
3600	20.786	68.633	199.736	180.672	117.087			3600
3700	20.786	70.712	200.306	181.195	119.165			3700
3800	20.786	72.790	200.860	181.705	121.244			3800
3900	20.786	74.869	201.400	182.203	123.322			3900
4000	20.786	76.948	201.927	182.690	125.401			4000
4100	20.786	79.026	202.440	183.165	127.480			4100
4200	20.786	81.105	202.941	183.630	129.558			4200
4300	20.786	83.184	203.430	184.085	131.637			4300
4400	20.786	85.262	203.908	184.530	133.716			4400
4500	20.786	87.341	204.375	184.966	135.794			4500
4600	20.786	89.419	204.832	185.393	137.873			4600
4700	20.786	91.498	205.279	185.811	139.951			4700
4800	20.786	93.577	205.716	186.221	142.030			4800
4900	20.786	95.655	206.145	186.623	144.109			4900
5000	20.786	97.734	206.565	187.018	146.187			5000

TABLE A84.—THERMODYNAMIC PROPERTIES FOR Na^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	206.976	187.405	148.266			5100
5200	20.786	101.891	207.380	187.786	150.345			5200
5300	20.786	103.970	207.776	188.159	152.423			5300
5400	20.786	106.048	208.165	188.526	154.502			5400
5500	20.786	108.127	208.546	188.887	156.581			5500
5600	20.786	110.206	208.921	189.241	158.659			5600
5700	20.786	112.284	209.288	189.589	160.738			5700
5800	20.786	114.363	209.650	189.932	162.816			5800
5900	20.786	116.442	210.005	190.269	164.895			5900
6000	20.786	118.520	210.355	190.601	166.974			6000
6200	20.786	122.677	211.036	191.250	171.131			6200
6400	20.786	126.835	211.696	191.878	175.288			6400
6600	20.786	130.992	212.336	192.489	179.445			6600
6800	20.786	135.149	212.956	193.081	183.603			6800
7000	20.786	139.306	213.559	193.658	187.760			7000
7200	20.786	143.464	214.144	194.219	191.917			7200
7400	20.786	147.621	214.714	194.765	196.074			7400
7600	20.786	151.778	215.268	195.297	200.232			7600
7800	20.786	155.936	215.808	195.816	204.389			7800
8000	20.786	160.093	216.334	196.323	208.546			8000
8500	20.786	170.486	217.595	197.537	218.939			8500
9000	20.786	180.879	218.783	198.685	229.332			9000
9500	20.786	191.272	219.907	199.773	239.726			9500
10000	20.786	201.665	220.973	200.806	250.119			10000
10500	20.786	212.058	221.987	201.791	260.512			10500
11000	20.786	222.452	222.954	202.731	270.905			11000
11500	20.786	232.845	223.878	203.631	281.298			11500
12000	20.786	243.238	224.763	204.493	291.691			12000
12500	20.786	253.631	225.611	205.321	302.084			12500
13000	20.786	264.024	226.426	206.117	312.478			13000
13500	20.786	274.417	227.211	206.884	322.871			13500
14000	20.786	284.810	227.967	207.623	333.264			14000
14500	20.786	295.204	228.696	208.337	343.657			14500
15000	20.786	305.597	229.401	209.028	354.050			15000
15500	20.786	315.990	230.082	209.696	364.443			15500
16000	20.786	326.383	230.742	210.343	374.836			16000
16500	20.786	336.776	231.382	210.971	385.230			16500
17000	20.786	347.169	232.003	211.581	395.623			17000
17500	20.786	357.562	232.605	212.173	406.016			17500
18000	20.786	367.956	233.191	212.749	416.409			18000
18500	20.786	378.349	233.760	213.309	426.802			18500
19000	20.786	388.742	234.315	213.854	437.195			19000
19500	20.786	399.135	234.854	214.386	447.588			19500
20000	20.786	409.528	235.381	214.904	457.981			20000

*Assigned reference element phase change at 371.01 K

TABLE A85.—THERMODYNAMIC PROPERTIES FOR Nb

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–8.354	----------	----------	714.759	720.000	----------	0
100	28.819	–5.907	153.825	212.894	717.206	721.666	–369.5714	100
200	29.932	–2.955	174.243	189.019	720.158	722.519	–181.0005	200
298.15	30.159	0.000	186.262	186.262	723.113	723.113	–118.8588	298.15
300	30.156	0.056	186.448	186.262	723.169	723.123	–118.0775	300
400	29.646	3.050	195.067	187.441	726.164	723.611	–86.5917	400
500	28.840	5.975	201.597	189.646	729.089	723.971	–67.6887	500
600	28.051	8.819	206.784	192.085	731.932	724.201	–55.0815	600
700	27.366	11.589	211.055	194.499	734.702	724.315	–46.0742	700
800	26.785	14.296	214.670	196.801	737.409	724.325	–39.3181	800
900	26.295	16.949	217.796	198.964	740.062	724.239	–34.0637	900
1000	25.880	19.557	220.545	200.987	742.670	724.067	–29.8608	1000
1100	25.533	22.127	222.994	202.878	745.241	723.818	–26.4231	1100
1200	25.248	24.666	225.203	204.648	747.779	723.495	–23.5595	1200
1300	25.024	27.179	227.215	206.308	750.292	723.110	–21.1377	1300
1400	24.857	29.673	229.063	207.868	752.786	722.666	–19.0630	1400
1500	24.748	32.152	230.774	209.339	755.266	722.164	–17.2661	1500
1600	24.696	34.624	232.369	210.729	757.737	721.602	–15.6950	1600
1700	24.701	37.094	233.866	212.046	760.207	720.981	–14.3098	1700
1800	24.760	39.566	235.280	213.298	762.679	720.298	–13.0797	1800
1900	24.872	42.047	236.621	214.491	765.160	719.552	–11.9801	1900
2000	25.035	44.542	237.901	215.630	767.655	718.744	–10.9916	2000
2100	25.244	47.056	239.127	216.719	770.169	717.873	–10.0982	2100
2200	25.498	49.593	240.307	217.765	772.706	716.938	–9.2872	2200
2300	25.790	52.157	241.447	218.770	775.270	715.934	–8.5476	2300
2400	26.118	54.752	242.551	219.738	777.865	714.855	–7.8706	2400
2500	26.475	57.381	243.625	220.672	780.494	713.689	–7.2488	2500
2600	26.859	60.048	244.670	221.575	783.161	712.416	–6.6758	2600
2700	27.263	62.754	245.692	222.449	785.867	710.999	–6.1462	2700
*2800	27.683	65.501	246.691	223.297	788.614	683.026	–5.6645	2800
2900	28.116	68.291	247.670	224.121	791.404	682.469	–5.2253	2900
3000	28.557	71.124	248.630	224.922	794.237	681.956	–4.8157	3000
3100	29.003	74.002	249.574	225.702	797.115	681.486	–4.4329	3100
3200	29.450	76.925	250.502	226.463	800.038	681.062	–4.0741	3200
3300	29.896	79.892	251.415	227.205	803.005	680.682	–3.7374	3300
3400	30.338	82.904	252.314	227.930	806.017	680.347	–3.4205	3400
3500	30.774	85.960	253.200	228.640	809.073	680.055	–3.1220	3500
3600	31.201	89.059	254.072	229.334	812.172	679.807	–2.8401	3600
3700	31.619	92.200	254.933	230.014	815.313	679.601	–2.5736	3700
3800	32.027	95.382	255.782	230.681	818.495	679.436	–2.3211	3800
3900	32.423	98.605	256.619	231.336	821.718	679.311	–2.0817	3900
4000	32.807	101.866	257.445	231.978	824.979	679.226	–1.8543	4000
4100	33.179	105.166	258.259	232.609	828.279	679.178	–1.6379	4100
4200	33.539	108.502	259.063	233.229	831.615	679.167	–1.4319	4200
4300	33.886	111.873	259.856	233.839	834.986	679.191	–1.2355	4300
4400	34.221	115.278	260.639	234.440	838.392	679.249	–1.0480	4400
4500	34.543	118.717	261.412	235.030	841.830	679.340	–0.8688	4500

TABLE A85.—THERMODYNAMIC PROPERTIES FOR Nb (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	34.855	122.186	262.175	235.612	845.300	679.463	–0.6973	4600
4700	35.154	125.687	262.927	236.185	848.800	679.616	–0.5332	4700
4800	35.444	129.217	263.670	236.750	852.330	679.798	–0.3758	4800
4900	35.723	132.774	264.404	237.307	855.888	680.009	–0.2248	4900
5000	35.994	136.360	265.128	237.856	859.473	680.247	–0.0798	5000
5100	36.254	139.971	265.843	238.398	863.085	680.511	0.0596	5100
5200	36.507	143.609	266.550	238.933	866.722	680.802	0.1936	5200
5300	36.752	147.271	267.247	239.460	870.384	681.117	0.3227	5300
5400	36.989	150.957	267.936	239.981	874.070	681.455	0.4470	5400
5500	37.223	154.667	268.617	240.496	877.780	681.819	0.5669	5500
5600	37.446	158.399	269.289	241.004	881.512	682.203	0.6826	5600
5700	37.669	162.154	269.954	241.506	885.267	682.611	0.7942	5700
5800	37.880	165.928	270.610	242.002	889.041	683.038	0.9021	5800
5900	38.094	169.727	271.260	242.493	892.840	683.489	1.0064	5900
6000	38.293	173.541	271.901	242.977	896.654	683.956	1.1073	6000
6200	38.684	181.231	273.161	243.931	904.344			6200
6400	39.075	189.007	274.396	244.863	912.120			6400
6600	39.430	196.843	275.601	245.776	919.956			6600
6800	39.762	204.742	276.780	246.671	927.855			6800
7000	40.068	212.697	277.932	247.547	935.810			7000
7200	40.399	220.739	279.070	248.412	943.853			7200
7400	40.690	228.849	280.181	249.256	951.962			7400
7600	40.927	237.012	281.270	250.084	960.125			7600
7800	41.106	245.216	282.335	250.897	968.329			7800
8000	41.226	253.451	283.378	251.696	976.564			8000
8500	41.278	274.090	285.880	253.634	997.204			8500
9000	41.014	294.675	288.233	255.492	1017.788			9000
9500	40.500	315.063	290.438	257.274	1038.176			9500
10000	39.803	335.145	292.498	258.984	1058.258			10000
10500	38.987	354.846	294.421	260.626	1077.959			10500
11000	38.107	374.122	296.215	262.204	1097.235			11000
11500	37.204	392.950	297.889	263.719	1116.063			11500
12000	36.311	411.328	299.453	265.176	1134.441			12000
12500	35.450	429.266	300.918	266.577	1152.379			12500
13000	34.634	446.784	302.292	267.924	1169.898			13000
13500	33.870	463.908	303.585	269.221	1187.021			13500
14000	33.161	480.664	304.804	270.470	1203.777			14000
14500	32.503	497.077	305.956	271.674	1220.190			14500
15000	31.890	513.174	307.047	272.835	1236.287			15000
15500	31.316	528.974	308.083	273.956	1252.087			15500
16000	30.773	544.496	309.069	275.038	1267.609			16000
16500	30.253	559.751	310.008	276.083	1282.864			16500
17000	29.750	574.752	310.903	277.094	1297.865			17000
17500	29.258	589.504	311.759	278.073	1312.617			17500
18000	28.776	604.012	312.576	279.020	1327.125			18000
18500	28.303	618.281	313.358	279.938	1341.394			18500
19000	27.843	632.316	314.107	280.827	1355.429			19000
19500	27.403	646.126	314.824	281.689	1369.239			19500
20000	26.996	659.725	315.513	282.527	1382.838			20000

***Assigned reference element phase change at 2750 K**

TABLE A86.—THERMODYNAMIC PROPERTIES FOR Nb^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–8.589	----------	----------	1385.016	1384.059	----------	0
298.15	30.291	0.000	182.978	182.978	1393.605	1393.605	–235.3988	298.15
300	30.281	0.056	183.166	182.979	1393.661	1393.653	–233.8931	300
400	29.431	3.045	191.772	184.158	1396.650	1396.214	–173.1797	400
500	28.442	5.938	198.230	186.354	1399.543	1398.620	–136.6859	500
600	27.713	8.743	203.346	188.775	1402.348	1400.891	–112.3155	600
700	27.306	11.491	207.584	191.168	1405.096	1403.062	–94.8805	700
800	27.139	14.212	211.217	193.452	1407.817	1405.164	–81.7842	800
900	27.111	16.924	214.411	195.607	1410.528	1407.216	–71.5831	900
1000	27.145	19.636	217.269	197.633	1413.241	1409.227	–63.4103	1000
1100	27.198	22.353	219.859	199.537	1415.958	1411.203	–56.7141	1100
1200	27.249	25.076	222.227	201.331	1418.681	1413.143	–51.1261	1200
1300	27.294	27.803	224.410	203.023	1421.408	1415.050	–46.3914	1300
1400	27.336	30.535	226.435	204.624	1424.139	1416.923	–42.3276	1400
1500	27.382	33.270	228.322	206.142	1426.875	1418.755	–38.8010	1500
1600	27.438	36.011	230.091	207.584	1429.616	1420.542	–35.7114	1600
1700	27.510	38.759	231.757	208.957	1432.363	1422.277	–32.9818	1700
1800	27.602	41.514	233.331	210.268	1435.119	1423.956	–30.5526	1800
1900	27.716	44.280	234.827	211.522	1437.884	1425.573	–28.3766	1900
2000	27.853	47.058	236.252	212.723	1440.663	1427.127	–26.4160	2000
2100	28.011	49.851	237.615	213.876	1443.456	1428.614	–24.6402	2100
2200	28.189	52.661	238.922	214.985	1446.266	1430.030	–23.0243	2200
2300	28.384	55.489	240.179	216.053	1449.094	1431.369	–21.5474	2300
2400	28.593	58.338	241.391	217.084	1451.943	1432.622	–20.1924	2400
2500	28.813	61.208	242.563	218.080	1454.813	1433.776	–18.9447	2500
2600	29.041	64.101	243.697	219.043	1457.706	1434.808	–17.7921	2600
2700	29.274	67.017	244.798	219.977	1460.621	1435.679	–16.7242	2700
*2800	29.508	69.956	245.867	220.882	1463.560	1409.977	–15.7410	2800
2900	29.742	72.918	246.906	221.762	1466.523	1411.671	–14.8335	2900
3000	29.972	75.904	247.918	222.617	1469.509	1413.388	–13.9855	3000
3100	30.196	78.912	248.905	223.449	1472.517	1415.128	–13.1911	3100
3200	30.413	81.943	249.867	224.260	1475.548	1416.890	–12.4456	3200
3300	30.621	84.995	250.806	225.050	1478.599	1418.673	–11.7443	3300
3400	30.818	88.067	251.723	225.821	1481.671	1420.477	–11.0834	3400
3500	31.003	91.158	252.619	226.574	1484.763	1422.299	–10.4595	3500
3600	31.176	94.267	253.495	227.310	1487.872	1424.140	–9.8695	3600
3700	31.337	97.393	254.351	228.029	1490.997	1425.997	–9.3107	3700
3800	31.484	100.534	255.189	228.733	1494.139	1427.870	–8.7806	3800
3900	31.619	103.689	256.009	229.422	1497.294	1429.756	–8.2770	3900
4000	31.740	106.857	256.811	230.096	1500.462	1431.656	–7.7980	4000
4100	31.848	110.037	257.596	230.758	1503.641	1433.567	–7.3417	4100
4200	31.974	113.227	258.366	231.407	1506.831	1435.488	–6.9065	4200
4300	32.075	116.429	259.119	232.043	1510.034	1437.422	–6.4911	4300
4400	32.158	119.641	259.858	232.667	1513.246	1439.365	–6.0939	4400
4500	32.227	122.861	260.581	233.279	1516.465	1441.316	–5.7140	4500
4600	32.283	126.086	261.290	233.880	1519.691	1443.273	–5.3500	4600
4700	32.329	129.317	261.985	234.471	1522.921	1445.235	–5.0011	4700
4800	32.367	132.552	262.666	235.051	1526.156	1447.202	–4.6663	4800
4900	32.397	135.790	263.334	235.621	1529.395	1449.171	–4.3447	4900
5000	32.422	139.031	263.989	236.182	1532.636	1451.144	–4.0355	5000

TABLE A86.—THERMODYNAMIC PROPERTIES FOR Nb^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	32.443	142.274	264.631	236.734	1535.879	1453.118	–3.7380	5100
5200	32.460	145.519	265.261	237.276	1539.124	1455.095	–3.4517	5200
5300	32.476	148.766	265.879	237.810	1542.371	1457.073	–3.1757	5300
5400	32.489	152.014	266.487	238.336	1545.619	1459.053	–2.9096	5400
5500	32.503	155.264	267.083	238.853	1548.869	1461.034	–2.6528	5500
5600	32.516	158.515	267.669	239.362	1552.120	1463.016	–2.4049	5600
5700	32.530	161.767	268.244	239.864	1555.372	1465.000	–2.1653	5700
5800	32.545	165.021	268.810	240.358	1558.625	1466.985	–1.9337	5800
5900	32.561	168.276	269.367	240.845	1561.881	1468.972	–1.7096	5900
6000	32.580	171.533	269.914	241.325	1565.138	1470.960	–1.4927	6000
6200	32.623	178.053	270.983	242.265	1571.658			6200
6400	32.677	184.583	272.020	243.178	1578.188			6400
6600	32.742	191.125	273.026	244.068	1584.729			6600
6800	32.821	197.681	274.005	244.934	1591.286			6800
7000	32.912	204.254	274.957	245.778	1597.859			7000
7200	33.017	210.847	275.886	246.602	1604.452			7200
7400	33.136	217.462	276.792	247.405	1611.067			7400
7600	33.267	224.102	277.678	248.190	1617.707			7600
7800	33.410	230.770	278.543	248.958	1624.374			7800
8000	33.565	237.467	279.391	249.708	1631.071			8000
8500	33.999	254.355	281.439	251.515	1647.960			8500
9000	34.489	271.476	283.396	253.232	1665.080			9000
9500	35.018	288.851	285.275	254.869	1682.455			9500
10000	35.572	306.498	287.085	256.435	1700.102			10000
10500	36.134	324.424	288.834	257.936	1718.029			10500
11000	36.691	342.630	290.528	259.380	1736.235			11000
11500	37.228	361.112	292.171	260.770	1754.716			11500
12000	37.733	379.854	293.766	262.111	1773.458			12000
12500	38.197	398.838	295.316	263.409	1792.442			12500
13000	38.608	418.041	296.822	264.665	1811.646			13000
13500	38.961	437.436	298.286	265.883	1831.040			13500
14000	39.250	456.992	299.708	267.066	1850.597			14000
14500	39.471	476.675	301.090	268.216	1870.280			14500
15000	39.623	496.451	302.431	269.334	1890.056			15000
15500	39.706	516.286	303.731	270.423	1909.891			15500
16000	39.722	536.146	304.992	271.483	1929.750			16000
16500	39.676	555.997	306.214	272.517	1949.602			16500
17000	39.574	575.813	307.397	273.526	1969.418			17000
17500	39.424	595.564	308.542	274.510	1989.168			17500
18000	39.237	615.230	309.650	275.471	2008.835			18000
18500	39.025	634.797	310.723	276.409	2028.401			18500
19000	38.804	654.255	311.760	277.326	2047.859			19000
19500	38.589	673.602	312.766	278.222	2067.206			19500
20000	38.399	692.846	313.740	279.098	2086.451			20000

*Assigned reference element phase change at 2750 K

TABLE A87.—THERMODYNAMIC PROPERTIES FOR Nb^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–8.654	----------	----------	622.400	633.839	----------	0
298.15	28.948	0.000	186.097	186.097	631.054	631.054	–103.8352	298.15
300	28.913	0.054	186.276	186.098	631.108	631.023	–103.1534	300
400	27.029	2.850	194.333	187.209	633.904	629.234	–75.7208	400
500	25.474	5.471	200.189	189.247	636.525	627.211	–59.3113	500
600	24.342	7.959	204.728	191.463	639.013	625.007	–48.4086	600
700	23.538	10.350	208.416	193.630	641.404	622.665	–40.6494	700
800	22.962	12.674	211.520	195.677	643.728	620.212	–34.8524	800
900	22.542	14.948	214.199	197.590	646.002	617.669	–30.3618	900
1000	22.228	17.186	216.557	199.371	648.240	615.048	–26.7844	1000
1100	21.989	19.396	218.664	201.031	650.450	612.360	–23.8700	1100
1200	21.803	21.585	220.569	202.581	652.639	609.609	–21.4520	1200
1300	21.656	23.758	222.308	204.032	654.812	606.805	–19.4155	1300
1400	21.539	25.917	223.908	205.396	656.972	603.948	–17.6780	1400
1500	21.443	28.066	225.391	206.680	659.120	601.036	–16.1793	1500
1600	21.364	30.207	226.772	207.893	661.261	598.065	–14.8744	1600
1700	21.299	32.340	228.065	209.042	663.394	595.029	–13.7287	1700
1800	21.244	34.467	229.281	210.133	665.521	591.922	–12.7156	1800
1900	21.197	36.589	230.428	211.171	667.643	588.738	–11.8139	1900
2000	21.157	38.706	231.515	212.161	669.760	585.474	–11.0069	2000
2100	21.122	40.820	232.546	213.108	671.874	582.125	–10.2808	2100
2200	21.093	42.931	233.528	214.014	673.985	578.685	–9.6246	2200
2300	21.066	45.039	234.465	214.883	676.093	575.146	–9.0290	2300
2400	21.043	47.144	235.361	215.718	678.198	571.499	–8.4864	2400
2500	21.023	49.248	236.220	216.521	680.302	567.729	–7.9905	2500
2600	21.005	51.349	237.044	217.294	682.403	563.811	–7.5359	2600
2700	20.989	53.449	237.836	218.040	684.503	559.709	–7.1178	2700
*2800	20.975	55.547	238.599	218.761	686.601	529.009	–6.7416	2800
2900	20.962	57.644	239.335	219.458	688.698	525.680	–6.4024	2900
3000	20.951	59.740	240.046	220.132	690.794	522.350	–6.0878	3000
3100	20.940	61.834	240.732	220.786	692.888	519.019	–5.7953	3100
3200	20.930	63.928	241.397	221.420	694.982	515.687	–5.5229	3200
3300	20.922	66.020	242.041	222.035	697.074	512.353	–5.2686	3300
3400	20.914	68.112	242.665	222.633	699.166	509.019	–5.0309	3400
3500	20.907	70.203	243.272	223.214	701.257	505.685	–4.8082	3500
3600	20.900	72.293	243.860	223.779	703.347	502.349	–4.5992	3600
3700	20.894	74.383	244.433	224.329	705.437	499.013	–4.4029	3700
3800	20.888	76.472	244.990	224.866	707.526	495.676	–4.2181	3800
3900	20.883	78.561	245.533	225.389	709.615	492.339	–4.0440	3900
4000	20.878	80.649	246.061	225.899	711.703	489.001	–3.8797	4000
4100	20.874	82.736	246.577	226.397	713.790	485.663	–3.7245	4100
4200	20.870	84.824	247.080	226.884	715.878	482.324	–3.5777	4200
4300	20.866	86.910	247.571	227.359	717.964	478.985	–3.4386	4300
4400	20.862	88.997	248.050	227.824	720.051	475.646	–3.3069	4400
4500	20.859	91.083	248.519	228.279	722.137	472.306	–3.1818	4500
4600	20.856	93.168	248.978	228.724	724.223	468.966	–3.0631	4600
4700	20.853	95.254	249.426	229.159	726.308	465.626	–2.9502	4700
4800	20.850	97.339	249.865	229.586	728.393	462.285	–2.8427	4800
4900	20.847	99.424	250.295	230.004	730.478	458.944	–2.7404	4900
5000	20.845	101.509	250.716	230.414	732.563	455.603	–2.6430	5000

TABLE A87.—THERMODYNAMIC PROPERTIES FOR Nb^- (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.843	103.593	251.129	230.817	734.647	452.261	–2.5500	5100
5200	20.841	105.677	251.534	231.211	736.731	448.920	–2.4612	5200
5300	20.838	107.761	251.931	231.598	738.815	445.578	–2.3765	5300
5400	20.837	109.845	252.320	231.978	740.899	442.236	–2.2954	5400
5500	20.835	111.928	252.702	232.352	742.982	438.893	–2.2180	5500
5600	20.833	114.012	253.078	232.719	745.066	435.551	–2.1438	5600
5700	20.831	116.095	253.447	233.079	747.149	432.208	–2.0728	5700
5800	20.830	118.178	253.809	233.433	749.232	428.866	–2.0048	5800
5900	20.828	120.261	254.165	233.782	751.315	425.523	–1.9396	5900
6000	20.827	122.344	254.515	234.124	753.398	422.180	–1.8770	6000
6200	20.824	126.509	255.198	234.793	757.563			6200
6400	20.822	130.673	255.859	235.441	761.727			6400
6600	20.820	134.838	256.500	236.070	765.892			6600
6800	20.818	139.001	257.121	236.680	770.055			6800
7000	20.816	143.165	257.725	237.272	774.219			7000
7200	20.814	147.328	258.311	237.849	778.382			7200
7400	20.813	151.491	258.881	238.409	782.545			7400
7600	20.812	155.653	259.436	238.956	786.707			7600
7800	20.810	159.815	259.977	239.488	790.869			7800
8000	20.809	163.977	260.504	240.006	795.031			8000
8500	20.806	174.381	261.765	241.250	805.435			8500
9000	20.804	184.784	262.954	242.423	815.838			9000
9500	20.802	195.185	264.079	243.533	826.239			9500
10000	20.801	205.586	265.146	244.587	836.640			10000
10500	20.799	215.986	266.161	245.591	847.040			10500
11000	20.798	226.386	267.128	246.548	857.440			11000
11500	20.797	236.785	268.053	247.463	867.839			11500
12000	20.796	247.183	268.938	248.339	878.237			12000
12500	20.796	257.581	269.787	249.181	888.635			12500
13000	20.795	267.979	270.603	249.989	899.033			13000
13500	20.794	278.376	271.387	250.767	909.430			13500
14000	20.794	288.773	272.144	251.517	919.827			14000
14500	20.793	299.169	272.873	252.241	930.223			14500
15000	20.793	309.566	273.578	252.940	940.620			15000
15500	20.792	319.962	274.260	253.617	951.016			15500
16000	20.792	330.358	274.920	254.273	961.412			16000
16500	20.792	340.754	275.560	254.908	971.808			16500
17000	20.791	351.150	276.181	255.525	982.204			17000
17500	20.791	361.545	276.783	256.124	992.599			17500
18000	20.791	371.941	277.369	256.706	1002.995			18000
18500	20.791	382.336	277.939	257.272	1013.390			18500
19000	20.790	392.731	278.493	257.823	1023.785			19000
19500	20.790	403.126	279.033	258.360	1034.180			19500
20000	20.790	413.521	279.559	258.883	1044.575			20000

*Assigned reference element phase change at 2750 K

TABLE A88.—THERMODYNAMIC PROPERTIES FOR Ne

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–6.197	0	----------	0
100	20.786	–4.119	123.622	164.810	–4.119	0	0	100
200	20.786	–2.040	138.030	148.231	–2.040	0	0	200
298.15	20.786	0.000	146.330	146.330	0.000	0	0	298.15
300	20.786	0.038	146.458	146.330	0.038	0	0	300
400	20.786	2.117	152.438	147.145	2.117	0	0	400
500	20.786	4.196	157.076	148.685	4.196	0	0	500
600	20.786	6.274	160.866	150.409	6.274	0	0	600
700	20.786	8.353	164.070	152.138	8.353	0	0	700
800	20.786	10.432	166.846	153.807	10.432	0	0	800
900	20.786	12.510	169.294	155.394	12.510	0	0	900
1000	20.786	14.589	171.484	156.896	14.589	0	0	1000
1100	20.786	16.667	173.466	158.313	16.667	0	0	1100
1200	20.786	18.746	175.274	159.652	18.746	0	0	1200
1300	20.786	20.825	176.938	160.919	20.825	0	0	1300
1400	20.786	22.903	178.478	162.119	22.903	0	0	1400
1500	20.786	24.982	179.912	163.258	24.982	0	0	1500
1600	20.786	27.061	181.254	164.341	27.061	0	0	1600
1700	20.786	29.139	182.514	165.373	29.139	0	0	1700
1800	20.786	31.218	183.702	166.359	31.218	0	0	1800
1900	20.786	33.296	184.826	167.302	33.296	0	0	1900
2000	20.786	35.375	185.892	168.205	35.375	0	0	2000
2100	20.786	37.454	186.906	169.071	37.454	0	0	2100
2200	20.786	39.532	187.873	169.904	39.532	0	0	2200
2300	20.786	41.611	188.797	170.706	41.611	0	0	2300
2400	20.786	43.690	189.682	171.478	43.690	0	0	2400
2500	20.786	45.768	190.531	172.223	45.768	0	0	2500
2600	20.786	47.847	191.346	172.943	47.847	0	0	2600
2700	20.786	49.926	192.130	173.639	49.926	0	0	2700
2800	20.786	52.004	192.886	174.313	52.004	0	0	2800
2900	20.786	54.083	193.616	174.967	54.083	0	0	2900
3000	20.786	56.161	194.320	175.600	56.161	0	0	3000
3100	20.786	58.240	195.002	176.215	58.240	0	0	3100
3200	20.786	60.319	195.662	176.812	60.319	0	0	3200
3300	20.786	62.397	196.302	177.393	62.397	0	0	3300
3400	20.786	64.476	196.922	177.959	64.476	0	0	3400
3500	20.786	66.555	197.525	178.509	66.555	0	0	3500
3600	20.786	68.633	198.110	179.045	68.633	0	0	3600
3700	20.786	70.712	198.680	179.568	70.712	0	0	3700
3800	20.786	72.790	199.234	180.079	72.790	0	0	3800
3900	20.786	74.869	199.774	180.577	74.869	0	0	3900
4000	20.786	76.948	200.300	181.063	76.948	0	0	4000
4100	20.786	79.026	200.814	181.539	79.026	0	0	4100
4200	20.786	81.105	201.314	182.004	81.105	0	0	4200
4300	20.786	83.184	201.804	182.459	83.184	0	0	4300
4400	20.786	85.262	202.281	182.904	85.262	0	0	4400
4500	20.786	87.341	202.749	183.339	87.341	0	0	4500

TABLE A88.—THERMODYNAMIC PROPERTIES FOR Ne (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.786	89.419	203.205	183.766	89.419	0	0	4600
4700	20.786	91.498	203.652	184.185	91.498	0	0	4700
4800	20.786	93.577	204.090	184.595	93.577	0	0	4800
4900	20.786	95.655	204.519	184.997	95.655	0	0	4900
5000	20.786	97.734	204.939	185.392	97.734	0	0	5000
5100	20.786	99.813	205.350	185.779	99.813	0	0	5100
5200	20.786	101.891	205.754	186.159	101.891	0	0	5200
5300	20.786	103.970	206.150	186.533	103.970	0	0	5300
5400	20.786	106.048	206.538	186.900	106.048	0	0	5400
5500	20.786	108.127	206.920	187.260	108.127	0	0	5500
5600	20.786	110.206	207.294	187.615	110.206	0	0	5600
5700	20.786	112.284	207.662	187.963	112.284	0	0	5700
5800	20.786	114.363	208.024	188.306	114.363	0	0	5800
5900	20.786	116.442	208.379	188.643	116.442	0	0	5900
6000	20.786	118.520	208.728	188.975	118.520	0	0	6000
6200	20.786	122.677	209.410	189.623	122.677	0	0	6200
6400	20.786	126.835	210.070	190.252	126.835	0	0	6400
6600	20.786	130.992	210.710	190.862	130.992	0	0	6600
6800	20.786	135.149	211.330	191.455	135.149	0	0	6800
7000	20.786	139.306	211.933	192.032	139.306	0	0	7000
7200	20.786	143.464	212.518	192.593	143.464	0	0	7200
7400	20.786	147.621	213.088	193.139	147.621	0	0	7400
7600	20.786	151.778	213.642	193.671	151.778	0	0	7600
7800	20.786	155.936	214.182	194.190	155.936	0	0	7800
8000	20.786	160.093	214.708	194.697	160.093	0	0	8000
8500	20.786	170.486	215.968	195.911	170.486	0	0	8500
9000	20.786	180.879	217.156	197.059	180.879	0	0	9000
9500	20.786	191.272	218.280	198.146	191.272	0	0	9500
10000	20.787	201.665	219.347	199.180	201.665	0	0	10000
10500	20.787	212.059	220.361	200.165	212.059	0	0	10500
11000	20.788	222.452	221.328	201.105	222.452	0	0	11000
11500	20.789	232.846	222.252	202.004	232.846	0	0	11500
12000	20.792	243.242	223.137	202.867	243.242	0	0	12000
12500	20.796	253.638	223.985	203.694	253.638	0	0	12500
13000	20.808	264.049	224.802	204.490	264.049	0	0	13000
13500	20.819	274.455	225.588	205.258	274.455	0	0	13500
14000	20.834	284.869	226.345	205.997	284.869	0	0	14000
14500	20.859	295.292	227.077	206.712	295.292	0	0	14500
15000	20.892	305.728	227.784	207.402	305.728	0	0	15000
15500	20.936	316.184	228.470	208.071	316.184	0	0	15500
16000	20.993	326.666	229.135	208.719	326.666	0	0	16000
16500	21.066	337.181	229.782	209.347	337.181	0	0	16500
17000	21.157	347.735	230.413	209.958	347.735	0	0	17000
17500	21.268	358.341	231.028	210.551	358.341	0	0	17500
18000	21.402	369.008	231.628	211.128	369.008	0	0	18000
18500	21.560	379.747	232.217	211.690	379.747	0	0	18500
19000	21.747	390.571	232.795	212.238	390.571	0	0	19000
19500	21.963	401.497	233.362	212.772	401.497	0	0	19500
20000	22.212	412.540	233.921	213.294	412.540	0	0	20000

TABLE A89.—THERMODYNAMIC PROPERTIES FOR Ne^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.304	----------	----------	2080.662	2080.662	----------	0
298.15	22.120	0.000	158.310	158.310	2086.966	2086.966	–363.8970	298.15
300	22.134	0.041	158.446	158.310	2087.007	2087.007	–361.6423	300
400	22.650	2.284	164.895	159.186	2089.250	2089.250	–270.7556	400
500	22.788	4.558	169.970	160.853	2091.524	2091.524	–216.1639	500
600	22.718	6.835	174.120	162.729	2093.801	2093.801	–179.7295	600
700	22.562	9.099	177.611	164.613	2096.065	2096.065	–153.6766	700
800	22.382	11.346	180.612	166.429	2098.312	2098.312	–134.1158	800
900	22.207	13.576	183.238	168.154	2100.542	2100.542	–118.8855	900
1000	22.048	15.788	185.570	169.781	2102.754	2102.754	–106.6884	1000
1100	21.907	17.986	187.664	171.314	2104.952	2104.952	–96.6984	1100
1200	21.784	20.170	189.565	172.757	2107.136	2107.136	–88.3648	1200
1300	21.678	22.343	191.305	174.117	2109.309	2109.309	–81.3060	1300
1400	21.586	24.506	192.908	175.403	2111.472	2111.472	–75.2493	1400
1500	21.507	26.661	194.394	176.620	2113.627	2113.627	–69.9948	1500
1600	21.438	28.808	195.780	177.775	2115.774	2115.774	–65.3924	1600
1700	21.378	30.949	197.078	178.873	2117.915	2117.915	–61.3274	1700
1800	21.326	33.084	198.298	179.918	2120.050	2120.050	–57.7104	1800
1900	21.279	35.214	199.450	180.916	2122.180	2122.180	–54.4709	1900
2000	21.239	37.340	200.540	181.870	2124.306	2124.306	–51.5524	2000
2100	21.203	39.462	201.576	182.784	2126.428	2126.428	–48.9092	2100
2200	21.171	41.581	202.561	183.661	2128.547	2128.547	–46.5039	2200
2300	21.142	43.696	203.502	184.503	2130.662	2130.662	–44.3055	2300
2400	21.117	45.809	204.401	185.314	2132.775	2132.775	–42.2884	2400
2500	21.094	47.920	205.263	186.095	2134.886	2134.886	–40.4308	2500
2600	21.073	50.028	206.090	186.848	2136.994	2136.994	–38.7144	2600
2700	21.055	52.135	206.884	187.575	2139.101	2139.101	–37.1236	2700
2800	21.038	54.239	207.650	188.279	2141.205	2141.205	–35.6449	2800
2900	21.022	56.342	208.388	188.960	2143.308	2143.308	–34.2669	2900
3000	21.008	58.444	209.100	189.619	2145.410	2145.410	–32.9794	3000
3100	20.995	60.544	209.789	190.259	2147.510	2147.510	–31.7739	3100
3200	20.983	62.643	210.455	190.879	2149.609	2149.609	–30.6426	3200
3300	20.973	64.741	211.101	191.482	2151.706	2151.706	–29.5788	3300
3400	20.963	66.837	211.727	192.069	2153.803	2153.803	–28.5766	3400
3500	20.953	68.933	212.334	192.639	2155.899	2155.899	–27.6308	3500
3600	20.945	71.028	212.924	193.194	2157.994	2157.994	–26.7366	3600
3700	20.937	73.122	213.498	193.735	2160.088	2160.088	–25.8900	3700
3800	20.930	75.215	214.056	194.263	2162.181	2162.181	–25.0871	3800
3900	20.923	77.308	214.600	194.777	2164.274	2164.274	–24.3247	3900
4000	20.917	79.400	215.130	195.280	2166.366	2166.366	–23.5997	4000
4100	20.911	81.491	215.646	195.770	2168.457	2168.457	–22.9094	4100
4200	20.905	83.582	216.150	196.249	2170.548	2170.548	–22.2513	4200
4300	20.900	85.672	216.642	196.718	2172.638	2172.638	–21.6232	4300
4400	20.895	87.762	217.122	197.176	2174.728	2174.728	–21.0231	4400
4500	20.891	89.852	217.592	197.625	2176.817	2176.817	–20.4491	4500
4600	20.886	91.940	218.051	198.064	2178.906	2178.906	–19.8996	4600
4700	20.882	94.029	218.500	198.494	2180.995	2180.995	–19.3729	4700
4800	20.879	96.117	218.940	198.915	2183.083	2183.083	–18.8677	4800
4900	20.875	98.205	219.370	199.328	2185.171	2185.171	–18.3827	4900
5000	20.872	100.292	219.792	199.733	2187.258	2187.258	–17.9166	5000

TABLE A89.—THERMODYNAMIC PROPERTIES FOR Ne^+ (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.869	102.379	220.205	200.131	2189.345	2189.345	–17.4683	5100
5200	20.866	104.466	220.610	200.521	2191.432	2191.432	–17.0369	5200
5300	20.863	106.552	221.008	200.903	2193.518	2193.518	–16.6214	5300
5400	20.860	108.638	221.398	201.279	2195.604	2195.604	–16.2209	5400
5500	20.858	110.724	221.780	201.649	2197.690	2197.690	–15.8345	5500
5600	20.855	112.810	222.156	202.012	2199.776	2199.776	–15.4617	5600
5700	20.853	114.895	222.525	202.368	2201.861	2201.861	–15.1015	5700
5800	20.851	116.980	222.888	202.719	2203.946	2203.946	–14.7535	5800
5900	20.849	119.065	223.244	203.064	2206.031	2206.031	–14.4169	5900
6000	20.847	121.150	223.595	203.403	2208.116	2208.116	–14.0913	6000
6200	20.843	125.319	224.278	204.065	2212.285	2212.285	–13.4706	6200
6400	20.840	129.487	224.940	204.708	2216.453	2216.453	–12.8876	6400
6600	20.836	133.655	225.581	205.330	2220.621	2220.621	–12.3389	6600
6800	20.834	137.822	226.203	205.935	2224.788	2224.788	–11.8216	6800
7000	20.831	141.988	226.807	206.523	2228.954	2228.954	–11.3328	7000
7200	20.829	146.154	227.394	207.095	2233.120	2233.120	–10.8704	7200
7400	20.827	150.320	227.964	207.651	2237.286	2237.286	–10.4322	7400
7600	20.824	154.485	228.520	208.193	2241.451	2241.451	–10.0162	7600
7800	20.823	158.650	229.061	208.721	2245.616	2245.616	–9.6208	7800
8000	20.821	162.814	229.588	209.236	2249.780	2249.780	–9.2445	8000
8500	20.817	173.223	230.850	210.471	2260.189	2260.189	–8.3785	8500
9000	20.814	183.631	232.040	211.636	2270.597	2270.597	–7.6051	9000
9500	20.811	194.037	233.165	212.740	2281.003	2281.003	–6.9100	9500
10000	20.809	204.442	234.232	213.788	2291.408	2291.408	–6.2815	10000
10500	20.807	214.846	235.248	214.786	2301.812	2301.812	–5.7103	10500
11000	20.805	225.249	236.216	215.738	2312.215	2312.214	–5.1887	11000
11500	20.803	235.651	237.140	216.649	2322.617	2322.615	–4.7102	11500
12000	20.802	246.052	238.026	217.521	2333.018	2333.014	–4.2697	12000
12500	20.801	256.453	238.875	218.359	2343.419	2343.411	–3.8626	12500
13000	20.800	266.853	239.691	219.163	2353.819	2353.805	–3.4852	13000
13500	20.799	277.252	240.476	219.938	2364.218	2364.193	–3.1341	13500
14000	20.798	287.652	241.232	220.685	2374.618	2374.573	–2.8067	14000
14500	20.797	298.050	241.962	221.407	2385.016	2384.942	–2.5006	14500
15000	20.796	308.449	242.667	222.104	2395.415	2395.297	–2.2136	15000
15500	20.796	318.847	243.349	222.778	2405.813	2405.628	–1.9439	15500
16000	20.795	329.244	244.009	223.431	2416.210	2415.943	–1.6901	16000
16500	20.795	339.642	244.649	224.064	2426.608	2426.213	–1.4506	16500
17000	20.794	350.039	245.270	224.679	2437.005	2436.471	–1.2242	17000
17500	20.794	360.436	245.872	225.276	2447.402	2446.641	–1.0099	17500
18000	20.794	370.833	246.458	225.856	2457.799	2456.925	–0.8065	18000
18500	20.793	381.230	247.028	226.421	2468.196	2467.004	–0.6135	18500
19000	20.793	391.626	247.582	226.970	2478.592	2476.993	–0.4298	19000
19500	20.793	402.023	248.123	227.506	2488.989	2486.875	–0.2548	19500
20000	20.794	412.420	248.649	228.028	2499.386	2496.628	–0.0880	20000

TABLE A90.—THERMODYNAMIC PROPERTIES FOR Ni

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.825	----------	----------	423.292	428.078	----------	0
100	23.511	–4.650	156.501	203.003	425.466	429.744	–216.6845	100
200	23.396	–2.288	172.885	184.325	427.829	430.218	–104.3833	200
298.15	23.361	0.000	182.193	182.193	430.117	430.117	–67.3964	298.15
300	23.367	0.043	182.337	182.193	430.160	430.112	–66.9318	300
400	23.859	2.403	189.122	183.115	432.519	429.743	–48.2166	400
500	24.374	4.815	194.504	184.873	434.932	429.189	–36.9993	500
600	24.734	7.272	198.982	186.861	437.389	428.367	–29.5329	600
*700	24.925	9.757	202.811	188.873	439.873	427.529	–24.2112	700
800	24.981	12.253	206.144	190.828	442.369	426.938	–20.2261	800
900	24.942	14.750	209.085	192.697	444.866	426.306	–17.1310	900
1000	24.841	17.239	211.708	194.469	447.356	425.606	–14.6587	1000
1100	24.701	19.717	214.070	196.145	449.833	424.826	–12.6395	1100
1200	24.538	22.179	216.212	197.730	452.295	423.959	–10.9601	1200
1300	24.365	24.624	218.169	199.228	454.741	422.995	–9.5421	1300
1400	24.187	27.052	219.968	200.646	457.168	421.927	–8.3296	1400
1500	24.012	29.461	221.631	201.990	459.578	420.751	–7.2815	1500
1600	23.842	31.854	223.175	203.267	461.971	419.465	–6.3671	1600
1700	23.679	34.230	224.616	204.481	464.347	418.061	–5.5629	1700
*1800	23.525	36.590	225.965	205.637	466.707	399.389	–4.8713	1800
1900	23.380	38.935	227.233	206.741	469.052	397.844	–4.2625	1900
2000	23.246	41.267	228.429	207.795	471.383	396.284	–3.7167	2000
2100	23.121	43.585	229.560	208.805	473.701	394.711	–3.2248	2100
2200	23.007	45.891	230.633	209.773	476.008	393.126	–2.7794	2200
2300	22.904	48.187	231.653	210.702	478.303	391.530	–2.3744	2300
2400	22.810	50.472	232.626	211.596	480.589	389.925	–2.0047	2400
2500	22.726	52.749	233.555	212.456	482.866	388.311	–1.6659	2500
2600	22.651	55.018	234.445	213.285	485.134	386.688	–1.3545	2600
2700	22.585	57.279	235.299	214.084	487.396	385.059	–1.0674	2700
2800	22.529	59.535	236.119	214.857	489.652	383.423	–0.8019	2800
2900	22.481	61.786	236.909	215.603	491.902	381.783	–0.5558	2900
3000	22.442	64.032	237.670	216.326	494.148	380.138	–0.3271	3000
3100	22.411	66.274	238.406	217.027	496.391	378.489	–0.1140	3100
3200	22.388	68.514	239.117	217.706	498.631	376.838	0.0848	3200
3300	22.373	70.752	239.805	218.365	500.869	375.185	0.2708	3300
3400	22.367	72.989	240.473	219.006	503.105	373.531	0.4451	3400
3500	22.368	75.226	241.122	219.629	505.342	371.876	0.6087	3500
3600	22.378	77.463	241.752	220.234	507.579	370.222	0.7625	3600
3700	22.395	79.701	242.365	220.824	509.818	368.570	0.9074	3700
3800	22.421	81.942	242.963	221.399	512.059	366.919	1.0440	3800
3900	22.456	84.186	243.546	221.959	514.302	365.272	1.1730	3900
4000	22.498	86.433	244.115	222.506	516.550	363.629	1.2951	4000
4100	22.550	88.686	244.671	223.040	518.802	361.990	1.4106	4100
4200	22.610	90.944	245.215	223.562	521.060	360.357	1.5202	4200
4300	22.679	93.208	245.748	224.071	523.325	358.730	1.6242	4300
4400	22.758	95.480	246.270	224.570	525.597	357.111	1.7230	4400
4500	22.845	97.760	246.782	225.058	527.877	355.500	1.8170	4500

TABLE A90.—THERMODYNAMIC PROPERTIES FOR Ni (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	22.942	100.049	247.285	225.536	530.166	353.898	1.9065	4600
4700	23.049	102.349	247.780	226.004	532.465	352.306	1.9918	4700
4800	23.165	104.659	248.266	226.462	534.776	350.726	2.0732	4800
4900	23.291	106.982	248.745	226.912	537.099	349.157	2.1509	4900
5000	23.427	109.318	249.217	227.354	539.435	347.602	2.2252	5000
5100	23.573	111.668	249.683	227.787	541.784	346.061	2.2962	5100
5200	23.729	114.033	250.142	228.212	544.149	344.535	2.3642	5200
5300	23.895	116.414	250.595	228.631	546.530	343.025	2.4294	5300
5400	24.071	118.812	251.044	229.041	548.929	341.532	2.4919	5400
5500	24.256	121.228	251.487	229.445	551.344	340.056	2.5518	5500
5600	24.452	123.663	251.926	229.843	553.779	338.600	2.6093	5600
5700	24.656	126.118	252.360	230.234	556.234	337.164	2.6646	5700
5800	24.871	128.594	252.791	230.619	558.710	335.749	2.7178	5800
5900	25.095	131.091	253.218	230.999	561.208	334.355	2.7689	5900
6000	25.330	133.612	253.641	231.373	563.729	332.986	2.8182	6000
6200	25.828	138.728	254.480	232.105	568.844			6200
6400	26.346	143.937	255.307	232.817	574.054			6400
6600	26.909	149.262	256.126	233.511	579.378			6600
6800	27.494	154.696	256.937	234.188	584.813			6800
7000	28.106	160.251	257.742	234.849	590.367			7000
7200	28.768	165.901	258.539	235.497	596.018			7200
7400	29.448	171.723	259.336	236.130	601.839			7400
7600	30.131	177.680	260.130	236.751	607.797			7600
7800	30.813	183.775	260.922	237.361	613.892			7800
8000	31.487	190.005	261.711	237.960	620.122			8000
8500	33.114	206.160	263.669	239.415	636.276			8500
9000	34.626	223.100	265.605	240.816	653.217			9000
9500	35.993	240.762	267.514	242.171	670.878			9500
10000	37.197	259.066	269.392	243.485	689.183			10000
10500	38.226	277.929	271.232	244.763	708.046			10500
11000	39.074	297.262	273.031	246.007	727.378			11000
11500	39.736	316.972	274.783	247.220	747.089			11500
12000	40.212	336.967	276.485	248.405	767.083			12000
12500	40.503	357.153	278.133	249.561	787.270			12500
13000	40.613	377.440	279.724	250.691	807.556			13000
13500	40.547	397.736	281.256	251.794	827.853			13500
14000	40.314	417.958	282.727	252.873	848.075			14000
14500	39.926	438.025	284.136	253.927	868.141			14500
15000	39.396	457.860	285.481	254.957	887.977			15000
15500	38.740	477.399	286.762	255.962	907.516			15500
16000	37.979	496.583	287.980	256.944	926.700			16000
16500	37.135	515.365	289.136	257.902	945.481			16500
17000	36.234	533.709	290.231	258.837	963.825			17000
17500	35.307	551.594	291.268	259.749	981.711			17500
18000	34.386	569.016	292.250	260.638	999.132			18000
18500	33.508	585.987	293.180	261.505	1016.103			18500
19000	32.714	602.538	294.063	262.350	1032.654			19000
19500	32.047	618.723	294.904	263.174	1048.839			19500
20000	31.556	634.614	295.709	263.978	1064.731			20000

***Assigned reference element phase change at 631 K and 1728 K**

TABLE A91.—THERMODYNAMIC PROPERTIES FOR Ni^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.206	----------	----------	1166.389	1164.977	----------	0
298.15	20.990	0.000	174.574	174.574	1172.595	1172.595	–196.7743	298.15
300	20.996	0.039	174.704	174.575	1172.633	1172.624	–195.5075	300
400	21.503	2.162	180.808	175.404	1174.756	1174.097	–144.4362	400
500	22.127	4.343	185.673	176.987	1176.938	1175.391	–113.7566	500
600	22.669	6.584	189.758	178.784	1179.179	1176.431	–93.2827	600
*700	23.050	8.872	193.283	180.609	1181.466	1177.475	–78.6467	700
800	23.271	11.189	196.377	182.391	1183.783	1178.784	–67.6581	800
900	23.365	13.522	199.124	184.100	1186.116	1180.066	–59.1019	900
1000	23.374	15.859	201.587	185.728	1188.454	1181.292	–52.2497	1000
1100	23.334	18.195	203.813	187.273	1190.789	1182.450	–46.6376	1100
1200	23.277	20.525	205.841	188.737	1193.120	1183.530	–41.9565	1200
1300	23.226	22.850	207.702	190.125	1195.445	1184.523	–37.9921	1300
1400	23.201	25.171	209.422	191.443	1197.766	1185.428	–34.5913	1400
1500	23.215	27.492	211.023	192.695	1200.086	1186.241	–31.6417	1500
1600	23.275	29.816	212.523	193.888	1202.410	1186.965	–29.0592	1600
1700	23.387	32.149	213.937	195.026	1204.743	1187.596	–26.7792	1700
*1800	23.551	34.495	215.278	196.114	1207.090	1170.990	–24.7723	1800
1900	23.766	36.860	216.557	197.157	1209.455	1171.543	–22.9835	1900
2000	24.029	39.250	217.783	198.158	1211.844	1172.120	–21.3727	2000
2100	24.334	41.668	218.962	199.121	1214.262	1172.725	–19.9147	2100
2200	24.676	44.118	220.102	200.049	1216.712	1173.363	–18.5884	2200
2300	25.049	46.604	221.207	200.945	1219.198	1174.037	–17.3769	2300
2400	25.445	49.128	222.281	201.811	1221.723	1174.749	–16.2656	2400
2500	25.857	51.693	223.328	202.651	1224.288	1175.501	–15.2426	2500
2600	26.280	54.300	224.351	203.466	1226.895	1176.296	–14.2976	2600
2700	26.706	56.949	225.351	204.258	1229.544	1177.132	–13.4221	2700
2800	27.131	59.641	226.330	205.029	1232.236	1178.012	–12.6085	2800
2900	27.549	62.375	227.289	205.780	1234.970	1178.933	–11.8504	2900
3000	27.957	65.151	228.230	206.513	1237.745	1179.896	–11.1423	3000
3100	28.350	67.966	229.153	207.228	1240.561	1180.899	–10.4794	3100
3200	28.725	70.820	230.059	207.928	1243.415	1181.941	–9.8573	3200
3300	29.081	73.711	230.948	208.612	1246.305	1183.019	–9.2724	3300
3400	29.414	76.636	231.822	209.282	1249.230	1184.131	–8.7214	3400
3500	29.725	79.593	232.679	209.938	1252.187	1185.276	–8.2014	3500
3600	30.011	82.580	233.520	210.581	1255.174	1186.450	–7.7098	3600
3700	30.274	85.594	234.346	211.213	1258.189	1187.652	–7.2443	3700
3800	30.512	88.634	235.157	211.832	1261.228	1188.879	–6.8029	3800
3900	30.726	91.696	235.952	212.440	1264.290	1190.129	–6.3837	3900
4000	30.916	94.778	236.732	213.038	1267.373	1191.399	–5.9850	4000
4100	31.085	97.878	237.498	213.625	1270.473	1192.687	–5.6053	4100
4200	31.231	100.994	238.249	214.203	1273.589	1193.990	–5.2433	4200
4300	31.357	104.124	238.985	214.770	1276.718	1195.307	–4.8978	4300
4400	31.463	107.265	239.707	215.329	1279.860	1196.636	–4.5676	4400
4500	31.551	110.416	240.415	215.879	1283.010	1197.974	–4.2518	4500
4600	31.623	113.575	241.110	216.420	1286.169	1199.321	–3.9493	4600
4700	31.678	116.740	241.790	216.952	1289.334	1200.673	–3.6594	4700
4800	31.719	119.910	242.458	217.477	1292.504	1202.031	–3.3813	4800
4900	31.747	123.083	243.112	217.993	1295.678	1203.392	–3.1142	4900
5000	31.762	126.259	243.754	218.502	1298.853	1204.755	–2.8575	5000

TABLE A91.—THERMODYNAMIC PROPERTIES FOR Ni^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	31.767	129.435	244.383	219.003	1302.030	1206.119	–2.6105	5100
5200	31.761	132.612	244.999	219.497	1305.206	1207.483	–2.3728	5200
5300	31.747	135.787	245.604	219.984	1308.382	1208.846	–2.1439	5300
5400	31.725	138.961	246.198	220.464	1311.555	1210.207	–1.9231	5400
5500	31.696	142.132	246.779	220.937	1314.726	1211.566	–1.7102	5500
5600	31.661	145.300	247.350	221.404	1317.894	1212.921	–1.5046	5600
5700	31.620	148.464	247.910	221.864	1321.058	1214.273	–1.3060	5700
5800	31.575	151.624	248.460	222.318	1324.218	1215.620	–1.1140	5800
5900	31.526	154.779	248.999	222.766	1327.373	1216.963	–0.9284	5900
6000	31.474	157.929	249.529	223.207	1330.523	1218.300	–0.7487	6000
6200	31.362	164.213	250.559	224.073	1336.807			6200
6400	31.243	170.473	251.553	224.916	1343.068			6400
6600	31.121	176.709	252.512	225.738	1349.304			6600
6800	30.998	182.921	253.439	226.539	1355.516			6800
7000	30.878	189.109	254.336	227.321	1361.703			7000
7200	30.761	195.273	255.204	228.083	1367.867			7200
7400	30.650	201.414	256.046	228.828	1374.008			7400
7600	30.547	207.533	256.862	229.555	1380.128			7600
7800	30.451	213.633	257.654	230.265	1386.227			7800
8000	30.364	219.714	258.424	230.960	1392.309			8000
8500	30.190	234.850	260.259	232.630	1407.444			8500
9000	30.082	249.915	261.981	234.213	1422.509			9000
9500	30.044	264.943	263.606	235.718	1437.538			9500
10000	30.078	279.971	265.148	237.151	1452.566			10000
10500	30.181	295.033	266.618	238.519	1467.627			10500
11000	30.353	310.164	268.025	239.829	1482.758			11000
11500	30.593	325.397	269.380	241.084	1497.992			11500
12000	30.897	340.767	270.688	242.291	1513.362			12000
12500	31.264	356.305	271.956	243.452	1528.899			12500
13000	31.690	372.038	273.190	244.572	1544.633			13000
13500	32.176	388.002	274.395	245.655	1560.596			13500
14000	32.719	404.221	275.575	246.702	1576.816			14000
14500	33.303	420.709	276.732	247.718	1593.303			14500
15000	33.947	437.516	277.872	248.704	1610.110			15000
15500	34.631	454.644	278.995	249.663	1627.239			15500
16000	35.296	472.033	280.098	250.596	1644.628			16000
16500	36.043	489.851	281.195	251.507	1662.445			16500
17000	36.773	508.241	282.303	252.406	1680.836			17000
17500	37.518	526.813	283.380	253.276	1699.408			17500
18000	38.268	545.760	284.447	254.127	1718.354			18000
18500	39.015	565.081	285.506	254.961	1737.675			18500
19000	39.755	584.773	286.556	255.778	1757.368			19000
19500	40.481	604.833	287.598	256.581	1777.427			19500
20000	41.189	625.251	288.632	257.369	1797.846			20000

*Assigned reference element phase change at 631 K and 1728 K

TABLE A92.—THERMODYNAMIC PROPERTIES FOR Ni^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.207	----------	----------	305.557	316.541	----------	0
298.15	21.018	0.000	174.580	174.580	311.764	311.764	–48.1556	298.15
300	21.025	0.039	174.710	174.581	311.803	311.717	–47.8188	300
400	21.564	2.166	180.827	175.411	313.931	309.038	–34.3025	400
500	22.202	4.355	185.708	176.998	316.119	306.181	–26.2656	500
600	22.737	6.603	189.805	178.800	318.368	303.071	–20.9596	600
*700	23.099	8.897	193.340	180.631	320.661	299.964	–17.2096	700
800	23.297	11.218	196.439	182.417	322.982	297.119	–14.4244	800
900	23.367	13.552	199.188	184.131	325.316	294.246	–12.2789	900
1000	23.349	15.888	201.650	185.762	327.652	291.314	–10.5793	1000
1100	23.274	18.220	203.872	187.309	329.984	288.309	–9.2029	1100
1200	23.166	20.542	205.893	188.774	332.306	285.224	–8.0679	1200
1300	23.040	22.852	207.742	190.163	334.617	282.046	–7.1181	1300
1400	22.908	25.150	209.445	191.481	336.914	278.770	–6.3132	1400
1500	22.776	27.434	211.021	192.731	339.198	275.389	–5.6239	1500
1600	22.648	29.705	212.486	193.921	341.469	271.903	–5.0282	1600
1700	22.526	31.964	213.856	195.054	343.728	268.303	–4.5094	1700
*1800	22.412	34.210	215.140	196.134	345.975	247.440	–4.0753	1800
1900	22.305	36.446	216.349	197.167	348.211	243.706	–3.7002	1900
2000	22.206	38.672	217.490	198.155	350.436	239.961	–3.3677	2000
2100	22.114	40.888	218.572	199.101	352.652	236.208	–3.0716	2100
2200	22.030	43.095	219.598	200.010	354.859	232.445	–2.8066	2200
2300	21.953	45.294	220.576	200.883	357.058	228.674	–2.5686	2300
2400	21.881	47.485	221.509	201.723	359.250	224.896	–2.3540	2400
2500	21.816	49.670	222.401	202.532	361.435	221.111	–2.1598	2500
2600	21.755	51.849	223.255	203.313	363.613	217.320	–1.9836	2600
2700	21.699	54.021	224.075	204.067	365.786	213.523	–1.8233	2700
2800	21.648	56.189	224.863	204.796	367.953	209.721	–1.6771	2800
2900	21.600	58.351	225.622	205.501	370.116	205.913	–1.5434	2900
3000	21.557	60.509	226.353	206.184	372.273	202.101	–1.4209	3000
3100	21.516	62.663	227.060	206.846	374.427	198.285	–1.3084	3100
3200	21.478	64.812	227.742	207.488	376.577	194.465	–1.2050	3200
3300	21.443	66.958	228.403	208.112	378.723	190.642	–1.1098	3300
3400	21.411	69.101	229.042	208.718	380.865	186.815	–1.0219	3400
3500	21.381	71.241	229.662	209.308	383.005	182.984	–0.9407	3500
3600	21.352	73.377	230.264	209.882	385.142	179.151	–0.8657	3600
3700	21.326	75.511	230.849	210.441	387.275	175.315	–0.7962	3700
3800	21.301	77.642	231.417	210.985	389.407	171.477	–0.7317	3800
3900	21.279	79.771	231.970	211.516	391.536	167.636	–0.6720	3900
4000	21.257	81.898	232.509	212.034	393.663	163.793	–0.6165	4000
4100	21.237	84.023	233.033	212.540	395.787	159.948	–0.5649	4100
4200	21.218	86.146	233.545	213.034	397.910	156.101	–0.5170	4200
4300	21.200	88.266	234.044	213.517	400.031	152.253	–0.4724	4300
4400	21.183	90.386	234.531	213.989	402.150	148.402	–0.4309	4400
4500	21.168	92.503	235.007	214.451	404.268	144.550	–0.3922	4500
4600	21.153	94.619	235.472	214.903	406.384	140.696	–0.3562	4600
4700	21.139	96.734	235.927	215.345	408.498	136.841	–0.3227	4700
4800	21.125	98.847	236.372	215.779	410.611	132.984	–0.2915	4800
4900	21.113	100.959	236.807	216.203	412.723	129.127	–0.2624	4900
5000	21.101	103.070	237.234	216.620	414.834	125.267	–0.2353	5000

TABLE A92.—THERMODYNAMIC PROPERTIES FOR Ni^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.090	105.179	237.651	217.028	416.943	121.407	–0.2100	5100
5200	21.079	107.288	238.061	217.429	419.052	117.546	–0.1864	5200
5300	21.069	109.395	238.462	217.822	421.159	113.684	–0.1645	5300
5400	21.059	111.501	238.856	218.208	423.266	109.820	–0.1441	5400
5500	21.050	113.607	239.242	218.587	425.371	105.956	–0.1252	5500
5600	21.042	115.711	239.622	218.959	427.476	102.091	–0.1075	5600
5700	21.033	117.815	239.994	219.325	429.580	98.225	–0.0911	5700
5800	21.025	119.918	240.360	219.684	431.682	94.358	–0.0759	5800
5900	21.018	122.020	240.719	220.038	433.785	90.491	–0.0618	5900
6000	21.011	124.122	241.072	220.385	435.886	86.622	–0.0487	6000
6200	20.997	128.322	241.761	221.064	440.087			6200
6400	20.985	132.521	242.427	221.721	444.285			6400
6600	20.974	136.717	243.073	222.358	448.481			6600
6800	20.964	140.910	243.699	222.977	452.675			6800
7000	20.954	145.102	244.306	223.578	456.866			7000
7200	20.945	149.292	244.897	224.162	461.056			7200
7400	20.937	153.480	245.470	224.730	465.245			7400
7600	20.930	157.667	246.029	225.283	469.431			7600
7800	20.923	161.852	246.572	225.822	473.617			7800
8000	20.916	166.036	247.102	226.347	477.801			8000
8500	20.902	176.491	248.370	227.606	488.255			8500
9000	20.890	186.939	249.564	228.793	498.703			9000
9500	20.880	197.381	250.693	229.916	509.145			9500
10000	20.871	207.819	251.764	230.982	519.583			10000
10500	20.863	218.252	252.782	231.996	530.017			10500
11000	20.857	228.682	253.752	232.963	540.447			11000
11500	20.851	239.109	254.679	233.887	550.873			11500
12000	20.846	249.533	255.567	234.772	561.297			12000
12500	20.841	259.955	256.417	235.621	571.719			12500
13000	20.837	270.374	257.235	236.437	582.139			13000
13500	20.833	280.792	258.021	237.222	592.556			13500
14000	20.830	291.208	258.779	237.978	602.972			14000
14500	20.827	301.622	259.510	238.708	613.387			14500
15000	20.825	312.035	260.216	239.413	623.800			15000
15500	20.822	322.447	260.898	240.095	634.211			15500
16000	20.820	332.857	261.560	240.756	644.622			16000
16500	20.818	343.267	262.200	241.396	655.031			16500
17000	20.816	353.676	262.822	242.017	665.440			17000
17500	20.815	364.083	263.425	242.620	675.848			17500
18000	20.813	374.490	264.011	243.206	686.255			18000
18500	20.812	384.896	264.582	243.776	696.661			18500
19000	20.810	395.302	265.137	244.331	707.066			19000
19500	20.809	405.707	265.677	244.872	717.471			19500
20000	20.808	416.111	266.204	245.398	727.876			20000

*Assigned reference element phase change at 631 K and 1728 K

TABLE A93.—THERMODYNAMIC PROPERTIES FOR O

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.725	----------	----------	242.450	246.790	----------	0
100	23.703	–4.518	135.949	181.133	244.657	247.546	–126.7267	100
200	22.734	–2.186	152.155	163.087	246.989	248.423	–61.9854	200
298.15	21.912	0.000	161.060	161.060	249.175	249.175	–40.5984	298.15
300	21.901	0.041	161.196	161.061	249.216	249.188	–40.3292	300
400	21.483	2.207	167.433	161.914	251.382	249.869	–29.4689	400
500	21.257	4.343	172.200	163.513	253.518	250.476	–22.9357	500
600	21.125	6.462	176.063	165.293	255.637	251.014	–18.5701	600
700	21.040	8.570	179.312	167.070	257.745	251.495	–15.4455	700
800	20.984	10.671	182.118	168.779	259.846	251.927	–13.0977	800
900	20.944	12.767	184.587	170.401	261.942	252.320	–11.2687	900
1000	20.915	14.860	186.792	171.932	264.035	252.681	–9.8033	1000
1100	20.894	16.950	188.784	173.375	266.125	253.016	–8.6027	1100
1200	20.877	19.039	190.602	174.736	268.214	253.330	–7.6009	1200
1300	20.864	21.126	192.272	176.021	270.301	253.624	–6.7521	1300
1400	20.854	23.212	193.818	177.238	272.387	253.903	–6.0239	1400
1500	20.845	25.297	195.257	178.392	274.472	254.166	–5.3920	1500
1600	20.839	27.381	196.602	179.488	276.556	254.415	–4.8386	1600
1700	20.834	29.465	197.865	180.533	278.640	254.652	–4.3498	1700
1800	20.830	31.548	199.055	181.529	280.723	254.875	–3.9149	1800
1900	20.827	33.631	200.182	182.481	282.806	255.087	–3.5255	1900
2000	20.827	35.713	201.250	183.393	284.888	255.286	–3.1747	2000
2100	20.827	37.796	202.266	184.268	286.971	255.474	–2.8571	2100
2200	20.830	39.879	203.235	185.108	289.054	255.650	–2.5682	2200
2300	20.835	41.962	204.161	185.917	291.137	255.816	–2.3042	2300
2400	20.842	44.046	205.048	186.695	293.221	255.970	–2.0620	2400
2500	20.851	46.130	205.899	187.447	295.305	256.114	–1.8392	2500
2600	20.863	48.216	206.717	188.172	297.391	256.248	–1.6333	2600
2700	20.877	50.303	207.505	188.874	299.478	256.372	–1.4426	2700
2800	20.894	52.392	208.264	189.553	301.567	256.487	–1.2654	2800
2900	20.915	54.482	208.998	190.211	303.657	256.594	–1.1004	2900
3000	20.937	56.575	209.707	190.849	305.750	256.692	–0.9463	3000
3100	20.963	58.670	210.394	191.468	307.845	256.783	–0.8021	3100
3200	20.992	60.767	211.060	192.070	309.942	256.867	–0.6669	3200
3300	21.023	62.868	211.706	192.655	312.043	256.944	–0.5398	3300
3400	21.056	64.972	212.334	193.225	314.147	257.015	–0.4202	3400
3500	21.092	67.079	212.945	193.780	316.254	257.082	–0.3073	3500
3600	21.130	69.190	213.540	194.320	318.365	257.143	–0.2007	3600
3700	21.171	71.306	214.120	194.848	320.481	257.200	–0.0999	3700
3800	21.213	73.425	214.685	195.362	322.600	257.253	–0.0043	3800
3900	21.257	75.548	215.236	195.865	324.723	257.302	0.0863	3900
4000	21.302	77.676	215.775	196.356	326.851	257.349	0.1725	4000
4100	21.349	79.809	216.302	196.836	328.984	257.392	0.2545	4100
4200	21.397	81.946	216.817	197.306	331.121	257.434	0.3326	4200
4300	21.446	84.088	217.321	197.765	333.263	257.473	0.4070	4300
4400	21.495	86.235	217.814	198.215	335.410	257.510	0.4781	4400
4500	21.545	88.387	218.298	198.656	337.562	257.546	0.5460	4500

TABLE A93.—THERMODYNAMIC PROPERTIES FOR O (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	21.596	90.544	218.772	199.088	339.719	257.580	0.6110	4600
4700	21.647	92.706	219.237	199.512	341.881	257.613	0.6733	4700
4800	21.698	94.874	219.693	199.928	344.049	257.645	0.7329	4800
4900	21.749	97.046	220.141	200.336	346.221	257.676	0.7901	4900
5000	21.799	99.223	220.581	200.736	348.398	257.707	0.8451	5000
5100	21.850	101.406	221.013	201.130	350.581	257.736	0.8979	5100
5200	21.899	103.593	221.438	201.516	352.768	257.766	0.9486	5200
5300	21.949	105.786	221.856	201.896	354.961	257.795	0.9975	5300
5400	21.998	107.983	222.266	202.270	357.158	257.823	1.0445	5400
5500	22.046	110.185	222.670	202.637	359.360	257.852	1.0899	5500
5600	22.093	112.392	223.068	202.998	361.567	257.881	1.1336	5600
5700	22.139	114.604	223.460	203.354	363.779	257.909	1.1758	5700
5800	22.185	116.820	223.845	203.704	365.995	257.939	1.2166	5800
5900	22.229	119.041	224.225	204.048	368.216	257.968	1.2559	5900
6000	22.273	121.266	224.599	204.388	370.441	257.998	1.2940	6000
6200	22.357	125.729	225.330	205.051	374.904	258.060	1.3665	6200
6400	22.436	130.208	226.041	205.696	379.383	258.127	1.4344	6400
6600	22.511	134.703	226.733	206.323	383.878	258.200	1.4982	6600
6800	22.581	139.212	227.406	206.934	388.387	258.281	1.5584	6800
7000	22.647	143.735	228.062	207.528	392.910	258.371	1.6151	7000
7200	22.708	148.271	228.700	208.107	397.446	258.473	1.6686	7200
7400	22.764	152.818	229.323	208.672	401.993	258.588	1.7193	7400
7600	22.816	157.376	229.931	209.224	406.551	258.719	1.7674	7600
7800	22.864	161.944	230.524	209.762	411.119	258.868	1.8130	7800
8000	22.908	166.522	231.104	210.289	415.697	259.038	1.8563	8000
8500	23.000	178.004	232.495	211.554	427.179	259.567	1.9559	8500
9000	23.061	189.520	233.812	212.755	438.695	260.258	2.0446	9000
9500	23.109	201.063	235.060	213.896	450.238	261.138	2.1242	9500
10000	23.150	212.629	236.247	214.984	461.804	262.231	2.1962	10000
10500	23.192	224.214	237.378	216.024	473.389	263.552	2.2616	10500
11000	23.236	235.820	238.457	217.019	484.995	265.117	2.3213	11000
11500	23.288	247.451	239.491	217.974	496.626	266.935	2.3762	11500
12000	23.348	259.110	240.483	218.891	508.285	269.011	2.4269	12000
12500	23.417	270.800	241.438	219.774	519.975	271.347	2.4739	12500
13000	23.495	282.528	242.358	220.625	531.703	273.943	2.5178	13000
13500	23.581	294.297	243.246	221.446	543.472	276.793	2.5587	13500
14000	23.672	306.110	244.106	222.241	555.285	279.895	2.5972	14000
14500	23.769	317.970	244.938	223.009	567.145	283.239	2.6335	14500
15000	23.868	329.879	245.745	223.753	579.054	286.817	2.6677	15000
15500	23.967	341.837	246.529	224.475	591.012	290.620	2.7001	15500
16000	24.066	353.845	247.292	225.177	603.020	294.636	2.7309	16000
16500	24.161	365.902	248.033	225.858	615.077	298.855	2.7602	16500
17000	24.253	378.006	248.757	226.521	627.181	303.267	2.7883	17000
17500	24.341	390.155	249.461	227.166	639.330	307.858	2.8151	17500
18000	24.424	402.346	250.148	227.795	651.521	312.617	2.8408	18000
18500	24.502	414.579	250.818	228.408	663.754	317.536	2.8655	18500
19000	24.577	426.848	251.472	229.007	676.023	322.601	2.8893	19000
19500	24.649	439.155	252.112	229.591	688.330	327.806	2.9122	19500
20000	24.722	451.497	252.737	230.162	700.672	333.144	2.9344	20000

TABLE A94.—THERMODYNAMIC PROPERTIES FOR O^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1562.590	1560.732	----------	0
298.15	20.786	0.000	154.961	154.961	1568.787	1568.787	–271.0060	298.15
300	20.786	0.038	155.089	154.961	1568.826	1568.837	–269.3111	300
400	20.786	2.117	161.069	155.776	1570.904	1571.508	–200.9704	400
500	20.786	4.196	165.707	157.316	1572.983	1574.136	–159.8960	500
600	20.786	6.274	169.497	159.040	1575.062	1576.713	–132.4674	600
700	20.786	8.353	172.701	160.769	1577.140	1579.243	–112.8436	700
800	20.786	10.432	175.477	162.437	1579.219	1581.731	–98.1023	800
900	20.786	12.510	177.925	164.025	1581.297	1584.186	–86.6189	900
1000	20.786	14.589	180.115	165.526	1583.376	1586.611	–77.4179	1000
1100	20.786	16.667	182.096	166.944	1585.455	1589.013	–69.8784	1100
1200	20.786	18.746	183.905	168.283	1587.533	1591.395	–63.5860	1200
1300	20.786	20.825	185.569	169.550	1589.612	1593.760	–58.2537	1300
1400	20.786	22.903	187.109	170.750	1591.691	1596.110	–53.6763	1400
1500	20.786	24.982	188.543	171.889	1593.769	1598.445	–49.7035	1500
1600	20.786	27.061	189.885	172.972	1595.848	1600.768	–46.2222	1600
1700	20.786	29.139	191.145	174.004	1597.926	1603.078	–43.1460	1700
1800	20.786	31.218	192.333	174.990	1600.005	1605.376	–40.4077	1800
1900	20.786	33.296	193.457	175.933	1602.084	1607.661	–37.9541	1900
2000	20.786	35.375	194.523	176.836	1604.162	1609.936	–35.7427	2000
2100	20.786	37.454	195.537	177.702	1606.241	1612.198	–33.7391	2100
2200	20.786	39.532	196.504	178.535	1608.320	1614.449	–31.9151	2200
2300	20.787	41.611	197.428	179.337	1610.398	1616.688	–30.2474	2300
2400	20.787	43.690	198.313	180.109	1612.477	1618.916	–28.7166	2400
2500	20.787	45.768	199.162	180.854	1614.556	1621.132	–27.3063	2500
2600	20.788	47.847	199.977	181.574	1616.634	1623.338	–26.0027	2600
2700	20.789	49.926	200.761	182.270	1618.713	1625.533	–24.7940	2700
2800	20.790	52.005	201.518	182.944	1620.792	1627.717	–23.6702	2800
2900	20.792	54.084	202.247	183.597	1622.871	1629.891	–22.6224	2900
3000	20.795	56.163	202.952	184.231	1624.951	1632.055	–21.6432	3000
3100	20.799	58.243	203.634	184.846	1627.030	1634.209	–20.7260	3100
3200	20.804	60.323	204.294	185.443	1629.111	1636.354	–19.8649	3200
3300	20.810	62.404	204.935	186.024	1631.191	1638.489	–19.0550	3300
3400	20.818	64.485	205.556	186.590	1633.273	1640.617	–18.2917	3400
3500	20.828	66.568	206.160	187.140	1635.355	1642.737	–17.5711	3500
3600	20.839	68.651	206.747	187.677	1637.438	1644.849	–16.8897	3600
3700	20.854	70.736	207.318	188.200	1639.523	1646.954	–16.2443	3700
3800	20.870	72.822	207.874	188.710	1641.609	1649.053	–15.6321	3800
3900	20.890	74.910	208.416	189.209	1643.697	1651.145	–15.0505	3900
4000	20.913	77.000	208.946	189.696	1645.787	1653.232	–14.4973	4000
4100	20.939	79.092	209.462	190.171	1647.880	1655.315	–13.9704	4100
4200	20.968	81.188	209.967	190.637	1649.975	1657.392	–13.4680	4200
4300	21.001	83.286	210.461	191.092	1652.073	1659.466	–12.9883	4300
4400	21.038	85.388	210.944	191.538	1654.175	1661.538	–12.5299	4400
4500	21.080	87.494	211.417	191.974	1656.281	1663.606	–12.0913	4500
4600	21.125	89.604	211.881	192.402	1658.391	1665.671	–11.6713	4600
4700	21.175	91.719	212.336	192.821	1660.506	1667.736	–11.2686	4700
4800	21.229	93.839	212.782	193.233	1662.626	1669.800	–10.8822	4800
4900	21.288	95.965	213.221	193.636	1664.752	1671.863	–10.5112	4900
5000	21.351	98.097	213.651	194.032	1666.884	1673.927	–10.1545	5000

TABLE A94.—THERMODYNAMIC PROPERTIES FOR O^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.419	100.235	214.075	194.421	1669.023	1675.991	–9.8114	5100
5200	21.491	102.381	214.492	194.803	1671.168	1678.057	–9.4811	5200
5300	21.568	104.534	214.902	195.178	1673.321	1680.125	–9.1629	5300
5400	21.650	106.695	215.306	195.547	1675.482	1682.196	–8.8561	5400
5500	21.736	108.864	215.704	195.910	1677.651	1684.270	–8.5601	5500
5600	21.826	111.042	216.096	196.267	1679.829	1686.349	–8.2743	5600
5700	21.921	113.229	216.483	196.618	1682.016	1688.432	–7.9981	5700
5800	22.020	115.426	216.865	196.964	1684.213	1690.520	–7.7312	5800
5900	22.124	117.633	217.243	197.305	1686.421	1692.615	–7.4730	5900
6000	22.231	119.851	217.615	197.640	1688.638	1694.716	–7.2231	6000
6200	22.457	124.320	218.348	198.296	1693.107	1698.941	–6.7466	6200
6400	22.697	128.835	219.065	198.934	1697.622	1703.201	–6.2987	6400
6600	22.951	133.399	219.767	199.555	1702.187	1707.501	–5.8770	6600
6800	23.215	138.016	220.456	200.159	1706.803	1711.846	–5.4790	6800
7000	23.490	142.686	221.133	200.749	1711.474	1716.240	–5.1029	7000
7200	23.773	147.413	221.799	201.325	1716.200	1720.690	–4.7467	7200
7400	24.062	152.196	222.454	201.887	1720.983	1725.199	–4.4089	7400
7600	24.357	157.038	223.099	202.437	1725.825	1729.771	–4.0880	7600
7800	24.654	161.939	223.736	202.975	1730.726	1734.411	–3.7827	7800
8000	24.954	166.900	224.364	203.501	1735.687	1739.121	–3.4920	8000
8500	25.700	179.563	225.899	204.774	1748.351	1751.225	–2.8218	8500
9000	26.428	192.597	227.389	205.989	1761.384	1763.826	–2.2218	9000
9500	27.117	205.985	228.836	207.154	1774.772	1776.944	–1.6811	9500
10000	27.755	219.705	230.244	208.273	1788.492	1790.585	–1.1908	10000
10500	28.331	233.730	231.612	209.352	1802.517	1804.739	–0.7437	10500
11000	28.839	248.025	232.942	210.394	1816.812	1819.386	–0.3340	11000
11500	29.276	262.557	234.234	211.403	1831.344	1834.498	0.0432	11500
12000	29.640	277.289	235.488	212.381	1846.076	1850.041	0.3918	12000
12500	29.934	292.185	236.704	213.329	1860.972	1865.975	0.7153	12500
13000	30.160	307.211	237.883	214.251	1875.999	1882.262	1.0165	13000
13500	30.325	322.335	239.024	215.148	1891.122	1898.861	1.2978	13500
14000	30.432	337.526	240.129	216.020	1906.314	1915.734	1.5613	14000
14500	30.488	352.758	241.198	216.870	1921.546	1932.843	1.8089	14500
15000	30.498	368.007	242.232	217.698	1936.794	1950.154	2.0420	15000
15500	30.470	383.250	243.232	218.506	1952.037	1967.635	2.2620	15500
16000	30.407	398.471	244.198	219.294	1967.258	1985.257	2.4701	16000
16500	30.317	413.653	245.133	220.063	1982.440	2002.995	2.6674	16500
17000	30.203	428.784	246.036	220.813	1997.571	2020.826	2.8547	17000
17500	30.071	443.853	246.910	221.547	2012.640	2038.731	3.0329	17500
18000	29.924	458.852	247.755	222.263	2027.640	2056.691	3.2027	18000
18500	29.767	473.776	248.573	222.963	2042.563	2074.694	3.3647	18500
19000	29.603	488.619	249.364	223.647	2057.406	2092.725	3.5195	19000
19500	29.434	503.378	250.131	224.317	2072.165	2110.777	3.6676	19500
20000	29.264	518.052	250.874	224.971	2086.840	2128.839	3.8096	20000

TABLE A95.—THERMODYNAMIC PROPERTIES FOR O^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.571	----------	----------	95.275	105.813	----------	0
298.15	21.685	0.000	157.797	157.797	101.846	101.846	–16.0539	298.15
300	21.677	0.040	157.931	157.797	101.886	101.820	–15.9439	300
400	21.359	2.190	164.119	158.643	104.037	100.406	–11.5395	400
500	21.181	4.317	168.864	160.231	106.163	98.924	–8.9350	500
600	21.073	6.429	172.716	162.001	108.275	97.378	–7.2251	600
700	21.003	8.532	175.959	163.769	110.379	95.776	–6.0235	700
800	20.956	10.630	178.760	165.472	112.476	94.126	–5.1375	800
900	20.923	12.724	181.226	167.088	114.570	92.438	–4.4605	900
1000	20.898	14.815	183.429	168.614	116.661	90.719	–3.9288	1000
1100	20.880	16.904	185.420	170.053	118.750	88.974	–3.5020	1100
1200	20.866	18.991	187.236	171.410	120.837	87.207	–3.1534	1200
1300	20.854	21.077	188.906	172.693	122.923	85.422	–2.8643	1300
1400	20.845	23.162	190.451	173.907	125.008	83.621	–2.6216	1400
1500	20.838	25.246	191.889	175.058	127.092	81.805	–2.4159	1500
1600	20.832	27.330	193.234	176.153	129.176	79.975	–2.2398	1600
1700	20.827	29.413	194.496	177.195	131.259	78.132	–2.0879	1700
1800	20.823	31.495	195.687	178.189	133.341	76.276	–1.9561	1800
1900	20.819	33.577	196.813	179.140	135.423	74.408	–1.8410	1900
2000	20.816	35.659	197.880	180.051	137.505	72.528	–1.7400	2000
2100	20.813	37.740	198.896	180.924	139.587	70.636	–1.6509	2100
2200	20.811	39.822	199.864	181.763	141.668	68.732	–1.5721	2200
2300	20.809	41.903	200.789	182.571	143.749	66.816	–1.5021	2300
2400	20.807	43.983	201.675	183.348	145.830	64.889	–1.4398	2400
2500	20.805	46.064	202.524	184.098	147.910	62.950	–1.3842	2500
2600	20.804	48.144	203.340	184.823	149.991	61.001	–1.3344	2600
2700	20.803	50.225	204.125	185.523	152.071	59.039	–1.2897	2700
2800	20.802	52.305	204.882	186.201	154.151	57.067	–1.2496	2800
2900	20.801	54.385	205.612	186.858	156.231	55.085	–1.2135	2900
3000	20.800	56.465	206.317	187.495	158.311	53.092	–1.1810	3000
3100	20.799	58.545	206.999	188.113	160.391	51.090	–1.1518	3100
3200	20.798	60.625	207.659	188.714	162.471	49.077	–1.1254	3200
3300	20.797	62.705	208.299	189.298	164.551	47.054	–1.1016	3300
3400	20.797	64.784	208.920	189.866	166.631	45.023	–1.0802	3400
3500	20.796	66.864	209.523	190.419	168.710	42.983	–1.0608	3500
3600	20.796	68.944	210.109	190.958	170.790	40.934	–1.0434	3600
3700	20.795	71.023	210.678	191.483	172.869	38.877	–1.0278	3700
3800	20.795	73.103	211.233	191.995	174.949	36.812	–1.0137	3800
3900	20.794	75.182	211.773	192.496	177.028	34.738	–1.0011	3900
4000	20.794	77.261	212.299	192.984	179.108	32.658	–0.9898	4000
4100	20.793	79.341	212.813	193.461	181.187	30.569	–0.9797	4100
4200	20.793	81.420	213.314	193.928	183.266	28.474	–0.9708	4200
4300	20.793	83.499	213.803	194.385	185.346	26.372	–0.9629	4300
4400	20.793	85.579	214.281	194.832	187.425	24.263	–0.9559	4400
4500	20.792	87.658	214.749	195.269	189.504	22.147	–0.9497	4500
4600	20.792	89.737	215.206	195.697	191.583	20.024	–0.9444	4600
4700	20.792	91.816	215.653	196.117	193.663	17.896	–0.9398	4700
4800	20.792	93.896	216.090	196.529	195.742	15.761	–0.9359	4800
4900	20.791	95.975	216.519	196.932	197.821	13.620	–0.9327	4900
5000	20.791	98.054	216.939	197.328	199.900	11.474	–0.9300	5000

TABLE A95.—THERMODYNAMIC PROPERTIES FOR O^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.791	100.133	217.351	197.717	201.979	9.322	–0.9279	5100
5200	20.791	102.212	217.755	198.098	204.058	7.164	–0.9262	5200
5300	20.791	104.291	218.151	198.473	206.137	5.002	–0.9251	5300
5400	20.790	106.370	218.539	198.841	208.216	2.833	–0.9244	5400
5500	20.790	108.449	218.921	199.203	210.295	0.660	–0.9241	5500
5600	20.790	110.528	219.295	199.558	212.374	–1.518	–0.9241	5600
5700	20.790	112.607	219.663	199.908	214.453	–3.700	–0.9246	5700
5800	20.790	114.686	220.025	200.251	216.532	–5.887	–0.9253	5800
5900	20.790	116.765	220.380	200.590	218.611	–8.078	–0.9264	5900
6000	20.790	118.844	220.730	200.922	220.690	–10.272	–0.9277	6000
6200	20.789	123.002	221.411	201.572	224.848	–14.673	–0.9312	6200
6400	20.789	127.160	222.071	202.203	229.006	–19.085	–0.9357	6400
6600	20.789	131.318	222.711	202.814	233.164	–23.506	–0.9409	6600
6800	20.789	135.476	223.332	203.409	237.322	–27.934	–0.9469	6800
7000	20.789	139.633	223.934	203.987	241.479	–32.367	–0.9535	7000
7200	20.789	143.791	224.520	204.549	245.637	–36.800	–0.9607	7200
7400	20.789	147.949	225.090	205.096	249.795	–41.231	–0.9683	7400
7600	20.788	152.106	225.644	205.630	253.953	–45.657	–0.9764	7600
7800	20.788	156.264	226.184	206.150	258.110	–50.076	–0.9848	7800
8000	20.788	160.422	226.710	206.658	262.268	–54.483	–0.9936	8000
8500	20.788	170.816	227.971	207.875	272.662	–65.436	–1.0166	8500
9000	20.788	181.210	229.159	209.024	283.056	–76.260	–1.0407	9000
9500	20.788	191.604	230.283	210.114	293.450	–86.922	–1.0656	9500
10000	20.788	201.997	231.349	211.149	303.844	–97.394	–1.0909	10000
10500	20.787	212.391	232.363	212.135	314.237	–107.658	–1.1164	10500
11000	20.787	222.785	233.330	213.077	324.631	–117.699	–1.1419	11000
11500	20.787	233.178	234.254	213.978	335.025	–127.511	–1.1672	11500
12000	20.787	243.572	235.139	214.841	345.418	–137.093	–1.1922	12000
12500	20.787	253.966	235.987	215.670	355.812	–146.448	–1.2169	12500
13000	20.787	264.359	236.803	216.467	366.205	–155.580	–1.2411	13000
13500	20.787	274.753	237.587	217.235	376.599	–164.497	–1.2650	13500
14000	20.787	285.146	238.343	217.976	386.992	–173.209	–1.2883	14000
14500	20.787	295.539	239.073	218.691	397.386	–181.724	–1.3111	14500
15000	20.787	305.933	239.777	219.382	407.779	–190.055	–1.3334	15000
15500	20.787	316.326	240.459	220.051	418.172	–198.210	–1.3552	15500
16000	20.787	326.720	241.119	220.699	428.566	–206.201	–1.3765	16000
16500	20.787	337.113	241.759	221.327	438.959	–214.038	–1.3973	16500
17000	20.787	347.506	242.379	221.938	449.353	–221.731	–1.4176	17000
17500	20.787	357.900	242.982	222.530	459.746	–229.288	–1.4374	17500
18000	20.787	368.293	243.567	223.107	470.139	–236.720	–1.4567	18000
18500	20.787	378.686	244.137	223.667	480.533	–244.034	–1.4756	18500
19000	20.787	389.080	244.691	224.213	490.926	–251.238	–1.4940	19000
19500	20.787	399.473	245.231	224.745	501.319	–258.339	–1.5119	19500
20000	20.787	409.866	245.757	225.264	511.712	–265.344	–1.5294	20000

TABLE A96.—THERMODYNAMIC PROPERTIES FOR P

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	310.303	315.663	----------	0
100	20.786	–4.119	140.492	181.680	312.381	316.853	–159.0892	100
*200	20.786	–2.040	154.900	165.101	314.460	316.669	–76.2912	200
298.15	20.786	0.000	163.200	163.200	316.500	316.500	–49.0699	298.15
300	20.786	0.038	163.328	163.200	316.538	316.494	–48.7280	300
*400	20.786	2.117	169.308	164.015	318.617	315.338	–34.9832	400
500	20.786	4.196	173.946	165.555	320.696	314.805	–26.7540	500
600	20.786	6.274	177.736	167.279	322.774	314.271	–21.2773	600
700	20.786	8.353	180.940	169.008	324.853	313.738	–17.3720	700
800	20.786	10.432	183.716	170.677	326.932	313.204	–14.4480	800
900	20.786	12.510	186.164	172.264	329.010	312.671	–12.1777	900
1000	20.787	14.589	188.354	173.766	331.089	312.138	–10.3646	1000
1100	20.788	16.668	190.336	175.183	333.168	311.604	–8.8836	1100
1200	20.791	18.747	192.145	176.522	335.247	311.071	–7.6516	1200
1300	20.798	20.826	193.809	177.789	337.326	310.539	–6.6109	1300
1400	20.810	22.906	195.351	178.989	339.406	310.007	–5.7204	1400
1500	20.832	24.988	196.787	180.128	341.488	309.477	–4.9500	1500
1600	20.865	27.073	198.133	181.212	343.573	308.950	–4.2770	1600
1700	20.914	29.162	199.399	182.245	345.662	308.427	–3.6842	1700
1800	20.981	31.256	200.596	183.231	347.756	307.909	–3.1582	1800
1900	21.069	33.359	201.733	184.175	349.859	307.400	–2.6883	1900
2000	21.179	35.471	202.816	185.081	351.971	306.900	–2.2661	2000
2100	21.313	37.595	203.853	185.950	354.095	306.412	–1.8847	2100
2200	21.471	39.734	204.848	186.787	356.234	305.939	–1.5385	2200
2300	21.653	41.890	205.806	187.593	358.390	305.483	–1.2230	2300
2400	21.859	44.066	206.732	188.371	360.566	305.047	–0.9341	2400
2500	22.088	46.263	207.629	189.124	362.763	304.632	–0.6687	2500
2600	22.337	48.484	208.500	189.852	364.984	304.241	–0.4241	2600
2700	22.605	50.731	209.348	190.558	367.231	303.876	–0.1978	2700
2800	22.890	53.005	210.175	191.244	369.505	303.538	0.0120	2800
2900	23.189	55.309	210.983	191.911	371.809	303.230	0.2072	2900
3000	23.500	57.644	211.775	192.560	374.144	302.953	0.3891	3000
3100	23.821	60.010	212.550	193.192	376.510	302.707	0.5592	3100
3200	24.148	62.408	213.312	193.809	378.908	302.493	0.7185	3200
3300	24.480	64.839	214.060	194.412	381.339	302.312	0.8681	3300
3400	24.814	67.304	214.796	195.000	383.804	302.165	1.0088	3400
3500	25.148	69.802	215.520	195.576	386.302	302.051	1.1414	3500
3600	25.480	72.334	216.233	196.140	388.834	301.971	1.2666	3600
3700	25.808	74.898	216.936	196.693	391.398	301.923	1.3850	3700
3800	26.130	77.495	217.628	197.235	393.995	301.908	1.4972	3800
3900	26.444	80.124	218.311	197.766	396.624	301.925	1.6036	3900
4000	26.750	82.784	218.984	198.288	399.284	301.973	1.7047	4000
4100	27.045	85.473	219.649	198.801	401.973	302.050	1.8009	4100
4200	27.329	88.192	220.304	199.306	404.692	302.157	1.8925	4200
4300	27.601	90.939	220.950	199.801	407.439	302.292	1.9799	4300
4400	27.861	93.712	221.588	200.289	410.212	302.453	2.0634	4400
4500	28.107	96.511	222.216	200.770	413.011	302.640	2.1432	4500

TABLE A96.—THERMODYNAMIC PROPERTIES FOR P (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	28.338	99.333	222.837	201.243	415.833	302.850	2.2196	4600
4700	28.556	102.178	223.449	201.709	418.678	303.083	2.2928	4700
4800	28.760	105.044	224.052	202.168	421.544	303.337	2.3630	4800
4900	28.948	107.929	224.647	202.620	424.429	303.610	2.4304	4900
5000	29.123	110.833	225.233	203.067	427.333	303.902	2.4952	5000
5100	29.283	113.753	225.812	203.507	430.253	304.210	2.5574	5100
5200	29.429	116.689	226.382	203.942	433.189	304.534	2.6174	5200
5300	29.561	119.639	226.944	204.370	436.139	304.872	2.6751	5300
5400	29.680	122.601	227.497	204.794	439.101	305.222	2.7308	5400
5500	29.785	125.574	228.043	205.211	442.074	305.583	2.7845	5500
5600	29.878	128.558	228.581	205.624	445.058	305.954	2.8364	5600
5700	29.959	131.550	229.110	206.031	448.050	306.334	2.8865	5700
5800	30.028	134.549	229.632	206.434	451.049	306.722	2.9349	5800
5900	30.087	137.555	230.146	206.831	454.055	307.116	2.9818	5900
6000	30.134	140.566	230.652	207.224	457.066	307.515	3.0271	6000
6200	30.201	146.600	231.641	207.996	463.100			6200
6400	30.233	152.644	232.600	208.750	469.144			6400
6600	30.235	158.691	233.531	209.487	475.191			6600
6800	30.214	164.736	234.433	210.207	481.236			6800
7000	30.172	170.775	235.308	210.912	487.275			7000
7200	30.116	176.804	236.158	211.601	493.304			7200
7400	30.049	182.820	236.982	212.276	499.320			7400
7600	29.977	188.822	237.782	212.937	505.322			7600
7800	29.903	194.809	238.560	213.584	511.309			7800
8000	29.830	200.780	239.315	214.218	517.280			8000
8500	29.630	215.641	241.119	215.750	532.141			8500
9000	29.576	230.439	242.810	217.206	546.939			9000
9500	29.623	245.234	244.411	218.597	561.734			9500
10000	29.776	260.079	245.933	219.925	576.579			10000
10500	30.030	275.026	247.392	221.199	591.526			10500
11000	30.377	290.124	248.797	222.422	606.624			11000
11500	30.806	305.417	250.156	223.598	621.917			11500
12000	31.303	320.942	251.477	224.732	637.442			12000
12500	31.855	336.729	252.766	225.828	653.229			12500
13000	32.447	352.804	254.027	226.889	669.304			13000
13500	33.063	369.180	255.263	227.916	685.680			13500
14000	33.691	385.868	256.477	228.915	702.368			14000
14500	34.316	402.871	257.670	229.886	719.371			14500
15000	34.927	420.182	258.844	230.832	736.682			15000
15500	35.509	437.793	259.999	231.754	754.293			15500
16000	36.052	455.685	261.135	232.654	772.185			16000
16500	36.545	473.837	262.252	233.535	790.337			16500
17000	36.980	492.221	263.350	234.395	808.721			17000
17500	37.346	510.804	264.427	235.238	827.304			17500
18000	37.637	529.554	265.483	236.063	846.054			18000
18500	37.848	548.429	266.517	236.873	864.929			18500
19000	37.972	567.387	267.529	237.666	883.887			19000
19500	38.004	586.386	268.515	238.444	902.886			19500
20000	37.942	605.375	269.477	239.209	921.875			20000

***Assigned reference element phase change at 195.4 K and 317.3 K**

TABLE A97.—THERMODYNAMIC PROPERTIES FOR P^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–8.142	----------	----------	1328.312	1327.474	----------	0
*298.15	25.859	0.000	166.971	166.971	1336.453	1336.453	–226.4642	298.15
300	25.818	0.048	167.131	166.972	1336.501	1336.496	–225.0203	300
*400	24.059	2.534	174.296	167.960	1338.988	1337.826	–166.8276	400
500	23.011	4.883	179.542	169.776	1341.337	1339.641	–131.8659	500
600	22.373	7.150	183.677	171.760	1343.603	1341.375	–108.5270	600
700	21.966	9.366	187.093	173.713	1345.819	1343.057	–91.8350	700
800	21.695	11.548	190.007	175.572	1348.001	1344.706	–79.3004	800
900	21.506	13.707	192.551	177.321	1350.161	1346.332	–69.5394	900
1000	21.371	15.851	194.809	178.959	1352.304	1347.942	–61.7212	1000
1100	21.275	17.983	196.841	180.493	1354.436	1349.541	–55.3168	1100
1200	21.206	20.107	198.689	181.934	1356.560	1351.131	–49.9735	1200
1300	21.160	22.225	200.385	183.289	1358.678	1352.716	–45.4470	1300
1400	21.134	24.339	201.952	184.567	1360.793	1354.297	–41.5625	1400
1500	21.126	26.452	203.410	185.775	1362.906	1355.877	–38.1921	1500
1600	21.134	28.565	204.773	186.920	1365.019	1357.456	–35.2395	1600
1700	21.156	30.680	206.055	188.008	1367.133	1359.037	–32.6312	1700
1800	21.192	32.797	207.265	189.045	1369.250	1360.621	–30.3100	1800
1900	21.239	34.918	208.412	190.034	1371.372	1362.209	–28.2308	1900
2000	21.297	37.045	209.503	190.981	1373.498	1363.802	–26.3573	2000
2100	21.363	39.178	210.544	191.888	1375.631	1365.402	–24.6602	2100
2200	21.436	41.318	211.539	192.759	1377.771	1367.009	–23.1156	2200
2300	21.514	43.465	212.494	193.596	1379.919	1368.623	–21.7036	2300
2400	21.596	45.621	213.411	194.403	1382.074	1370.245	–20.4078	2400
2500	21.681	47.785	214.295	195.181	1384.238	1371.875	–19.2142	2500
2600	21.768	49.957	215.147	195.932	1386.411	1373.514	–18.1112	2600
2700	21.855	52.138	215.970	196.659	1388.592	1375.162	–17.0886	2700
2800	21.942	54.328	216.766	197.363	1390.781	1376.819	–16.1379	2800
2900	22.027	56.526	217.538	198.046	1392.980	1378.484	–15.2517	2900
3000	22.110	58.733	218.286	198.708	1395.187	1380.157	–14.4236	3000
3100	22.191	60.948	219.012	199.351	1397.402	1381.839	–13.6479	3100
3200	22.269	63.171	219.718	199.977	1399.625	1383.528	–12.9199	3200
3300	22.343	65.402	220.404	200.585	1401.856	1385.226	–12.2352	3300
3400	22.414	67.640	221.072	201.178	1404.093	1386.930	–11.5899	3400
3500	22.482	69.885	221.723	201.756	1406.338	1388.642	–10.9807	3500
3600	22.545	72.136	222.357	202.319	1408.590	1390.360	–10.4047	3600
3700	22.605	74.394	222.976	202.869	1410.847	1392.084	–9.8592	3700
3800	22.661	76.657	223.579	203.407	1413.111	1393.814	–9.3417	3800
3900	22.713	78.926	224.169	203.931	1415.379	1395.549	–8.8501	3900
4000	22.761	81.199	224.744	204.445	1417.653	1397.289	–8.3826	4000
4100	22.805	83.478	225.307	204.947	1419.931	1399.034	–7.9373	4100
4200	22.845	85.760	225.857	205.438	1422.214	1400.784	–7.5126	4200
4300	22.883	88.047	226.395	205.919	1424.500	1402.537	–7.1073	4300
4400	22.916	90.337	226.921	206.390	1426.790	1404.293	–6.7198	4400
4500	22.947	92.630	227.437	206.852	1429.083	1406.053	–6.3491	4500
4600	22.974	94.926	227.941	207.305	1431.379	1407.816	–5.9941	4600
4700	22.999	97.225	228.436	207.750	1433.678	1409.581	–5.6538	4700
4800	23.021	99.526	228.920	208.186	1435.979	1411.349	–5.3272	4800
4900	23.040	101.829	229.395	208.614	1438.282	1413.118	–5.0136	4900
5000	23.056	104.134	229.861	209.034	1440.587	1414.890	–4.7121	5000

TABLE A97.—THERMODYNAMIC PROPERTIES FOR P^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	23.071	106.440	230.317	209.447	1442.893	1416.663	–4.4221	5100
5200	23.083	108.748	230.766	209.853	1445.201	1418.437	–4.1429	5200
5300	23.093	111.056	231.205	210.251	1447.510	1420.213	–3.8739	5300
5400	23.101	113.366	231.637	210.643	1449.820	1421.989	–3.6146	5400
5500	23.108	115.677	232.061	211.029	1452.130	1423.766	–3.3643	5500
5600	23.113	117.988	232.477	211.408	1454.441	1425.544	–3.1227	5600
5700	23.116	120.299	232.887	211.781	1456.753	1427.322	–2.8893	5700
5800	23.118	122.611	233.289	212.149	1459.064	1429.100	–2.6636	5800
5900	23.119	124.923	233.684	212.511	1461.376	1430.879	–2.4454	5900
6000	23.118	127.235	234.072	212.867	1463.688	1432.657	–2.2341	6000
6200	23.115	131.858	234.830	213.563	1468.311			6200
6400	23.107	136.480	235.564	214.239	1472.934			6400
6600	23.097	141.101	236.275	214.896	1477.554			6600
6800	23.085	145.719	236.964	215.535	1482.172			6800
7000	23.072	150.335	237.633	216.157	1486.788			7000
7200	23.058	154.948	238.283	216.763	1491.401			7200
7400	23.043	159.558	238.915	217.353	1496.011			7400
7600	23.028	164.165	239.529	217.928	1500.618			7600
7800	23.014	168.769	240.127	218.490	1505.222			7800
8000	23.000	173.370	240.709	219.038	1509.824			8000
8500	22.971	184.863	242.103	220.354	1521.316			8500
9000	22.953	196.343	243.415	221.599	1532.797			9000
9500	22.950	207.819	244.656	222.781	1544.272			9500
10000	22.966	219.297	245.834	223.904	1555.750			10000
10500	23.001	230.788	246.955	224.975	1567.241			10500
11000	23.061	242.302	248.026	225.999	1578.756			11000
11500	23.146	253.853	249.053	226.979	1590.306			11500
12000	23.259	265.453	250.041	227.919	1601.906			12000
12500	23.402	277.116	250.993	228.823	1613.570			12500
13000	23.578	288.860	251.914	229.694	1625.313			13000
13500	23.788	300.700	252.808	230.534	1637.153			13500
14000	24.036	312.654	253.677	231.345	1649.107			14000
14500	24.322	324.741	254.525	232.129	1661.195			14500
15000	24.650	336.982	255.355	232.890	1673.436			15000
15500	25.020	349.397	256.169	233.628	1685.850			15500
16000	25.435	362.008	256.970	234.345	1698.461			16000
16500	25.895	374.835	257.760	235.042	1711.289			16500
17000	26.376	387.868	258.537	235.722	1724.322			17000
17500	26.906	401.163	259.308	236.384	1737.616			17500
18000	27.471	414.721	260.072	237.032	1751.174			18000
18500	28.075	428.568	260.830	237.664	1765.022			18500
19000	28.742	442.771	261.588	238.284	1779.224			19000
19500	29.450	457.317	262.343	238.891	1793.770			19500
20000	30.198	472.227	263.098	239.487	1808.681			20000

*Assigned reference element phase change at 195.4 K and 317.3 K

TABLE A98.—THERMODYNAMIC PROPERTIES FOR P^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.748	----------	----------	232.079	243.636	----------	0
*298.15	22.169	0.000	169.126	169.126	238.827	238.827	–36.2485	298.15
300	22.156	0.041	169.263	169.126	238.868	238.785	–35.9905	300
*400	21.664	2.230	175.562	169.988	241.056	235.660	–25.6668	400
500	21.388	4.381	180.364	171.602	243.208	233.121	–19.5427	500
600	21.222	6.511	184.248	173.396	245.338	230.560	–15.5048	600
700	21.115	8.627	187.511	175.186	247.454	227.986	–12.6526	700
800	21.043	10.735	190.325	176.906	249.562	225.403	–10.5376	800
900	20.992	12.837	192.801	178.538	251.663	222.814	–8.9114	900
1000	20.955	14.934	195.010	180.076	253.761	220.221	–7.6255	1000
1100	20.927	17.028	197.006	181.526	255.855	217.624	–6.5857	1100
1200	20.905	19.119	198.826	182.893	257.946	215.025	–5.7296	1200
1300	20.888	21.209	200.499	184.184	260.036	212.424	–5.0139	1300
1400	20.875	23.297	202.046	185.405	262.124	209.822	–4.4078	1400
1500	20.863	25.384	203.486	186.563	264.211	207.218	–3.8891	1500
1600	20.854	27.470	204.832	187.663	266.297	204.613	–3.4409	1600
1700	20.847	29.555	206.096	188.711	268.382	202.007	–3.0504	1700
1800	20.840	31.639	207.288	189.710	270.466	199.401	–2.7078	1800
1900	20.835	33.723	208.414	190.665	272.550	196.794	–2.4052	1900
2000	20.830	35.806	209.483	191.580	274.633	194.187	–2.1365	2000
2100	20.826	37.889	210.499	192.457	276.716	191.579	–1.8966	2100
2200	20.823	39.972	211.468	193.299	278.798	188.971	–1.6814	2200
2300	20.820	42.054	212.393	194.109	280.881	186.362	–1.4877	2300
2400	20.817	44.136	213.279	194.889	282.962	183.754	–1.3125	2400
2500	20.815	46.217	214.129	195.642	285.044	181.145	–1.1537	2500
2600	20.813	48.299	214.945	196.369	287.125	178.535	–1.0092	2600
2700	20.811	50.380	215.731	197.072	289.206	175.926	–0.8773	2700
2800	20.809	52.461	216.488	197.752	291.287	173.316	–0.7566	2800
2900	20.807	54.542	217.218	198.410	293.368	170.706	–0.6460	2900
3000	20.806	56.622	217.923	199.049	295.449	168.096	–0.5442	3000
3100	20.805	58.703	218.605	199.669	297.529	165.486	–0.4506	3100
3200	20.804	60.783	219.266	200.271	299.610	162.876	–0.3641	3200
3300	20.803	62.863	219.906	200.857	301.690	160.266	–0.2842	3300
3400	20.802	64.944	220.527	201.426	303.770	157.655	–0.2102	3400
3500	20.801	67.024	221.130	201.980	305.851	155.045	–0.1415	3500
3600	20.800	69.104	221.716	202.521	307.931	152.434	–0.0778	3600
3700	20.799	71.184	222.286	203.047	310.011	149.824	–0.0185	3700
3800	20.799	73.264	222.841	203.561	312.091	147.213	0.0367	3800
3900	20.798	75.344	223.381	204.062	314.170	144.602	0.0881	3900
4000	20.797	77.423	223.907	204.552	316.250	141.991	0.1361	4000
4100	20.797	79.503	224.421	205.030	318.330	139.380	0.1809	4100
4200	20.796	81.583	224.922	205.498	320.410	136.769	0.2228	4200
4300	20.796	83.662	225.411	205.955	322.489	134.158	0.2619	4300
4400	20.796	85.742	225.890	206.403	324.569	131.547	0.2986	4400
4500	20.795	87.821	226.357	206.841	326.648	128.936	0.3330	4500
4600	20.795	89.901	226.814	207.270	328.728	126.325	0.3652	4600
4700	20.794	91.980	227.261	207.691	330.807	123.714	0.3954	4700
4800	20.794	94.060	227.699	208.103	332.887	121.103	0.4237	4800
4900	20.794	96.139	228.128	208.507	334.966	118.492	0.4504	4900
5000	20.793	98.219	228.548	208.904	337.045	115.880	0.4753	5000

TABLE A98.—THERMODYNAMIC PROPERTIES FOR P^- (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.793	100.298	228.959	209.293	339.125	113.269	0.4988	5100
5200	20.793	102.377	229.363	209.675	341.204	110.658	0.5209	5200
5300	20.793	104.457	229.759	210.051	343.283	108.046	0.5416	5300
5400	20.792	106.536	230.148	210.419	345.363	105.435	0.5611	5400
5500	20.792	108.615	230.529	210.781	347.442	102.824	0.5794	5500
5600	20.792	110.694	230.904	211.137	349.521	100.212	0.5966	5600
5700	20.792	112.773	231.272	211.487	351.600	97.601	0.6128	5700
5800	20.792	114.853	231.634	211.832	353.679	94.989	0.6280	5800
5900	20.791	116.932	231.989	212.170	355.759	92.378	0.6423	5900
6000	20.791	119.011	232.339	212.503	357.838	89.766	0.6557	6000
6200	20.791	123.169	233.020	213.154	361.996			6200
6400	20.791	127.327	233.680	213.786	366.154			6400
6600	20.790	131.485	234.320	214.398	370.312			6600
6800	20.790	135.643	234.941	214.993	374.470			6800
7000	20.790	139.801	235.544	215.572	378.628			7000
7200	20.790	143.959	236.129	216.135	382.786			7200
7400	20.790	148.117	236.699	216.683	386.944			7400
7600	20.789	152.275	237.253	217.217	391.102			7600
7800	20.789	156.433	237.793	217.738	395.260			7800
8000	20.789	160.591	238.320	218.246	399.418			8000
8500	20.789	170.985	239.580	219.464	409.812			8500
9000	20.789	181.380	240.768	220.615	420.207			9000
9500	20.788	191.774	241.892	221.705	430.601			9500
10000	20.788	202.168	242.958	222.742	440.995			10000
10500	20.788	212.562	243.973	223.729	451.389			10500
11000	20.788	222.956	244.940	224.671	461.783			11000
11500	20.788	233.350	245.864	225.572	472.177			11500
12000	20.788	243.744	246.748	226.436	482.570			12000
12500	20.787	254.137	247.597	227.266	492.964			12500
13000	20.787	264.531	248.412	228.064	503.358			13000
13500	20.787	274.925	249.197	228.832	513.751			13500
14000	20.787	285.318	249.953	229.573	524.145			14000
14500	20.787	295.712	250.682	230.288	534.539			14500
15000	20.787	306.105	251.387	230.980	544.932			15000
15500	20.787	316.499	252.069	231.649	555.326			15500
16000	20.787	326.892	252.729	232.298	565.719			16000
16500	20.787	337.286	253.368	232.927	576.113			16500
17000	20.787	347.679	253.989	233.537	586.506			17000
17500	20.787	358.073	254.591	234.130	596.900			17500
18000	20.787	368.466	255.177	234.707	607.293			18000
18500	20.787	378.860	255.746	235.268	617.686			18500
19000	20.787	389.253	256.301	235.814	628.080			19000
19500	20.787	399.646	256.841	236.346	638.473			19500
20000	20.787	410.040	257.367	236.865	648.867			20000

*Assigned reference element phase change at 195.4 K and 317.3 K

TABLE A99.—THERMODYNAMIC PROPERTIES FOR Pb

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	189.003	195.873	----------	0
100	20.786	–4.119	152.669	193.857	191.081	196.185	–96.4270	100
200	20.786	–2.040	167.077	177.278	193.160	195.741	–45.2327	200
298.15	20.786	0.000	175.377	175.377	195.200	195.200	–28.4216	298.15
300	20.786	0.038	175.505	175.377	195.238	195.189	–28.2107	300
400	20.786	2.117	181.485	176.192	197.317	194.543	–19.7269	400
500	20.786	4.196	186.123	177.732	199.396	193.793	–14.6549	500
600	20.786	6.274	189.913	179.456	201.474	192.945	–11.2876	600
*700	20.787	8.353	193.117	181.184	203.553	187.165	–8.9531	700
800	20.790	10.432	195.893	182.853	205.632	186.229	–7.2116	800
900	20.801	12.511	198.342	184.441	207.711	185.327	–5.8637	900
1000	20.829	14.593	200.535	185.943	209.793	184.457	–4.7906	1000
1100	20.888	16.678	202.523	187.361	211.878	183.618	–3.9166	1100
1200	20.991	18.772	204.345	188.701	213.972	182.811	–3.1916	1200
1300	21.118	20.893	206.044	189.973	216.093	182.051	–2.5807	1300
1400	21.330	23.014	207.616	191.177	218.214	181.306	–2.0592	1400
1500	21.684	25.164	209.099	192.323	220.364	180.600	–1.6091	1500
1600	22.173	27.356	210.513	193.416	222.556	179.944	–1.2168	1600
1700	22.780	29.602	211.875	194.462	224.802	179.345	–0.8718	1700
1800	23.483	31.915	213.197	195.467	227.115	178.811	–0.5661	1800
1900	24.258	34.301	214.487	196.434	229.501	178.348	–0.2934	1900
2000	25.086	36.768	215.752	197.368	231.968	177.958	–0.0485	2000
2100	25.946	39.320	216.997	198.273	234.520	177.641	0.1726	2100
2200	26.822	41.958	218.224	199.152	237.158	177.399	0.3733	2200
2300	27.698	44.684	219.436	200.008	239.884	177.229	0.5563	2300
2400	28.563	47.497	220.633	200.842	242.697	177.128	0.7240	2400
2500	29.406	50.396	221.816	201.658	245.596	177.093	0.8782	2500
2600	30.219	53.377	222.985	202.456	248.577	177.118	1.0205	2600
2700	30.994	56.438	224.140	203.237	251.638	177.200	1.1523	2700
2800	31.726	59.575	225.281	204.004	254.775	177.333	1.2748	2800
2900	32.412	62.782	226.406	204.757	257.982	177.512	1.3889	2900
3000	33.048	66.055	227.516	205.498	261.255	177.730	1.4955	3000
3100	33.632	69.390	228.609	206.226	264.590	177.983	1.5954	3100
3200	34.163	72.780	229.686	206.942	267.980	178.264	1.6892	3200
3300	34.640	76.221	230.744	207.647	271.421	178.569	1.7775	3300
3400	35.064	79.706	231.785	208.342	274.906	178.892	1.8607	3400
3500	35.434	83.232	232.807	209.026	278.432	179.229	1.9393	3500
3600	35.753	86.792	233.810	209.701	281.992	179.575	2.0136	3600
3700	36.021	90.381	234.793	210.366	285.581			3700
3800	36.240	93.994	235.757	211.021	289.194			3800
3900	36.412	97.627	236.700	211.668	292.827			3900
4000	36.540	101.275	237.624	212.305	296.475			4000
4100	36.625	104.934	238.527	212.934	300.134			4100
4200	36.671	108.599	239.410	213.554	303.799			4200
4300	36.681	112.267	240.274	214.165	307.467			4300
4400	36.655	115.934	241.117	214.768	311.134			4400
4500	36.599	119.597	241.940	215.363	314.797			4500

TABLE A99.—THERMODYNAMIC PROPERTIES FOR Pb (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	36.514	123.253	242.743	215.949	318.453			4600
4700	36.403	126.899	243.527	216.528	322.099			4700
4800	36.270	130.533	244.293	217.098	325.733			4800
4900	36.117	134.152	245.039	217.661	329.352			4900
5000	35.947	137.755	245.767	218.216	332.955			5000
5100	35.763	141.341	246.477	218.763	336.541			5100
5200	35.567	144.907	247.169	219.303	340.107			5200
5300	35.363	148.454	247.845	219.835	343.654			5300
5400	35.153	151.980	248.504	220.360	347.180			5400
5500	34.939	155.484	249.147	220.877	350.684			5500
5600	34.724	158.968	249.775	221.388	354.168			5600
5700	34.511	162.430	250.387	221.891	357.630			5700
5800	34.301	165.870	250.986	222.388	361.070			5800
5900	34.098	169.290	251.570	222.877	364.490			5900
6000	33.902	172.690	252.142	223.360	367.890			6000
6200	33.536	179.153	253.147	224.252	374.353			6200
6400	33.325	185.838	254.209	225.172	381.038			6400
6600	33.175	192.486	255.232	226.067	387.686			6600
6800	33.073	199.111	256.220	226.939	394.311			6800
7000	33.009	205.719	257.178	227.790	400.919			7000
7200	32.974	212.316	258.108	228.619	407.516			7200
7400	32.962	218.910	259.011	229.428	414.110			7400
7600	32.969	225.502	259.890	230.218	420.702			7600
7800	32.988	232.098	260.746	230.990	427.298			7800
8000	33.018	238.698	261.582	231.745	433.898			8000
8500	33.123	255.232	263.587	233.559	450.432			8500
9000	33.248	271.824	265.483	235.281	467.024			9000
9500	33.377	288.481	267.285	236.918	483.681			9500
10000	33.498	305.200	269.000	238.480	500.400			10000
10500	33.605	321.976	270.637	239.972	517.176			10500
11000	33.691	338.801	272.202	241.402	534.001			11000
11500	33.752	355.664	273.701	242.774	550.864			11500
12000	33.784	372.549	275.138	244.093	567.749			12000
12500	33.782	389.442	276.518	245.362	584.642			12500
13000	33.742	406.324	277.842	246.586	601.524			13000
13500	33.659	423.177	279.114	247.768	618.377			13500
14000	33.531	439.976	280.336	248.909	635.176			14000
14500	33.354	456.699	281.510	250.013	651.899			14500
15000	33.126	473.322	282.637	251.082	668.522			15000
15500	32.844	489.816	283.718	252.117	685.016			15500
16000	32.507	506.156	284.756	253.121	701.356			16000
16500	32.116	522.314	285.750	254.095	717.514			16500
17000	31.670	538.263	286.703	255.040	733.463			17000
17500	31.173	553.975	287.614	255.958	749.175			17500
18000	30.628	569.428	288.484	256.849	764.628			18000
18500	30.038	584.596	289.316	257.716	779.796			18500
19000	29.411	599.459	290.108	258.558	794.659			19000
19500	28.754	614.002	290.864	259.377	809.202			19500
20000	28.075	628.210	291.583	260.173	823.410			20000

***Assigned reference element phase change at 600.65 K**

TABLE A100.—THERMODYNAMIC PROPERTIES FOR Pb^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	910.799	911.472	----------	0
298.15	20.786	0.000	181.140	181.140	916.997	916.997	–153.4773	298.15
300	20.786	0.038	181.268	181.140	917.035	917.024	–152.4866	300
400	20.786	2.117	187.248	181.955	919.114	918.457	–112.5420	400
500	20.786	4.196	191.886	183.495	921.192	919.785	–88.5387	500
600	20.786	6.274	195.676	185.219	923.271	921.016	–72.5140	600
*700	20.786	8.353	198.880	186.948	925.349	917.314	–61.1127	700
800	20.786	10.432	201.656	188.617	927.428	918.457	–52.5515	800
900	20.786	12.510	204.104	190.204	929.507	919.632	–45.8844	900
1000	20.786	14.589	206.294	191.705	931.585	920.838	–40.5437	1000
1100	20.786	16.667	208.275	193.123	933.664	922.072	–36.1683	1100
1200	20.786	18.746	210.084	194.462	935.743	923.328	–32.5172	1200
1300	20.787	20.825	211.748	195.729	937.821	924.604	–29.4236	1300
1400	20.788	22.904	213.288	196.929	939.900	925.895	–26.7682	1400
1500	20.790	24.982	214.723	198.068	941.979	927.198	–24.4636	1500
1600	20.795	27.062	216.065	199.151	944.058	928.507	–22.4443	1600
1700	20.802	29.141	217.326	200.184	946.138	929.820	–20.6600	1700
1800	20.814	31.222	218.515	201.169	948.219	931.133	–19.0717	1800
1900	20.831	33.304	219.641	202.112	950.301	932.444	–17.6486	1900
2000	20.854	35.389	220.710	203.015	952.385	933.750	–16.3660	2000
2100	20.886	37.476	221.728	203.882	954.472	935.048	–15.2040	2100
2200	20.927	39.566	222.700	204.716	956.563	936.336	–14.1461	2200
2300	20.979	41.661	223.632	205.518	958.658	937.614	–13.1789	2300
2400	21.042	43.762	224.526	206.292	960.759	938.879	–12.2911	2400
2500	21.116	45.870	225.386	207.038	962.867	940.131	–11.4732	2500
2600	21.203	47.986	226.216	207.760	964.982	941.370	–10.7172	2600
2700	21.301	50.111	227.018	208.459	967.108	942.595	–10.0163	2700
2800	21.412	52.247	227.795	209.135	969.243	943.806	–9.3647	2800
2900	21.534	54.394	228.548	209.792	971.390	945.003	–8.7572	2900
3000	21.667	56.554	229.281	210.429	973.550	946.186	–8.1894	3000
3100	21.811	58.728	229.993	211.049	975.724	947.357	–7.6577	3100
3200	21.964	60.916	230.688	211.652	977.913	948.516	–7.1586	3200
3300	22.126	63.121	231.367	212.239	980.117	949.663	–6.6891	3300
3400	22.296	65.342	232.030	212.811	982.338	950.800	–6.2468	3400
3500	22.472	67.580	232.678	213.370	984.577	951.928	–5.8292	3500
3600	22.654	69.836	233.314	213.915	986.833	953.049	–5.4343	3600
3700	22.840	72.111	233.937	214.448	989.108			3700
3800	23.029	74.404	234.549	214.969	991.401			3800
3900	23.221	76.717	235.149	215.478	993.713			3900
4000	23.413	79.049	235.740	215.978	996.045			4000
4100	23.606	81.400	236.320	216.467	998.396			4100
4200	23.798	83.770	236.891	216.946	1000.766			4200
4300	23.989	86.159	237.454	217.417	1003.156			4300
4400	24.177	88.568	238.007	217.878	1005.564			4400
4500	24.362	90.995	238.553	218.332	1007.991			4500

TABLE A100.—THERMODYNAMIC PROPERTIES FOR Pb^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	24.544	93.440	239.090	218.777	1010.436			4600
4700	24.721	95.903	239.620	219.215	1012.900			4700
4800	24.893	98.384	240.142	219.646	1015.380			4800
4900	25.059	100.882	240.657	220.069	1017.878			4900
5000	25.220	103.396	241.165	220.486	1020.392			5000
5100	25.375	105.925	241.666	220.896	1022.922			5100
5200	25.524	108.470	242.160	221.301	1025.467			5200
5300	25.665	111.030	242.648	221.699	1028.026			5300
5400	25.800	113.603	243.129	222.091	1030.600			5400
5500	25.929	116.190	243.603	222.478	1033.186			5500
5600	26.050	118.789	244.072	222.859	1035.785			5600
5700	26.164	121.399	244.534	223.236	1038.396			5700
5800	26.271	124.021	244.990	223.607	1041.018			5800
5900	26.372	126.654	245.440	223.973	1043.650			5900
6000	26.465	129.295	245.884	224.335	1046.292			6000
6200	26.632	134.606	246.754	225.044	1051.602			6200
6400	26.773	139.947	247.602	225.736	1056.943			6400
6600	26.890	145.313	248.428	226.411	1062.310			6600
6800	26.985	150.701	249.232	227.070	1067.698			6800
7000	27.058	156.106	250.015	227.715	1073.102			7000
7200	27.113	161.523	250.779	228.345	1078.520			7200
7400	27.150	166.950	251.522	228.961	1083.946			7400
7600	27.173	172.382	252.246	229.564	1089.379			7600
7800	27.184	177.818	252.952	230.155	1094.815			7800
8000	27.183	183.255	253.641	230.734	1100.251			8000
8500	27.147	196.839	255.288	232.130	1113.836			8500
9000	27.086	210.398	256.838	233.460	1127.395			9000
9500	27.024	223.925	258.300	234.729	1140.921			9500
10000	26.949	237.437	259.685	235.941	1154.433			10000
10500	26.932	250.905	260.999	237.103	1167.901			10500
11000	26.982	264.379	262.252	238.218	1181.376			11000
11500	27.115	277.900	263.454	239.289	1194.897			11500
12000	27.338	291.510	264.613	240.320	1208.506			12000
12500	27.656	305.255	265.735	241.315	1222.251			12500
13000	28.069	319.182	266.827	242.275	1236.178			13000
13500	28.574	333.339	267.896	243.204	1250.335			13500
14000	29.166	347.771	268.946	244.105	1264.767			14000
14500	29.836	362.517	269.980	244.979	1279.514			14500
15000	30.576	377.617	271.004	245.830	1294.614			15000
15500	31.374	393.103	272.020	246.658	1310.100			15500
16000	32.218	409.000	273.029	247.466	1325.996			16000
16500	33.098	425.328	274.034	248.256	1342.324			16500
17000	33.998	442.100	275.035	249.029	1359.097			17000
17500	34.908	459.326	276.034	249.787	1376.323			17500
18000	35.813	477.008	277.030	250.529	1394.004			18000
18500	36.702	495.137	278.023	251.259	1412.133			18500
19000	37.561	513.705	279.014	251.976	1430.702			19000
19500	38.380	532.692	280.000	252.682	1449.688			19500
20000	39.147	552.075	280.981	253.378	1469.072			20000

***Assigned reference element phase change at 600.65 K**

TABLE A101.—THERMODYNAMIC PROPERTIES FOR Pb^-

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	147.685	160.752	----------	0
298.15	20.786	0.000	186.903	186.903	153.882	153.882	–21.6768	298.15
300	20.786	0.038	187.031	186.903	153.920	153.833	–21.5105	300
400	20.786	2.117	193.011	187.719	155.999	151.108	–14.8678	400
500	20.786	4.196	197.650	189.258	158.078	148.279	–10.9553	500
600	20.786	6.274	201.439	190.982	160.156	145.352	–8.3974	600
*700	20.786	8.353	204.644	192.711	162.235	137.494	–6.6671	700
800	20.786	10.432	207.419	194.380	164.314	134.479	–5.3981	800
900	20.786	12.510	209.868	195.967	166.392	131.497	–4.4330	900
1000	20.786	14.589	212.058	197.469	168.471	128.546	–3.6781	1000
1100	20.786	16.667	214.039	198.886	170.549	125.622	–3.0744	1100
1200	20.786	18.746	215.847	200.226	172.628	122.722	–2.5829	1200
1300	20.786	20.825	217.511	201.492	174.707	119.840	–2.1767	1300
1400	20.786	22.903	219.052	202.692	176.785	116.974	–1.8367	1400
1500	20.786	24.982	220.486	203.831	178.864	114.119	–1.5493	1500
1600	20.786	27.061	221.827	204.914	180.943	111.270	–1.3039	1600
1700	20.786	29.139	223.087	205.947	183.021	108.425	–1.0929	1700
1800	20.786	31.218	224.275	206.932	185.100	105.579	–0.9102	1800
1900	20.786	33.296	225.399	207.875	187.178	102.729	–0.7511	1900
2000	20.786	35.375	226.466	208.778	189.257	99.871	–0.6118	2000
2100	20.786	37.454	227.480	209.645	191.336	97.004	–0.4894	2100
2200	20.786	39.532	228.447	210.477	193.414	94.123	–0.3813	2200
2300	20.786	41.611	229.371	211.279	195.493	91.227	–0.2856	2300
2400	20.786	43.690	230.255	212.051	197.572	88.313	–0.2007	2400
2500	20.786	45.768	231.104	212.797	199.650	85.379	–0.1250	2500
2600	20.786	47.847	231.919	213.516	201.729	82.423	–0.0576	2600
2700	20.786	49.926	232.704	214.213	203.807	79.444	0.0026	2700
2800	20.786	52.004	233.460	214.887	205.886	76.441	0.0565	2800
2900	20.786	54.083	234.189	215.540	207.965	73.412	0.1047	2900
3000	20.786	56.161	234.894	216.173	210.043	70.357	0.1479	3000
3100	20.786	58.240	235.575	216.788	212.122	67.275	0.1865	3100
3200	20.786	60.319	236.235	217.386	214.201	64.166	0.2211	3200
3300	20.786	62.397	236.875	217.967	216.279	61.030	0.2521	3300
3400	20.786	64.476	237.495	218.532	218.358	57.868	0.2798	3400
3500	20.786	66.555	238.098	219.082	220.436	54.679	0.3045	3500
3600	20.786	68.633	238.683	219.619	222.515	51.465	0.3265	3600
3700	20.786	70.712	239.253	220.142	224.594			3700
3800	20.786	72.790	239.807	220.652	226.672			3800
3900	20.786	74.869	240.347	221.150	228.751			3900
4000	20.786	76.948	240.873	221.637	230.830			4000
4100	20.786	79.026	241.387	222.112	232.908			4100
4200	20.786	81.105	241.888	222.577	234.987			4200
4300	20.786	83.184	242.377	223.032	237.065			4300
4400	20.786	85.262	242.855	223.477	239.144			4400
4500	20.786	87.341	243.322	223.913	241.223			4500
4600	20.786	89.419	243.779	224.340	243.301			4600
4700	20.786	91.498	244.226	224.758	245.380			4700
4800	20.786	93.577	244.663	225.168	247.459			4800
4900	20.786	95.655	245.092	225.570	249.537			4900
5000	20.786	97.734	245.512	225.965	251.616			5000

TABLE A101.—THERMODYNAMIC PROPERTIES FOR Pb^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	245.923	226.352	253.695			5100
5200	20.786	101.891	246.327	226.733	255.773			5200
5300	20.786	103.970	246.723	227.106	257.852			5300
5400	20.786	106.048	247.112	227.473	259.930			5400
5500	20.786	108.127	247.493	227.833	262.009			5500
5600	20.786	110.206	247.867	228.188	264.088			5600
5700	20.786	112.284	248.235	228.536	266.166			5700
5800	20.786	114.363	248.597	228.879	268.245			5800
5900	20.786	116.442	248.952	229.216	270.324			5900
6000	20.786	118.520	249.302	229.548	272.402			6000
6200	20.786	122.677	249.983	230.196	276.559			6200
6400	20.786	126.835	250.643	230.825	280.717			6400
6600	20.786	130.992	251.283	231.435	284.874			6600
6800	20.786	135.149	251.903	232.028	289.031			6800
7000	20.786	139.306	252.506	232.605	293.188			7000
7200	20.786	143.464	253.091	233.166	297.346			7200
7400	20.786	147.621	253.661	233.712	301.503			7400
7600	20.786	151.778	254.215	234.244	305.660			7600
7800	20.786	155.936	254.755	234.763	309.817			7800
8000	20.786	160.093	255.281	235.270	313.975			8000
8500	20.786	170.486	256.542	236.484	324.368			8500
9000	20.786	180.879	257.730	237.632	334.761			9000
9500	20.786	191.272	258.854	238.720	345.154			9500
10000	20.786	201.665	259.920	239.753	355.547			10000
10500	20.786	212.058	260.934	240.738	365.940			10500
11000	20.786	222.452	261.901	241.678	376.334			11000
11500	20.786	232.845	262.825	242.578	386.727			11500
12000	20.786	243.238	263.710	243.440	397.120			12000
12500	20.786	253.631	264.558	244.268	407.513			12500
13000	20.786	264.024	265.373	245.064	417.906			13000
13500	20.786	274.417	266.158	245.831	428.299			13500
14000	20.786	284.810	266.914	246.570	438.692			14000
14500	20.786	295.204	267.643	247.284	449.085			14500
15000	20.786	305.597	268.348	247.975	459.479			15000
15500	20.786	315.990	269.029	248.643	469.872			15500
16000	20.786	326.383	269.689	249.290	480.265			16000
16500	20.786	336.776	270.329	249.918	490.658			16500
17000	20.786	347.169	270.950	250.528	501.051			17000
17500	20.786	357.562	271.552	251.120	511.444			17500
18000	20.786	367.956	272.138	251.696	521.837			18000
18500	20.786	378.349	272.707	252.256	532.231			18500
19000	20.786	388.742	273.262	252.801	542.624			19000
19500	20.786	399.135	273.801	253.333	553.017			19500
20000	20.786	409.528	274.328	253.851	563.410			20000

*Assigned reference element phase change at 600.65 K

TABLE A102.—THERMODYNAMIC PROPERTIES FOR Rb

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	74.703	82.192	----------	0
100	20.786	–4.119	147.388	188.576	76.781	82.261	–37.7220	100
200	20.786	–2.040	161.796	171.997	78.860	81.689	–16.2916	200
298.15	20.786	0.000	170.095	170.095	80.900	80.900	–9.2988	298.15
300	20.786	0.038	170.224	170.096	80.938	80.880	–9.2114	300
*400	20.786	2.117	176.204	170.911	83.017	77.638	–5.7922	400
500	20.786	4.196	180.842	172.451	85.096	76.655	–3.7764	500
600	20.786	6.274	184.632	174.175	87.174	75.689	–2.4497	600
700	20.786	8.353	187.836	175.903	89.253	74.720	–1.5141	700
800	20.786	10.432	190.612	177.572	91.332	73.738	–0.8215	800
900	20.786	12.510	193.060	179.160	93.410	72.732	–0.2901	900
1000	20.786	14.589	195.250	180.661	95.489	71.688	0.1291	1000
1100	20.787	16.668	197.231	182.079	97.568	70.586	0.4671	1100
1200	20.788	18.746	199.040	183.418	99.646	69.406	0.7441	1200
1300	20.790	20.825	200.704	184.685	101.725	68.115	0.9745	1300
1400	20.795	22.904	202.245	185.885	103.804	66.678	1.1680	1400
1500	20.805	24.984	203.680	187.024	105.884	65.053	1.3319	1500
1600	20.822	27.066	205.023	188.107	107.966	63.194	1.4716	1600
1700	20.848	29.149	206.286	189.140	110.049	61.045	1.5909	1700
1800	20.887	31.235	207.479	190.126	112.135	58.547	1.6931	1800
1900	20.941	33.327	208.609	191.069	114.227	55.634	1.7804	1900
2000	21.015	35.424	209.685	191.973	116.324	52.232	1.8546	2000
2100	21.110	37.530	210.713	192.841	118.430	48.265	1.9172	2100
2200	21.231	39.647	211.698	193.676	120.547			2200
2300	21.378	41.778	212.644	194.480	122.678			2300
2400	21.556	43.924	213.558	195.256	124.824			2400
2500	21.766	46.090	214.442	196.006	126.990			2500
2600	22.010	48.278	215.300	196.732	129.178			2600
2700	22.290	50.493	216.136	197.435	131.393			2700
2800	22.610	52.738	216.952	198.118	133.638			2800
2900	22.971	55.016	217.752	198.781	135.916			2900
3000	23.373	57.333	218.537	199.426	138.233			3000
3100	23.821	59.692	219.311	200.055	140.592			3100
3200	24.316	62.098	220.075	200.669	142.998			3200
3300	24.851	64.554	220.830	201.269	145.454			3300
3400	25.442	67.067	221.581	201.855	147.967			3400
3500	26.089	69.644	222.327	202.429	150.544			3500
3600	26.767	72.280	223.070	202.992	153.180			3600
3700	27.517	74.994	223.813	203.545	155.894			3700
3800	28.322	77.785	224.558	204.088	158.685			3800
3900	29.184	80.660	225.304	204.622	161.560			3900
4000	30.061	83.609	226.051	205.148	164.509			4000
4100	31.024	86.663	226.805	205.667	167.563			4100
4200	31.897	89.853	227.575	206.182	170.753			4200
4300	32.778	93.087	228.336	206.688	173.987			4300
4400	33.661	96.409	229.100	207.189	177.309			4400
4500	34.554	99.820	229.866	207.684	180.720			4500

TABLE A102.—THERMODYNAMIC PROPERTIES FOR Rb (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	35.462	103.321	230.636	208.175	184.221			4600
4700	36.389	106.913	231.408	208.661	187.813			4700
4800	37.335	110.599	232.184	209.143	191.499			4800
4900	38.298	114.380	232.964	209.621	195.280			4900
5000	39.264	118.259	233.747	210.095	199.159			5000
5100	40.470	122.246	234.537	210.567	203.146			5100
5200	41.553	126.349	235.333	211.036	207.249			5200
5300	42.521	130.553	236.134	211.502	211.453			5300
5400	43.381	134.849	236.937	211.965	215.749			5400
5500	44.141	139.226	237.740	212.427	220.126			5500
5600	44.807	143.674	238.542	212.886	224.574			5600
5700	45.385	148.184	239.340	213.343	229.084			5700
5800	45.882	152.748	240.134	213.798	233.648			5800
5900	46.303	157.358	240.922	214.251	238.258			5900
6000	46.653	162.007	241.703	214.702	242.907			6000
6200	47.159	171.392	243.242	215.598	252.292			6200
6400	47.438	180.855	244.744	216.485	261.755			6400
6600	47.520	190.354	246.205	217.364	271.254			6600
6800	47.434	199.852	247.623	218.233	280.752			6800
7000	47.204	209.318	248.995	219.093	290.218			7000
7200	46.854	218.725	250.320	219.942	299.625			7200
7400	46.403	228.053	251.598	220.780	308.953			7400
7600	45.867	237.281	252.829	221.607	318.181			7600
7800	45.263	246.395	254.012	222.423	327.295			7800
8000	44.603	255.382	255.150	223.227	336.282			8000
8500	42.788	277.238	257.801	225.184	358.138			8500
9000	40.849	298.150	260.192	227.064	379.050			9000
9500	38.895	318.085	262.348	228.865	398.985			9500
10000	37.001	337.055	264.294	230.589	417.955			10000
10500	35.218	355.105	266.056	232.237	436.005			10500
11000	33.578	372.297	267.656	233.811	453.197			11000
11500	32.098	388.710	269.115	235.314	469.610			11500
12000	30.786	404.424	270.453	236.751	485.324			12000
12500	29.640	419.523	271.686	238.124	500.423			12500
13000	28.652	434.090	272.829	239.437	514.990			13000
13500	27.811	448.200	273.894	240.694	529.100			13500
14000	27.102	461.922	274.892	241.898	542.822			14000
14500	26.509	475.321	275.833	243.052	556.221			14500
15000	26.015	488.449	276.723	244.159	569.349			15000
15500	25.603	501.351	277.569	245.224	582.251			15500
16000	25.254	514.062	278.376	246.247	594.962			16000
16500	24.955	526.612	279.148	247.232	607.512			16500
17000	24.689	539.022	279.889	248.182	619.922			17000
17500	24.444	551.305	280.601	249.098	632.205			17500
18000	24.210	563.468	281.287	249.983	644.368			18000
18500	23.978	575.515	281.947	250.838	656.415			18500
19000	23.743	587.445	282.583	251.665	668.345			19000
19500	23.501	599.257	283.197	252.466	680.157			19500
20000	23.251	610.945	283.789	253.242	691.845			20000

***Assigned reference element phase change at 312.47 K**

TABLE A103.—THERMODYNAMIC PROPERTIES FOR Rb^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	483.932	485.223	----------	0
298.15	20.786	0.000	164.332	164.332	490.129	490.129	–80.1975	298.15
300	20.786	0.038	164.461	164.333	490.168	490.148	–79.6679	300
*400	20.786	2.117	170.441	165.148	492.246	488.984	–58.3933	400
500	20.786	4.196	175.079	166.687	494.325	490.080	–45.6094	500
600	20.786	6.274	178.869	168.411	496.403	491.193	–37.0676	600
700	20.786	8.353	182.073	170.140	498.482	492.302	–30.9522	700
800	20.786	10.432	184.848	171.809	500.561	493.398	–26.3554	800
900	20.786	12.510	187.297	173.397	502.639	494.472	–22.7723	900
1000	20.786	14.589	189.487	174.898	504.718	495.506	–19.8996	1000
1100	20.786	16.667	191.468	176.316	506.797	496.483	–17.5444	1100
1200	20.786	18.746	193.277	177.655	508.875	497.381	–15.5780	1200
1300	20.786	20.825	194.940	178.921	510.954	498.169	–13.9114	1300
1400	20.786	22.903	196.481	180.121	513.032	498.810	–12.4807	1400
1500	20.786	24.982	197.915	181.260	515.111	499.262	–11.2394	1500
1600	20.786	27.061	199.256	182.344	517.190	499.478	–10.1525	1600
1700	20.786	29.139	200.517	183.376	519.268	499.404	–9.1934	1700
1800	20.786	31.218	201.705	184.361	521.347	498.977	–8.3412	1800
1900	20.786	33.296	202.829	185.304	523.426	498.129	–7.5797	1900
2000	20.786	35.375	203.895	186.207	525.504	496.787	–6.8959	2000
2100	20.786	37.454	204.909	187.074	527.583	494.872	–6.2791	2100
2200	20.786	39.532	205.876	187.907	529.662			2200
2300	20.786	41.611	206.800	188.708	531.740			2300
2400	20.786	43.690	207.685	189.481	533.819			2400
2500	20.786	45.768	208.533	190.226	535.897			2500
2600	20.786	47.847	209.348	190.946	537.976			2600
2700	20.786	49.926	210.133	191.642	540.055			2700
2800	20.786	52.004	210.889	192.316	542.133			2800
2900	20.786	54.083	211.618	192.969	544.212			2900
3000	20.786	56.161	212.323	193.602	546.291			3000
3100	20.786	58.240	213.004	194.217	548.369			3100
3200	20.786	60.319	213.664	194.815	550.448			3200
3300	20.786	62.397	214.304	195.396	552.526			3300
3400	20.786	64.476	214.925	195.961	554.605			3400
3500	20.786	66.555	215.527	196.512	556.684			3500
3600	20.786	68.633	216.113	197.048	558.762			3600
3700	20.786	70.712	216.682	197.571	560.841			3700
3800	20.786	72.790	217.237	198.081	562.920			3800
3900	20.786	74.869	217.776	198.579	564.998			3900
4000	20.786	76.948	218.303	199.066	567.077			4000
4100	20.786	79.026	218.816	199.541	569.155			4100
4200	20.786	81.105	219.317	200.006	571.234			4200
4300	20.786	83.184	219.806	200.461	573.313			4300
4400	20.786	85.262	220.284	200.906	575.391			4400
4500	20.786	87.341	220.751	201.342	577.470			4500
4600	20.786	89.419	221.208	201.769	579.549			4600
4700	20.786	91.498	221.655	202.187	581.627			4700
4800	20.786	93.577	222.092	202.597	583.706			4800
4900	20.786	95.655	222.521	203.000	585.784			4900
5000	20.786	97.734	222.941	203.394	587.863			5000

TABLE A103.—THERMODYNAMIC PROPERTIES FOR Rb^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	223.353	203.782	589.942			5100
5200	20.786	101.891	223.756	204.162	592.020			5200
5300	20.786	103.970	224.152	204.535	594.099			5300
5400	20.786	106.048	224.541	204.902	596.178			5400
5500	20.786	108.127	224.922	205.263	598.256			5500
5600	20.786	110.206	225.297	205.617	600.335			5600
5700	20.786	112.284	225.665	205.966	602.413			5700
5800	20.786	114.363	226.026	206.308	604.492			5800
5900	20.786	116.442	226.381	206.646	606.571			5900
6000	20.786	118.520	226.731	206.977	608.649			6000
6200	20.786	122.677	227.412	207.626	612.807			6200
6400	20.786	126.835	228.072	208.254	616.964			6400
6600	20.786	130.992	228.712	208.865	621.121			6600
6800	20.786	135.149	229.332	209.458	625.278			6800
7000	20.786	139.306	229.935	210.034	629.436			7000
7200	20.786	143.464	230.521	210.595	633.593			7200
7400	20.786	147.621	231.090	211.141	637.750			7400
7600	20.786	151.778	231.644	211.674	641.907			7600
7800	20.786	155.936	232.184	212.193	646.065			7800
8000	20.786	160.093	232.711	212.699	650.222			8000
8500	20.786	170.486	233.971	213.914	660.615			8500
9000	20.786	180.879	235.159	215.061	671.008			9000
9500	20.787	191.272	236.283	216.149	681.401			9500
10000	20.787	201.666	237.349	217.182	691.795			10000
10500	20.788	212.059	238.363	218.167	702.188			10500
11000	20.789	222.453	239.330	219.107	712.583			11000
11500	20.792	232.849	240.254	220.007	722.978			11500
12000	20.798	243.246	241.139	220.869	733.375			12000
12500	20.807	253.647	241.989	221.697	743.776			12500
13000	20.821	264.054	242.805	222.493	754.183			13000
13500	20.843	274.469	243.591	223.260	764.598			13500
14000	20.877	284.899	244.350	224.000	775.028			14000
14500	20.925	295.349	245.083	224.714	785.478			14500
15000	20.994	305.828	245.794	225.405	795.957			15000
15500	21.089	316.347	246.483	226.074	806.476			15500
16000	21.217	326.922	247.155	226.722	817.051			16000
16500	21.386	337.570	247.810	227.351	827.700			16500
17000	21.604	348.315	248.452	227.963	838.444			17000
17500	21.884	359.184	249.082	228.557	849.313			17500
18000	22.234	370.209	249.703	229.136	860.338			18000
18500	22.669	381.431	250.318	229.700	871.560			18500
19000	23.197	392.889	250.929	230.251	883.018			19000
19500	23.839	404.643	251.540	230.789	894.772			19500
20000	24.597	416.738	252.152	231.315	906.867			20000

*Assigned reference element phase change at 312.47 K

TABLE A104.—THERMODYNAMIC PROPERTIES FOR Rb^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	21.621	35.308	----------	0
298.15	20.786	0.000	164.332	164.332	27.819	27.819	–1.3962	298.15
300	20.786	0.038	164.461	164.333	27.857	27.761	–1.3662	300
*400	20.786	2.117	170.441	165.148	29.936	22.440	–0.3001	400
500	20.786	4.196	175.079	166.688	32.014	19.378	0.2490	500
600	20.786	6.274	178.869	168.412	34.093	16.334	0.5614	600
700	20.786	8.353	182.073	170.140	36.171	13.286	0.7466	700
800	20.786	10.432	184.849	171.809	38.250	10.225	0.8569	800
900	20.786	12.510	187.297	173.397	40.329	7.141	0.9203	900
1000	20.786	14.589	189.487	174.898	42.407	4.018	0.9530	1000
1100	20.786	16.667	191.468	176.316	44.486	0.838	0.9648	1100
1200	20.786	18.746	193.277	177.655	46.565	–2.421	0.9619	1200
1300	20.786	20.825	194.941	178.922	48.643	–5.791	0.9484	1300
1400	20.786	22.903	196.481	180.121	50.722	–9.307	0.9269	1400
1500	20.786	24.982	197.915	181.260	52.801	–13.012	0.8993	1500
1600	20.786	27.061	199.257	182.344	54.879	–16.953	0.8668	1600
1700	20.786	29.139	200.517	183.376	56.958	–21.185	0.8303	1700
1800	20.786	31.218	201.705	184.362	59.036	–25.769	0.7903	1800
1900	20.786	33.296	202.829	185.304	61.115	–30.774	0.7473	1900
2000	20.786	35.375	203.895	186.207	63.194	–36.273	0.7013	2000
2100	20.786	37.454	204.909	187.074	65.272	–42.346	0.6526	2100
2200	20.786	39.532	205.876	187.907	67.351			2200
2300	20.786	41.611	206.800	188.708	69.430			2300
2400	20.786	43.690	207.685	189.481	71.508			2400
2500	20.786	45.768	208.533	190.226	73.587			2500
2600	20.786	47.847	209.348	190.946	75.665			2600
2700	20.786	49.926	210.133	191.642	77.744			2700
2800	20.786	52.004	210.889	192.316	79.823			2800
2900	20.786	54.083	211.618	192.969	81.901			2900
3000	20.786	56.161	212.323	193.603	83.980			3000
3100	20.786	58.240	213.005	194.218	86.059			3100
3200	20.786	60.319	213.665	194.815	88.137			3200
3300	20.786	62.397	214.304	195.396	90.216			3300
3400	20.786	64.476	214.925	195.961	92.294			3400
3500	20.786	66.555	215.527	196.512	94.373			3500
3600	20.786	68.633	216.113	197.048	96.452			3600
3700	20.786	70.712	216.682	197.571	98.530			3700
3800	20.786	72.790	217.237	198.081	100.609			3800
3900	20.786	74.869	217.777	198.579	102.688			3900
4000	20.786	76.948	218.303	199.066	104.766			4000
4100	20.786	79.026	218.816	199.541	106.845			4100
4200	20.786	81.105	219.317	200.006	108.923			4200
4300	20.786	83.184	219.806	200.461	111.002			4300
4400	20.786	85.262	220.284	200.906	113.081			4400
4500	20.786	87.341	220.751	201.342	115.159			4500
4600	20.786	89.419	221.208	201.769	117.238			4600
4700	20.786	91.498	221.655	202.187	119.317			4700
4800	20.786	93.577	222.093	202.598	121.395			4800
4900	20.786	95.655	222.521	203.000	123.474			4900
5000	20.786	97.734	222.941	203.394	125.552			5000

TABLE A104.—THERMODYNAMIC PROPERTIES FOR Rb^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	223.353	203.782	127.631			5100
5200	20.786	101.891	223.756	204.162	129.710			5200
5300	20.786	103.970	224.152	204.535	131.788			5300
5400	20.786	106.048	224.541	204.902	133.867			5400
5500	20.786	108.127	224.922	205.263	135.946			5500
5600	20.786	110.206	225.297	205.617	138.024			5600
5700	20.786	112.284	225.665	205.966	140.103			5700
5800	20.786	114.363	226.026	206.309	142.181			5800
5900	20.786	116.442	226.382	206.646	144.260			5900
6000	20.786	118.520	226.731	206.978	146.339			6000
6200	20.786	122.677	227.413	207.626	150.496			6200
6400	20.786	126.835	228.072	208.255	154.653			6400
6600	20.786	130.992	228.712	208.865	158.811			6600
6800	20.786	135.149	229.333	209.458	162.968			6800
7000	20.786	139.306	229.935	210.034	167.125			7000
7200	20.786	143.464	230.521	210.595	171.282			7200
7400	20.786	147.621	231.090	211.141	175.440			7400
7600	20.786	151.778	231.645	211.674	179.597			7600
7800	20.786	155.936	232.185	212.193	183.754			7800
8000	20.786	160.093	232.711	212.699	187.911			8000
8500	20.786	170.486	233.971	213.914	198.304			8500
9000	20.786	180.879	235.159	215.061	208.698			9000
9500	20.786	191.272	236.283	216.149	219.091			9500
10000	20.786	201.665	237.349	217.183	229.484			10000
10500	20.786	212.058	238.363	218.167	239.877			10500
11000	20.786	222.452	239.330	219.107	250.270			11000
11500	20.786	232.845	240.254	220.007	260.663			11500
12000	20.786	243.238	241.139	220.869	271.056			12000
12500	20.786	253.631	241.987	221.697	281.450			12500
13000	20.786	264.024	242.803	222.493	291.843			13000
13500	20.786	274.417	243.587	223.260	302.236			13500
14000	20.786	284.810	244.343	224.000	312.629			14000
14500	20.786	295.204	245.073	224.714	323.022			14500
15000	20.786	305.597	245.777	225.404	333.415			15000
15500	20.786	315.990	246.459	226.072	343.808			15500
16000	20.786	326.383	247.119	226.720	354.202			16000
16500	20.786	336.776	247.758	227.348	364.595			16500
17000	20.786	347.169	248.379	227.957	374.988			17000
17500	20.786	357.562	248.981	228.549	385.381			17500
18000	20.786	367.956	249.567	229.125	395.774			18000
18500	20.786	378.349	250.137	229.685	406.167			18500
19000	20.786	388.742	250.691	230.231	416.560			19000
19500	20.786	399.135	251.231	230.762	426.953			19500
20000	20.786	409.528	251.757	231.281	437.347			20000

*Assigned reference element phase change at 312.47 K

TABLE A105.—THERMODYNAMIC PROPERTIES FOR Rn

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–6.197	0	----------	0
100	20.786	–4.119	153.530	194.718	–4.119	0	0	100
200	20.786	–2.040	167.938	178.139	–2.040	0	0	200
298.15	20.786	0.000	176.238	176.238	0.000	0	0	298.15
300	20.786	0.038	176.367	176.238	0.038	0	0	300
400	20.786	2.117	182.346	177.054	2.117	0	0	400
500	20.786	4.196	186.985	178.593	4.196	0	0	500
600	20.786	6.274	190.774	180.317	6.274	0	0	600
700	20.786	8.353	193.979	182.046	8.353	0	0	700
800	20.786	10.432	196.754	183.715	10.432	0	0	800
900	20.786	12.510	199.203	185.302	12.510	0	0	900
1000	20.786	14.589	201.393	186.804	14.589	0	0	1000
1100	20.786	16.667	203.374	188.222	16.667	0	0	1100
1200	20.786	18.746	205.182	189.561	18.746	0	0	1200
1300	20.786	20.825	206.846	190.827	20.825	0	0	1300
1400	20.786	22.903	208.387	192.027	22.903	0	0	1400
1500	20.786	24.982	209.821	193.166	24.982	0	0	1500
1600	20.786	27.061	211.162	194.249	27.061	0	0	1600
1700	20.786	29.139	212.422	195.282	29.139	0	0	1700
1800	20.786	31.218	213.611	196.267	31.218	0	0	1800
1900	20.786	33.296	214.734	197.210	33.296	0	0	1900
2000	20.786	35.375	215.801	198.113	35.375	0	0	2000
2100	20.786	37.454	216.815	198.980	37.454	0	0	2100
2200	20.786	39.532	217.782	199.812	39.532	0	0	2200
2300	20.786	41.611	218.706	200.614	41.611	0	0	2300
2400	20.786	43.690	219.590	201.386	43.690	0	0	2400
2500	20.786	45.768	220.439	202.132	45.768	0	0	2500
2600	20.786	47.847	221.254	202.852	47.847	0	0	2600
2700	20.786	49.926	222.039	203.548	49.926	0	0	2700
2800	20.786	52.004	222.795	204.222	52.004	0	0	2800
2900	20.786	54.083	223.524	204.875	54.083	0	0	2900
3000	20.786	56.161	224.229	205.508	56.161	0	0	3000
3100	20.786	58.240	224.910	206.123	58.240	0	0	3100
3200	20.786	60.319	225.570	206.721	60.319	0	0	3200
3300	20.786	62.397	226.210	207.302	62.397	0	0	3300
3400	20.786	64.476	226.830	207.867	64.476	0	0	3400
3500	20.786	66.555	227.433	208.417	66.555	0	0	3500
3600	20.786	68.633	228.018	208.954	68.633	0	0	3600
3700	20.786	70.712	228.588	209.477	70.712	0	0	3700
3800	20.786	72.790	229.142	209.987	72.790	0	0	3800
3900	20.786	74.869	229.682	210.485	74.869	0	0	3900
4000	20.786	76.948	230.209	210.972	76.948	0	0	4000
4100	20.786	79.026	230.722	211.447	79.026	0	0	4100
4200	20.786	81.105	231.223	211.912	81.105	0	0	4200
4300	20.787	83.184	231.712	212.367	83.184	0	0	4300
4400	20.787	85.262	232.190	212.812	85.262	0	0	4400
4500	20.787	87.341	232.657	213.248	87.341	0	0	4500

TABLE A105.—THERMODYNAMIC PROPERTIES FOR Rn (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.787	89.420	233.114	213.675	89.420	0	0	4600
4700	20.787	91.498	233.561	214.093	91.498	0	0	4700
4800	20.788	93.577	233.998	214.503	93.577	0	0	4800
4900	20.788	95.656	234.427	214.905	95.656	0	0	4900
5000	20.789	97.735	234.847	215.300	97.735	0	0	5000
5100	20.790	99.814	235.259	215.687	99.814	0	0	5100
5200	20.791	101.893	235.662	216.068	101.893	0	0	5200
5300	20.793	103.972	236.058	216.441	103.972	0	0	5300
5400	20.795	106.051	236.447	216.808	106.051	0	0	5400
5500	20.797	108.131	236.829	217.169	108.131	0	0	5500
5600	20.800	110.211	237.204	217.523	110.211	0	0	5600
5700	20.803	112.291	237.572	217.872	112.291	0	0	5700
5800	20.808	114.371	237.934	218.214	114.371	0	0	5800
5900	20.813	116.452	238.289	218.552	116.452	0	0	5900
6000	20.820	118.534	238.639	218.883	118.534	0	0	6000
6200	20.836	122.700	239.322	219.532	122.700	0	0	6200
6400	20.859	126.869	239.984	220.161	126.869	0	0	6400
6600	20.889	131.043	240.626	220.771	131.043	0	0	6600
6800	20.930	135.224	241.250	221.364	135.224	0	0	6800
7000	20.985	139.416	241.858	221.941	139.416	0	0	7000
7200	21.056	143.619	242.450	222.503	143.619	0	0	7200
7400	21.146	147.838	243.028	223.050	147.838	0	0	7400
7600	21.251	152.074	243.593	223.583	152.074	0	0	7600
7800	21.384	156.335	244.146	224.103	156.335	0	0	7800
8000	21.546	160.624	244.689	224.611	160.624	0	0	8000
8500	22.237	171.528	246.010	225.830	171.528	0	0	8500
9000	23.104	182.852	247.304	226.987	182.852	0	0	9000
9500	24.229	194.674	248.582	228.090	194.674	0	0	9500
10000	25.627	207.127	249.859	229.147	207.127	0	0	10000
10500	27.296	220.346	251.149	230.164	220.346	0	0	10500
11000	29.223	234.466	252.462	231.147	234.466	0	0	11000
11500	31.383	249.608	253.808	232.103	249.608	0	0	11500
12000	33.742	265.882	255.193	233.036	265.882	0	0	12000
12500	36.260	283.377	256.621	233.951	283.377	0	0	12500
13000	38.889	302.160	258.094	234.851	302.160	0	0	13000
13500	41.580	322.276	259.612	235.740	322.276	0	0	13500
14000	44.284	343.743	261.173	236.620	343.743	0	0	14000
14500	46.949	366.554	262.774	237.494	366.554	0	0	14500
15000	49.526	390.678	264.409	238.364	390.678	0	0	15000
15500	51.967	416.057	266.073	239.231	416.057	0	0	15500
16000	54.228	442.615	267.760	240.096	442.615	0	0	16000
16500	56.270	470.249	269.460	240.960	470.249	0	0	16500
17000	58.058	498.843	271.167	241.823	498.843	0	0	17000
17500	59.561	528.259	272.873	242.686	528.259	0	0	17500
18000	60.755	558.351	274.568	243.548	558.351	0	0	18000
18500	61.624	588.960	276.245	244.410	588.960	0	0	18500
19000	62.157	619.919	277.896	245.269	619.919	0	0	19000
19500	62.349	651.060	279.514	246.126	651.060	0	0	19500
20000	62.206	682.212	281.092	246.981	682.212	0	0	20000

TABLE A106.—THERMODYNAMIC PROPERTIES FOR Rn^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1037.073			0
298.15	20.786	0.000	187.764	187.764	1043.270			298.15
300	20.786	0.038	187.893	187.765	1043.309			300
400	20.786	2.117	193.873	188.580	1045.387			400
500	20.786	4.196	198.511	190.120	1047.466			500
600	20.786	6.274	202.301	191.844	1049.545			600
700	20.786	8.353	205.505	193.572	1051.623			700
800	20.786	10.432	208.281	195.241	1053.702			800
900	20.786	12.510	210.729	196.829	1055.780			900
1000	20.786	14.589	212.919	198.330	1057.859			1000
1100	20.786	16.667	214.900	199.748	1059.938			1100
1200	20.786	18.746	216.709	201.087	1062.016			1200
1300	20.786	20.825	218.373	202.354	1064.095			1300
1400	20.786	22.903	219.913	203.553	1066.174			1400
1500	20.786	24.982	221.347	204.692	1068.252			1500
1600	20.786	27.061	222.689	205.776	1070.331			1600
1700	20.786	29.139	223.949	206.808	1072.410			1700
1800	20.786	31.218	225.137	207.794	1074.488			1800
1900	20.786	33.296	226.261	208.736	1076.567			1900
2000	20.786	35.375	227.327	209.639	1078.645			2000
2100	20.786	37.454	228.341	210.506	1080.724			2100
2200	20.786	39.532	229.308	211.339	1082.803			2200
2300	20.786	41.611	230.232	212.140	1084.881			2300
2400	20.786	43.690	231.117	212.913	1086.960			2400
2500	20.786	45.768	231.965	213.658	1089.039			2500
2600	20.786	47.847	232.781	214.378	1091.117			2600
2700	20.786	49.926	233.565	215.074	1093.196			2700
2800	20.786	52.004	234.321	215.748	1095.274			2800
2900	20.786	54.083	235.050	216.401	1097.353			2900
3000	20.787	56.161	235.755	217.035	1099.432			3000
3100	20.787	58.240	236.437	217.650	1101.510			3100
3200	20.787	60.319	237.097	218.247	1103.589			3200
3300	20.787	62.398	237.736	218.828	1105.668			3300
3400	20.788	64.476	238.357	219.393	1107.747			3400
3500	20.788	66.555	238.959	219.944	1109.825			3500
3600	20.789	68.634	239.545	220.480	1111.904			3600
3700	20.790	70.713	240.115	221.003	1113.983			3700
3800	20.791	72.792	240.669	221.513	1116.062			3800
3900	20.792	74.871	241.209	222.011	1118.141			3900
4000	20.794	76.950	241.736	222.498	1120.221			4000
4100	20.796	79.030	242.249	222.974	1122.300			4100
4200	20.798	81.110	242.750	223.438	1124.380			4200
4300	20.801	83.190	243.240	223.893	1126.460			4300
4400	20.804	85.270	243.718	224.338	1128.540			4400
4500	20.807	87.350	244.185	224.774	1130.621			4500
4600	20.811	89.431	244.643	225.201	1132.701			4600
4700	20.815	91.512	245.090	225.620	1134.783			4700
4800	20.820	93.594	245.529	226.030	1136.865			4800
4900	20.826	95.677	245.958	226.432	1138.947			4900
5000	20.832	97.759	246.379	226.827	1141.030			5000

TABLE A106.—THERMODYNAMIC PROPERTIES FOR Rn^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.838	99.843	246.791	227.214	1143.113			5100
5200	20.845	101.927	247.196	227.595	1145.197			5200
5300	20.853	104.012	247.593	227.968	1147.282			5300
5400	20.861	106.098	247.983	228.335	1149.368			5400
5500	20.870	108.184	248.366	228.696	1151.454			5500
5600	20.880	110.272	248.742	229.051	1153.542			5600
5700	20.890	112.360	249.112	229.399	1155.630			5700
5800	20.901	114.450	249.475	229.742	1157.720			5800
5900	20.912	116.540	249.833	230.080	1159.811			5900
6000	20.924	118.632	250.184	230.412	1161.902			6000
6200	20.951	122.820	250.871	231.061	1166.090			6200
6400	20.979	127.013	251.536	231.691	1170.283			6400
6600	21.010	131.212	252.182	232.302	1174.482			6600
6800	21.043	135.417	252.810	232.896	1178.687			6800
7000	21.079	139.629	253.421	233.474	1182.899			7000
7200	21.116	143.848	254.015	234.036	1187.119			7200
7400	21.155	148.075	254.594	234.584	1191.346			7400
7600	21.195	152.310	255.159	235.118	1195.581			7600
7800	21.237	156.554	255.710	235.639	1199.824			7800
8000	21.280	160.805	256.248	236.147	1204.075			8000
8500	21.392	171.473	257.541	237.368	1214.743			8500
9000	21.507	182.198	258.767	238.523	1225.468			9000
9500	21.624	192.981	259.933	239.620	1236.251			9500
10000	21.739	203.821	261.045	240.663	1247.092			10000
10500	21.851	214.719	262.109	241.659	1257.989			10500
11000	21.959	225.672	263.128	242.612	1268.942			11000
11500	22.061	236.677	264.106	243.526	1279.948			11500
12000	22.157	247.732	265.047	244.403	1291.002			12000
12500	22.245	258.833	265.953	245.247	1302.103			12500
13000	22.327	269.976	266.828	246.060	1313.246			13000
13500	22.400	281.158	267.672	246.845	1324.428			13500
14000	22.467	292.375	268.487	247.603	1335.645			14000
14500	22.526	303.624	269.277	248.337	1346.894			14500
15000	22.578	314.900	270.041	249.048	1358.170			15000
15500	22.623	326.200	270.783	249.737	1369.471			15500
16000	22.662	337.522	271.501	250.406	1380.792			16000
16500	22.695	348.862	272.199	251.056	1392.132			16500
17000	22.722	360.216	272.877	251.688	1403.486			17000
17500	22.744	371.583	273.536	252.303	1414.853			17500
18000	22.761	382.959	274.177	252.902	1426.230			18000
18500	22.774	394.343	274.801	253.485	1437.613			18500
19000	22.782	405.732	275.408	254.054	1449.003			19000
19500	22.787	417.125	276.000	254.609	1460.395			19500
20000	22.788	428.519	276.577	255.151	1471.789			20000

TABLE A107.—THERMODYNAMIC PROPERTIES FOR S

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.657	----------	----------	270.513	274.925	----------	0
100	21.356	–4.569	142.896	188.585	272.601	276.323	–137.5239	100
200	23.388	–2.320	158.397	169.998	274.850	276.930	–65.2870	200
298.15	23.674	0.000	167.832	167.832	277.170	277.170	–41.4665	298.15
300	23.669	0.044	167.979	167.833	277.214	277.171	–41.1668	300
*400	23.233	2.391	174.734	168.757	279.561	274.913	–29.1135	400
500	22.741	4.689	179.864	170.486	281.859	273.275	–21.9518	500
600	22.338	6.942	183.973	172.403	284.112	271.948	–17.2051	600
700	22.031	9.160	187.392	174.307	286.330	270.819	–13.8298	700
800	21.800	11.351	190.318	176.130	288.521	269.806	–11.3083	800
900	21.624	13.522	192.876	177.851	290.692	268.777	–9.3545	900
1000	21.490	15.677	195.147	179.469	292.847	267.732	–7.7975	1000
1100	21.386	17.821	197.190	180.989	294.991	266.676	–6.5286	1100
1200	21.307	19.955	199.047	182.418	297.125	265.610	–5.4754	1200
1300	21.249	22.083	200.750	183.763	299.253	264.538	–4.5878	1300
1400	21.209	24.206	202.323	185.034	301.376	263.461	–3.8301	1400
1500	21.186	26.325	203.786	186.235	303.495	262.380	–3.1761	1500
1600	21.178	28.443	205.153	187.376	305.613	261.298	–2.6062	1600
1700	21.184	30.561	206.437	188.459	307.731	260.216	–2.1055	1700
1800	21.203	32.681	207.648	189.492	309.851	259.136	–1.6622	1800
1900	21.234	34.802	208.795	190.478	311.972	258.057	–1.2672	1900
2000	21.276	36.928	209.885	191.421	314.098	256.983	–0.9132	2000
2100	21.327	39.058	210.925	192.326	316.228	255.913	–0.5943	2100
2200	21.386	41.193	211.918	193.194	318.363	254.848	–0.3056	2200
2300	21.452	43.335	212.870	194.029	320.505	253.790	–0.0430	2300
2400	21.523	45.484	213.785	194.833	322.654	252.739	0.1966	2400
2500	21.598	47.640	214.665	195.609	324.810	251.695	0.4162	2500
2600	21.677	49.804	215.513	196.358	326.974	250.659	0.6181	2600
2700	21.757	51.976	216.333	197.083	329.146	249.630	0.8042	2700
2800	21.838	54.155	217.126	197.785	331.325	248.610	0.9763	2800
2900	21.919	56.343	217.893	198.465	333.513	247.598	1.1359	2900
3000	22.000	58.539	218.638	199.125	335.709	246.594	1.2843	3000
3100	22.079	60.743	219.361	199.766	337.913	245.598	1.4225	3100
3200	22.157	62.955	220.063	200.389	340.125	244.610	1.5515	3200
3300	22.232	65.174	220.746	200.996	342.344	243.629	1.6723	3300
3400	22.305	67.401	221.411	201.587	344.571	242.656	1.7855	3400
3500	22.376	69.635	222.058	202.162	346.805	241.690	1.8918	3500
3600	22.443	71.876	222.689	202.724	349.046	240.731	1.9918	3600
3700	22.507	74.124	223.305	203.272	351.294	239.779	2.0860	3700
3800	22.568	76.378	223.906	203.807	353.548	238.833	2.1749	3800
3900	22.626	78.637	224.493	204.330	355.807	237.892	2.2589	3900
4000	22.681	80.903	225.067	204.841	358.073	236.958	2.3384	4000
4100	22.733	83.174	225.628	205.341	360.344	236.029	2.4137	4100
4200	22.782	85.449	226.176	205.831	362.619	235.104	2.4852	4200
4300	22.828	87.730	226.713	206.310	364.900	234.185	2.5531	4300
4400	22.871	90.015	227.238	206.780	367.185	233.270	2.6176	4400
4500	22.912	92.304	227.752	207.240	369.474	232.359	2.6790	4500

TABLE A107.—THERMODYNAMIC PROPERTIES FOR S (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	22.949	94.597	228.256	207.692	371.767	231.452	2.7375	4600
4700	22.985	96.894	228.750	208.135	374.064	230.549	2.7933	4700
4800	23.018	99.194	229.234	208.569	376.364	229.649	2.8466	4800
4900	23.050	101.497	229.709	208.996	378.667	228.752	2.8975	4900
5000	23.079	103.804	230.175	209.415	380.974	227.859	2.9462	5000
5100	23.106	106.113	230.633	209.826	383.283	226.968	2.9928	5100
5200	23.132	108.425	231.082	210.231	385.595	226.080	3.0374	5200
5300	23.156	110.739	231.522	210.628	387.909	225.194	3.0801	5300
5400	23.179	113.056	231.956	211.019	390.226	224.311	3.1212	5400
5500	23.200	115.375	232.381	211.404	392.545	223.430	3.1605	5500
5600	23.220	117.696	232.799	211.782	394.866	222.551	3.1984	5600
5700	23.240	120.019	233.210	212.154	397.189	221.674	3.2347	5700
5800	23.258	122.344	233.615	212.521	399.514	220.799	3.2697	5800
5900	23.275	124.671	234.012	212.882	401.841	219.926	3.3033	5900
6000	23.292	126.999	234.404	213.237	404.169	219.054	3.3357	6000
6200	23.324	131.661	235.168	213.932	408.831			6200
6400	23.354	136.328	235.909	214.608	413.498			6400
6600	23.384	141.002	236.628	215.264	418.172			6600
6800	23.413	145.682	237.327	215.903	422.852			6800
7000	23.443	150.367	238.006	216.525	427.537			7000
7200	23.481	155.072	238.669	217.131	432.242			7200
7400	23.503	159.771	239.312	217.722	436.941			7400
7600	23.528	164.474	239.939	218.298	441.644			7600
7800	23.559	169.183	240.551	218.861	446.353			7800
8000	23.595	173.898	241.148	219.411	451.068			8000
8500	23.715	185.724	242.582	220.732	462.894			8500
9000	23.882	197.621	243.942	221.984	474.791			9000
9500	24.094	209.613	245.238	223.174	486.783			9500
10000	24.349	221.722	246.480	224.308	498.892			10000
10500	24.644	233.969	247.675	225.393	511.139			10500
11000	24.974	246.372	248.829	226.432	523.542			11000
11500	25.335	258.948	249.947	227.430	536.118			11500
12000	25.725	271.712	251.034	228.391	548.882			12000
12500	26.137	284.677	252.092	229.318	561.847			12500
13000	26.570	297.853	253.126	230.214	575.023			13000
13500	27.020	311.250	254.137	231.081	588.420			13500
14000	27.482	324.875	255.128	231.922	602.045			14000
14500	27.952	338.732	256.100	232.740	615.902			14500
15000	28.426	352.827	257.056	233.534	629.997			15000
15500	28.899	367.158	257.996	234.308	644.328			15500
16000	29.364	381.725	258.921	235.063	658.895			16000
16500	29.815	396.520	259.831	235.800	673.690			16500
17000	30.245	411.536	260.728	236.520	688.706			17000
17500	30.645	426.761	261.610	237.224	703.931			17500
18000	31.007	442.176	262.479	237.913	719.346			18000
18500	31.318	457.759	263.333	238.589	734.929			18500
19000	31.569	473.484	264.171	239.251	750.654			19000
19500	31.747	489.317	264.994	239.901	766.487			19500
20000	31.838	505.217	265.799	240.538	782.387			20000

***Assigned reference element phase change at 368.3 and 388.36 K**

TABLE A108.—THERMODYNAMIC PROPERTIES FOR S^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1276.299	1274.514	----------	0
298.15	20.786	0.000	163.632	163.632	1282.496	1282.496	–216.7147	298.15
300	20.786	0.038	163.760	163.632	1282.535	1282.530	–215.3289	300
*400	20.786	2.117	169.740	164.447	1284.614	1282.083	–159.4790	400
500	20.786	4.196	174.378	165.987	1286.692	1282.304	–125.9910	500
600	20.786	6.274	178.168	167.711	1288.771	1282.881	–103.6605	600
700	20.786	8.353	181.372	169.440	1290.849	1283.691	–87.7014	700
800	20.786	10.432	184.148	171.109	1292.928	1284.645	–75.7236	800
900	20.786	12.510	186.596	172.696	1295.007	1285.602	–66.4007	900
1000	20.786	14.589	188.786	174.198	1297.085	1286.559	–58.9368	1000
1100	20.786	16.667	190.768	175.615	1299.164	1287.516	–52.8253	1100
1200	20.786	18.746	192.576	176.954	1301.243	1288.474	–47.7287	1200
1300	20.787	20.825	194.240	178.221	1303.321	1289.431	–43.4130	1300
1400	20.787	22.903	195.781	179.421	1305.400	1290.388	–39.7110	1400
1500	20.789	24.982	197.215	180.560	1307.479	1291.346	–36.5003	1500
1600	20.792	27.061	198.557	181.643	1309.558	1292.303	–33.6888	1600
1700	20.798	29.141	199.817	182.676	1311.637	1293.261	–31.2062	1700
1800	20.806	31.221	201.006	183.661	1313.717	1294.220	–28.9978	1800
1900	20.820	33.302	202.131	184.604	1315.799	1295.180	–27.0205	1900
2000	20.840	35.385	203.200	185.507	1317.882	1296.142	–25.2395	2000
2100	20.868	37.470	204.217	186.374	1319.967	1297.106	–23.6270	2100
2200	20.904	39.559	205.189	187.207	1322.055	1298.073	–22.1600	2200
2300	20.951	41.652	206.119	188.010	1324.148	1299.044	–20.8195	2300
2400	21.009	43.750	207.012	188.783	1326.246	1300.021	–19.5898	2400
2500	21.080	45.854	207.871	189.529	1328.350	1301.004	–18.4576	2500
2600	21.164	47.966	208.699	190.251	1330.462	1301.994	–17.4118	2600
2700	21.262	50.087	209.500	190.949	1332.584	1302.994	–16.4426	2700
2800	21.374	52.219	210.275	191.625	1334.715	1304.004	–15.5420	2800
2900	21.500	54.362	211.027	192.282	1336.859	1305.027	–14.7029	2900
3000	21.641	56.519	211.758	192.919	1339.016	1306.062	–13.9191	3000
3100	21.795	58.691	212.471	193.538	1341.187	1307.112	–13.1852	3100
3200	21.963	60.879	213.165	194.141	1343.375	1308.179	–12.4967	3200
3300	22.143	63.084	213.844	194.727	1345.580	1309.263	–11.8494	3300
3400	22.335	65.308	214.508	195.299	1347.804	1310.365	–11.2396	3400
3500	22.538	67.551	215.158	195.857	1350.048	1311.487	–10.6642	3500
3600	22.751	69.816	215.796	196.403	1352.312	1312.630	–10.1203	3600
3700	22.974	72.102	216.422	196.935	1354.598	1313.795	–9.6053	3700
3800	23.204	74.411	217.038	197.456	1356.907	1314.983	–9.1170	3800
3900	23.441	76.743	217.644	197.966	1359.239	1316.193	–8.6533	3900
4000	23.684	79.099	218.240	198.465	1361.596	1317.428	–8.2124	4000
4100	23.932	81.480	218.828	198.955	1363.976	1318.688	–7.7926	4100
4200	24.183	83.886	219.408	199.435	1366.382	1319.972	–7.3925	4200
4300	24.436	86.317	219.980	199.906	1368.813	1321.282	–7.0105	4300
4400	24.691	88.773	220.544	200.369	1371.269	1322.617	–6.6455	4400
4500	24.946	91.255	221.102	200.823	1373.751	1323.977	–6.2965	4500
4600	25.201	93.762	221.653	201.270	1376.259	1325.363	–5.9622	4600
4700	25.455	96.295	222.198	201.710	1378.791	1326.774	–5.6418	4700
4800	25.706	98.853	222.736	202.142	1381.349	1328.211	–5.3345	4800
4900	25.953	101.436	223.269	202.568	1383.932	1329.673	–5.0393	4900
5000	26.197	104.044	223.796	202.987	1386.540	1331.159	–4.7557	5000

TABLE A108.—THERMODYNAMIC PROPERTIES FOR S^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	26.437	106.675	224.317	203.400	1389.172	1332.669	–4.4829	5100
5200	26.671	109.331	224.833	203.807	1391.827	1334.203	–4.2202	5200
5300	26.900	112.009	225.343	204.209	1394.506	1335.761	–3.9672	5300
5400	27.122	114.711	225.848	204.605	1397.207	1337.340	–3.7233	5400
5500	27.337	117.434	226.347	204.996	1399.930	1338.942	–3.4880	5500
5600	27.546	120.178	226.842	205.382	1402.674	1340.565	–3.2608	5600
5700	27.747	122.942	227.331	205.762	1405.439	1342.208	–3.0413	5700
5800	27.940	125.727	227.815	206.138	1408.223	1343.871	–2.8291	5800
5900	28.125	128.530	228.295	206.510	1411.027	1345.553	–2.6238	5900
6000	28.303	131.352	228.769	206.877	1413.848	1347.253	–2.4252	6000
6200	28.632	137.046	229.702	207.598	1419.542			6200
6400	28.928	142.802	230.616	208.303	1425.299			6400
6600	29.189	148.615	231.510	208.993	1431.111			6600
6800	29.418	154.476	232.385	209.668	1436.972			6800
7000	29.613	160.379	233.241	210.330	1442.876			7000
7200	29.777	166.319	234.078	210.978	1448.815			7200
7400	29.912	172.288	234.895	211.613	1454.785			7400
7600	30.017	178.282	235.694	212.236	1460.778			7600
7800	30.096	184.293	236.475	212.848	1466.790			7800
8000	30.151	190.319	237.238	213.448	1472.815			8000
8500	30.190	205.409	239.068	214.902	1487.905			8500
9000	30.115	220.489	240.792	216.293	1502.986			9000
9500	29.953	235.509	242.416	217.625	1518.006			9500
10000	29.728	250.432	243.947	218.904	1532.928			10000
10500	29.462	265.230	245.391	220.131	1547.727			10500
11000	29.171	279.889	246.755	221.310	1562.386			11000
11500	28.871	294.400	248.045	222.445	1576.897			11500
12000	28.573	308.761	249.267	223.537	1591.257			12000
12500	28.286	322.975	250.428	224.590	1605.471			12500
13000	28.018	337.050	251.532	225.605	1619.546			13000
13500	27.777	350.997	252.585	226.585	1633.494			13500
14000	27.567	364.832	253.591	227.532	1647.328			14000
14500	27.393	378.570	254.555	228.447	1661.066			14500
15000	27.260	392.231	255.481	229.333	1674.728			15000
15500	27.171	405.837	256.374	230.191	1688.333			15500
16000	27.129	419.409	257.235	231.022	1701.906			16000
16500	27.138	432.973	258.070	231.829	1715.470			16500
17000	27.199	446.553	258.881	232.613	1729.049			17000
17500	27.318	460.179	259.671	233.375	1742.676			17500
18000	27.496	473.880	260.443	234.116	1756.377			18000
18500	27.735	487.686	261.199	234.838	1770.182			18500
19000	28.038	501.625	261.943	235.542	1784.122			19000
19500	28.402	515.728	262.675	236.228	1798.224			19500
20000	28.758	529.904	263.393	236.898	1812.400			20000

*Assigned reference element phase change at 368.3 and 388.36 K

TABLE A109.—THERMODYNAMIC PROPERTIES FOR S^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.465	----------	----------	63.904	74.513	----------	0
298.15	22.783	0.000	164.923	164.923	70.369	70.369	–6.4844	298.15
300	22.784	0.042	165.064	164.923	70.411	70.329	–6.4082	300
*400	22.653	2.317	171.608	165.816	72.685	65.920	–3.4006	400
500	22.370	4.568	176.633	167.497	74.937	62.157	–1.7229	500
600	22.096	6.791	180.687	169.368	77.160	58.721	–0.6692	600
700	21.869	8.989	184.075	171.234	79.357	55.493	0.0418	700
800	21.687	11.166	186.983	173.025	81.535	52.388	0.5456	800
900	21.543	13.327	189.529	174.720	83.696	49.271	0.9148	900
1000	21.429	15.476	191.792	176.317	85.844	46.141	1.1920	1000
1100	21.338	17.614	193.830	177.818	87.983	43.000	1.4039	1100
1200	21.264	19.744	195.684	179.230	90.113	39.851	1.5680	1200
1300	21.203	21.867	197.383	180.562	92.236	36.696	1.6963	1300
1400	21.153	23.985	198.953	181.821	94.354	33.535	1.7972	1400
1500	21.112	26.098	200.411	183.012	96.467	30.370	1.8768	1500
1600	21.077	28.208	201.772	184.142	98.576	27.201	1.9395	1600
1700	21.047	30.314	203.049	185.217	100.682	24.028	1.9887	1700
1800	21.021	32.417	204.251	186.242	102.786	20.853	2.0271	1800
1900	20.999	34.518	205.387	187.220	104.887	17.675	2.0566	1900
2000	20.980	36.617	206.464	188.155	106.986	14.496	2.0787	2000
2100	20.964	38.714	207.487	189.052	109.083	11.314	2.0948	2100
2200	20.949	40.810	208.462	189.912	111.178	8.131	2.1058	2200
2300	20.936	42.904	209.393	190.739	113.273	4.947	2.1126	2300
2400	20.925	44.997	210.284	191.535	115.366	1.761	2.1158	2400
2500	20.915	47.089	211.138	192.302	117.458	–1.426	2.1159	2500
2600	20.905	49.180	211.958	193.042	119.549	–4.613	2.1135	2600
2700	20.897	51.270	212.747	193.758	121.639	–7.802	2.1089	2700
2800	20.890	53.360	213.506	194.449	123.728	–10.991	2.1024	2800
2900	20.883	55.448	214.239	195.119	125.817	–14.181	2.0944	2900
3000	20.877	57.536	214.947	195.768	127.905	–17.372	2.0849	3000
3100	20.872	59.624	215.632	196.398	129.992	–20.563	2.0743	3100
3200	20.867	61.711	216.294	197.010	132.079	–23.754	2.0626	3200
3300	20.862	63.797	216.936	197.604	134.166	–26.947	2.0501	3300
3400	20.858	65.883	217.559	198.182	136.252	–30.139	2.0368	3400
3500	20.854	67.969	218.164	198.744	138.337	–33.332	2.0229	3500
3600	20.850	70.054	218.751	199.292	140.422	–36.526	2.0084	3600
3700	20.847	72.139	219.322	199.825	142.507	–39.720	1.9934	3700
3800	20.844	74.223	219.878	200.346	144.592	–42.914	1.9781	3800
3900	20.841	76.308	220.420	200.854	146.676	–46.108	1.9624	3900
4000	20.839	78.392	220.947	201.349	148.760	–49.303	1.9465	4000
4100	20.836	80.475	221.462	201.834	150.844	–52.497	1.9302	4100
4200	20.834	82.559	221.964	202.307	152.927	–55.693	1.9138	4200
4300	20.832	84.642	222.454	202.770	155.011	–58.888	1.8973	4300
4400	20.830	86.725	222.933	203.223	157.094	–62.083	1.8806	4400
4500	20.828	88.808	223.401	203.666	159.177	–65.279	1.8638	4500
4600	20.826	90.891	223.859	204.100	161.259	–68.475	1.8469	4600
4700	20.825	92.973	224.307	204.525	163.342	–71.671	1.8300	4700
4800	20.823	95.056	224.745	204.942	165.424	–74.867	1.8130	4800
4900	20.822	97.138	225.174	205.350	167.506	–78.064	1.7960	4900
5000	20.820	99.220	225.595	205.751	169.589	–81.260	1.7791	5000

TABLE A109.—THERMODYNAMIC PROPERTIES FOR S^- (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.819	101.302	226.007	206.144	171.671	–84.457	1.7621	5100
5200	20.818	103.384	226.412	206.530	173.752	–87.654	1.7451	5200
5300	20.817	105.466	226.808	206.909	175.834	–90.851	1.7282	5300
5400	20.816	107.547	227.197	207.281	177.916	–94.048	1.7114	5400
5500	20.815	109.629	227.579	207.647	179.997	–97.245	1.6945	5500
5600	20.814	111.710	227.954	208.006	182.079	–100.442	1.6778	5600
5700	20.813	113.791	228.323	208.359	184.160	–103.639	1.6611	5700
5800	20.812	115.873	228.684	208.706	186.241	–106.837	1.6445	5800
5900	20.811	117.954	229.040	209.048	188.322	–110.034	1.6279	5900
6000	20.810	120.035	229.390	209.384	190.403	–113.232	1.6114	6000
6200	20.809	124.197	230.072	210.041	194.565			6200
6400	20.807	128.358	230.733	210.677	198.727			6400
6600	20.806	132.520	231.373	211.294	202.888			6600
6800	20.805	136.681	231.994	211.894	207.049			6800
7000	20.804	140.842	232.597	212.477	211.210			7000
7200	20.803	145.002	233.183	213.044	215.371			7200
7400	20.802	149.163	233.753	213.596	219.531			7400
7600	20.801	153.323	234.308	214.134	223.692			7600
7800	20.801	157.483	234.848	214.658	227.852			7800
8000	20.800	161.643	235.375	215.170	232.012			8000
8500	20.798	172.043	236.636	216.396	242.411			8500
9000	20.797	182.442	237.825	217.553	252.810			9000
9500	20.796	192.840	238.949	218.650	263.208			9500
10000	20.795	203.238	240.016	219.692	273.606			10000
10500	20.794	213.635	241.030	220.684	284.003			10500
11000	20.794	224.032	241.998	221.631	294.400			11000
11500	20.793	234.428	242.922	222.537	304.797			11500
12000	20.792	244.825	243.807	223.405	315.193			12000
12500	20.792	255.221	244.656	224.238	325.589			12500
13000	20.791	265.617	245.471	225.039	335.985			13000
13500	20.791	276.012	246.256	225.811	346.381			13500
14000	20.791	286.408	247.012	226.554	356.776			14000
14500	20.790	296.803	247.742	227.272	367.172			14500
15000	20.790	307.198	248.446	227.967	377.567			15000
15500	20.790	317.593	249.128	228.638	387.962			15500
16000	20.790	327.988	249.788	229.289	398.357			16000
16500	20.790	338.383	250.428	229.920	408.751			16500
17000	20.789	348.778	251.049	230.532	419.146			17000
17500	20.789	359.172	251.651	231.127	429.541			17500
18000	20.789	369.567	252.237	231.705	439.935			18000
18500	20.789	379.961	252.806	232.268	450.330			18500
19000	20.789	390.356	253.361	232.816	460.724			19000
19500	20.789	400.750	253.901	233.349	471.119			19500
20000	20.788	411.144	254.427	233.870	481.513			20000

*Assigned reference element phase change at 368.3 and 388.36 K

TABLE A110.—THERMODYNAMIC PROPERTIES FOR Sc

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.002	----------	----------	370.698	375.905	----------	0
100	25.843	–4.687	148.543	195.414	373.013	377.516	–189.9934	100
200	23.389	–2.223	165.727	176.843	375.477	377.895	–91.3408	200
298.15	22.103	0.000	174.788	174.788	377.700	377.700	–58.8562	298.15
300	22.088	0.041	174.925	174.788	377.741	377.694	–58.4482	300
400	21.541	2.219	181.194	175.647	379.919	377.275	–42.0158	400
500	21.273	4.358	185.969	177.252	382.058	376.753	–32.1688	500
600	21.125	6.477	189.833	179.037	384.178	376.155	–25.6139	600
700	21.035	8.585	193.082	180.818	386.285	375.479	–20.9397	700
800	20.976	10.685	195.887	182.530	388.386	374.717	–17.4408	800
900	20.936	12.781	198.355	184.154	390.481	373.856	–14.7253	900
1000	20.908	14.873	200.559	185.686	392.573	372.884	–12.5582	1000
1100	20.888	16.963	202.551	187.130	394.663	371.792	–10.7901	1100
1200	20.875	19.051	204.368	188.492	396.751	370.568	–9.3212	1200
1300	20.869	21.138	206.038	189.778	398.838	369.206	–8.0826	1300
1400	20.873	23.225	207.585	190.996	400.925	367.700	–7.0250	1400
1500	20.890	25.313	209.026	192.150	403.013	366.049	–6.1124	1500
1600	20.924	27.403	210.375	193.248	405.104	364.252	–5.3176	1600
*1700	20.979	29.498	211.645	194.293	407.199	357.945	–4.6273	1700
1800	21.063	31.600	212.846	195.290	409.300	355.627	–4.0182	1800
*1900	21.181	33.712	213.988	196.245	411.412	339.236	–3.4952	1900
2000	21.338	35.838	215.078	197.159	413.538	336.962	–3.0304	2000
2100	21.542	37.981	216.124	198.038	415.682	334.705	–2.6127	2100
2200	21.796	40.148	217.132	198.883	417.848	332.472	–2.2355	2200
2300	22.106	42.342	218.107	199.698	420.043	330.266	–1.8935	2300
2400	22.476	44.571	219.056	200.485	422.271	328.095	–1.5820	2400
2500	22.908	46.840	219.982	201.246	424.540	325.964	–1.2973	2500
2600	23.404	49.155	220.890	201.984	426.855	323.879	–1.0361	2600
2700	23.964	51.523	221.783	202.701	429.223	321.847	–0.7959	2700
2800	24.588	53.950	222.666	203.398	431.650	319.874	–0.5742	2800
2900	25.274	56.442	223.541	204.078	434.142	317.966	–0.3691	2900
3000	26.020	59.006	224.410	204.741	436.707	316.131	–0.1787	3000
3100	26.820	61.648	225.276	205.389	439.348	314.372	–0.0016	3100
3200	27.671	64.372	226.141	206.024	442.072	312.696	0.1634	3200
3300	28.566	67.184	227.006	206.647	444.884	311.108	0.3177	3300
3400	29.499	70.087	227.872	207.259	447.787	309.611	0.4622	3400
3500	30.464	73.085	228.741	207.860	450.785	308.209	0.5978	3500
3600	31.452	76.180	229.613	208.452	453.880	306.904	0.7253	3600
3700	32.458	79.376	230.489	209.036	457.076	305.700	0.8454	3700
3800	33.472	82.672	231.368	209.612	460.372	304.596	0.9588	3800
3900	34.489	86.070	232.250	210.181	463.770	303.594	1.0659	3900
4000	35.500	89.570	233.136	210.744	467.270	302.694	1.1674	4000
4100	36.500	93.170	234.025	211.301	470.870	301.894	1.2637	4100
4200	37.482	96.869	234.917	211.853	474.569	301.193	1.3552	4200
4300	38.441	100.665	235.810	212.399	478.365	300.589	1.4422	4300
4400	39.373	104.556	236.704	212.942	482.256	300.080	1.5251	4400
4500	40.272	108.538	237.599	213.480	486.239	299.663	1.6042	4500

TABLE A110.—THERMODYNAMIC PROPERTIES FOR Sc (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	41.136	112.609	238.494	214.014	490.309	299.333	1.6798	4600
4700	41.962	116.764	239.387	214.544	494.464	299.088	1.7521	4700
4800	42.747	120.999	240.279	215.071	498.700	298.924	1.8213	4800
4900	43.491	125.311	241.168	215.594	503.012	298.835	1.8877	4900
5000	44.193	129.695	242.054	216.115	507.396	298.820	1.9514	5000
5100	44.852	134.147	242.935	216.632	511.847	298.871	2.0126	5100
5200	45.469	138.663	243.812	217.146	516.363	298.987	2.0715	5200
5300	46.040	143.236	244.683	217.657	520.936	299.160	2.1282	5300
5400	46.578	147.867	245.549	218.166	525.567	299.391	2.1828	5400
5500	47.073	152.548	246.408	218.672	530.248	299.672	2.2355	5500
5600	47.524	157.273	247.259	219.174	534.974	299.998	2.2863	5600
5700	47.948	162.047	248.104	219.675	539.747	300.371	2.3354	5700
5800	48.324	166.852	248.939	220.172	544.552	300.776	2.3829	5800
5900	48.654	171.718	249.761	220.657	549.418	301.242	2.4283	5900
6000	48.948	176.598	250.581	221.149	554.298	301.722	2.4728	6000
6200	49.354	186.428	252.193	222.124	564.128			6200
6400	49.768	196.340	253.766	223.088	574.040			6400
6600	50.149	206.332	255.304	224.041	584.032			6600
6800	50.469	216.396	256.806	224.983	594.096			6800
7000	50.713	226.515	258.273	225.913	604.215			7000
7200	50.869	236.675	259.704	226.832	614.375			7200
7400	50.934	246.857	261.098	227.739	624.557			7400
7600	50.908	257.042	262.457	228.635	634.742			7600
7800	50.792	267.214	263.778	229.519	644.914			7800
8000	50.592	277.353	265.061	230.392	655.054			8000
8500	49.764	302.460	268.106	232.522	680.160			8500
9000	48.558	327.054	270.918	234.578	704.754			9000
9500	47.090	350.975	273.505	236.560	728.675			9500
10000	45.466	374.117	275.879	238.467	751.818			10000
10500	43.775	396.429	278.057	240.301	774.129			10500
11000	42.088	417.893	280.054	242.064	795.594			11000
11500	40.458	438.527	281.889	243.756	816.228			11500
12000	38.921	458.367	283.578	245.380	836.067			12000
12500	37.498	477.467	285.137	246.940	855.167			12500
13000	36.200	495.887	286.582	248.437	873.587			13000
13500	35.029	513.688	287.926	249.875	891.389			13500
14000	33.978	530.935	289.181	251.257	908.635			14000
14500	33.035	547.684	290.356	252.585	925.384			14500
15000	32.185	563.985	291.462	253.863	941.685			15000
15500	31.411	579.881	292.504	255.092	957.581			15500
16000	30.696	595.406	293.490	256.277	973.106			16000
16500	30.021	610.585	294.424	257.419	988.285			16500
17000	29.371	625.432	295.311	258.520	1003.132			17000
17500	28.733	639.958	296.153	259.584	1017.658			17500
18000	28.096	654.165	296.953	260.611	1031.865			18000
18500	27.454	668.053	297.714	261.603	1045.753			18500
19000	26.805	681.619	298.438	262.563	1059.319			19000
19500	26.153	694.858	299.126	263.492	1072.559			19500
20000	25.507	707.773	299.780	264.391	1085.473			20000

***Assigned reference element phase change at 1609 K and 1814 K**

TABLE A111.—THERMODYNAMIC PROPERTIES FOR Sc^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.162	----------	----------	1009.983	1008.993	----------	0
298.15	21.762	0.000	178.338	178.338	1017.145	1017.145	–169.6003	298.15
300	21.751	0.040	178.473	178.338	1017.185	1017.177	–168.5014	300
400	21.372	2.193	184.669	179.186	1019.339	1018.811	–124.1934	400
500	21.267	4.324	189.423	180.776	1021.469	1020.359	–97.5666	500
600	21.323	6.452	193.304	182.550	1023.597	1021.849	–79.7887	600
700	21.489	8.592	196.602	184.328	1025.737	1023.284	–67.0720	700
800	21.738	10.753	199.487	186.046	1027.898	1024.661	–57.5212	800
900	22.053	12.942	202.065	187.685	1030.087	1025.972	–50.0831	900
1000	22.420	15.165	204.407	189.242	1032.310	1027.210	–44.1251	1000
1100	22.821	17.427	206.562	190.720	1034.572	1028.368	–39.2448	1100
1200	23.240	19.730	208.566	192.125	1036.875	1029.438	–35.1733	1200
1300	23.661	22.075	210.443	193.462	1039.220	1030.413	–31.7249	1300
1400	24.068	24.462	212.211	194.739	1041.607	1031.285	–28.7664	1400
1500	24.451	26.888	213.885	195.960	1044.033	1032.051	–26.2003	1500
1600	24.801	29.351	215.475	197.130	1046.496	1032.704	–23.9534	1600
*1700	25.115	31.847	216.988	198.254	1048.992	1028.878	–21.9771	1700
1800	25.390	34.372	218.431	199.335	1051.517	1029.062	–20.2207	1800
*1900	25.627	36.923	219.810	200.377	1054.069	1015.189	–18.6672	1900
2000	25.828	39.496	221.130	201.382	1056.642	1015.441	–17.2716	2000
2100	25.995	42.088	222.394	202.353	1059.233	1015.711	–16.0086	2100
2200	26.131	44.694	223.607	203.291	1061.840	1015.996	–14.8601	2200
2300	26.241	47.313	224.771	204.200	1064.458	1016.293	–13.8111	2300
2400	26.328	49.942	225.890	205.081	1067.087	1016.601	–12.8493	2400
2500	26.394	52.578	226.966	205.935	1069.723	1016.915	–11.9642	2500
2600	26.444	55.220	228.002	206.764	1072.365	1017.236	–11.1469	2600
2700	26.479	57.866	229.001	207.569	1075.012	1017.561	–10.3898	2700
2800	26.502	60.515	229.964	208.352	1077.661	1017.889	–9.6867	2800
2900	26.515	63.166	230.895	209.113	1080.312	1018.218	–9.0318	2900
3000	26.519	65.818	231.794	209.854	1082.963	1018.549	–8.4204	3000
3100	26.518	68.470	232.663	210.576	1085.615	1018.879	–7.8482	3100
3200	26.510	71.121	233.505	211.279	1088.267	1019.209	–7.3117	3200
3300	26.499	73.772	234.320	211.965	1090.917	1019.538	–6.8074	3300
3400	26.484	76.421	235.111	212.635	1093.566	1019.866	–6.3327	3400
3500	26.466	79.069	235.879	213.288	1096.214	1020.192	–5.8850	3500
3600	26.447	81.714	236.624	213.926	1098.859	1020.516	–5.4620	3600
3700	26.426	84.358	237.348	214.549	1101.503	1020.839	–5.0618	3700
3800	26.404	86.999	238.053	215.158	1104.145	1021.159	–4.6825	3800
3900	26.382	89.639	238.738	215.754	1106.784	1021.477	–4.3225	3900
4000	26.361	92.276	239.406	216.337	1109.421	1021.793	–3.9804	4000
4100	26.339	94.911	240.057	216.908	1112.056	1022.106	–3.6549	4100
4200	26.318	97.544	240.691	217.467	1114.689	1022.418	–3.3449	4200
4300	26.298	100.174	241.310	218.014	1117.320	1022.727	–3.0491	4300
4400	26.279	102.803	241.915	218.550	1119.948	1023.035	–2.7667	4400
4500	26.261	105.430	242.505	219.076	1122.575	1023.340	–2.4968	4500
4600	26.245	108.056	243.082	219.592	1125.201	1023.644	–2.2385	4600
4700	26.230	110.679	243.646	220.097	1127.824	1023.946	–1.9912	4700
4800	26.217	113.302	244.198	220.594	1130.447	1024.247	–1.7541	4800
4900	26.205	115.923	244.739	221.081	1133.068	1024.547	–1.5266	4900
5000	26.195	118.543	245.268	221.560	1135.688	1024.846	–1.3081	5000

TABLE A111.—THERMODYNAMIC PROPERTIES FOR Sc^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	26.187	121.162	245.787	222.030	1138.307	1025.143	–1.0982	5100
5200	26.181	123.780	246.295	222.491	1140.925	1025.440	–0.8962	5200
5300	26.176	126.398	246.794	222.945	1143.543	1025.737	–0.7018	5300
5400	26.173	129.015	247.283	223.391	1146.161	1026.033	–0.5146	5400
5500	26.172	131.633	247.763	223.830	1148.778	1026.329	–0.3341	5500
5600	26.173	134.250	248.235	224.262	1151.395	1026.625	–0.1601	5600
5700	26.176	136.867	248.698	224.686	1154.013	1026.921	0.0080	5700
5800	26.180	139.485	249.153	225.104	1156.630	1027.217	0.1702	5800
5900	26.186	142.103	249.601	225.516	1159.249	1027.514	0.3270	5900
6000	26.193	144.722	250.041	225.921	1161.867	1027.812	0.4787	6000
6200	26.213	149.963	250.900	226.713	1167.108			6200
6400	26.238	155.208	251.733	227.482	1172.353			6400
6600	26.269	160.458	252.541	228.229	1177.604			6600
6800	26.305	165.716	253.326	228.956	1182.861			6800
7000	26.345	170.981	254.089	229.663	1188.126			7000
7200	26.389	176.254	254.831	230.352	1193.399			7200
7400	26.436	181.536	255.555	231.023	1198.681			7400
7600	26.487	186.829	256.261	231.678	1203.974			7600
7800	26.542	192.131	256.949	232.317	1209.277			7800
8000	26.599	197.445	257.622	232.941	1214.591			8000
8500	26.756	210.783	259.239	234.441	1227.929			8500
9000	26.932	224.204	260.774	235.862	1241.350			9000
9500	27.129	237.719	262.235	237.212	1254.864			9500
10000	27.350	251.337	263.632	238.498	1268.482			10000
10500	27.601	265.073	264.972	239.727	1282.219			10500
11000	27.883	278.942	266.263	240.904	1296.088			11000
11500	28.200	292.961	267.509	242.034	1310.106			11500
12000	28.554	307.147	268.716	243.121	1324.292			12000
12500	28.947	321.519	269.889	244.168	1338.664			12500
13000	29.376	336.095	271.033	245.179	1353.240			13000
13500	29.838	350.889	272.149	246.158	1368.035			13500
14000	30.333	365.924	273.243	247.105	1383.069			14000
14500	30.856	381.212	274.316	248.025	1398.357			14500
15000	31.400	396.762	275.370	248.919	1413.908			15000
15500	31.960	412.585	276.407	249.789	1429.730			15500
16000	32.495	428.787	277.433	250.634	1445.932			16000
16500	33.025	445.168	278.441	251.461	1462.313			16500
17000	33.541	461.809	279.435	252.270	1478.955			17000
17500	34.039	478.706	280.414	253.060	1495.851			17500
18000	34.512	495.845	281.380	253.833	1512.990			18000
18500	34.956	513.212	282.332	254.590	1530.357			18500
19000	35.367	530.794	283.269	255.333	1547.939			19000
19500	35.742	548.573	284.193	256.061	1565.718			19500
20000	36.078	566.529	285.102	256.776	1583.675			20000

*Assigned reference element phase change at 1609 K and 1814 K

TABLE A112.—THERMODYNAMIC PROPERTIES FOR Sc^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	346.361	357.766	----------	0
298.15	20.786	0.000	187.196	187.196	352.559	352.559	–54.8994	298.15
300	20.786	0.038	187.325	187.197	352.597	352.512	–54.5185	300
400	20.786	2.117	193.305	188.012	354.676	349.914	–39.2253	400
500	20.786	4.196	197.943	189.552	356.755	347.254	–30.1187	500
600	20.786	6.274	201.733	191.276	358.833	344.536	–24.0948	600
700	20.786	8.353	204.937	193.004	360.912	341.753	–19.8263	700
800	20.786	10.432	207.713	194.673	362.990	338.890	–16.6513	800
900	20.786	12.510	210.161	196.261	365.069	335.934	–14.2031	900
1000	20.786	14.589	212.351	197.762	367.148	332.870	–12.2619	1000
1100	20.786	16.667	214.332	199.180	369.226	329.687	–10.6886	1100
1200	20.786	18.746	216.141	200.519	371.305	326.376	–9.3903	1200
1300	20.786	20.825	217.805	201.786	373.384	322.927	–8.3031	1300
1400	20.786	22.903	219.345	202.985	375.462	319.334	–7.3813	1400
1500	20.786	24.982	220.779	204.124	377.541	315.595	–6.5915	1500
1600	20.786	27.061	222.121	205.208	379.619	311.707	–5.9088	1600
*1700	20.786	29.139	223.381	206.240	381.698	303.305	–5.3213	1700
1800	20.786	31.218	224.569	207.226	383.777	298.885	–4.8072	1800
*1900	20.786	33.296	225.693	208.168	385.855	280.383	–4.3724	1900
2000	20.786	35.375	226.759	209.071	387.934	275.983	–3.9900	2000
2100	20.786	37.454	227.773	209.938	390.013	271.583	–3.6495	2100
2200	20.786	39.532	228.740	210.771	392.091	267.183	–3.3449	2200
2300	20.786	41.611	229.664	211.572	394.170	262.783	–3.0713	2300
2400	20.786	43.690	230.549	212.345	396.248	258.383	–2.8247	2400
2500	20.786	45.768	231.397	213.090	398.327	253.983	–2.6016	2500
2600	20.786	47.847	232.213	213.810	400.406	249.583	–2.3993	2600
2700	20.786	49.926	232.997	214.506	402.484	245.183	–2.2152	2700
2800	20.786	52.004	233.753	215.180	404.563	240.783	–2.0473	2800
2900	20.786	54.083	234.482	215.833	406.642	236.383	–1.8938	2900
3000	20.786	56.161	235.187	216.467	408.720	231.983	–1.7532	3000
3100	20.786	58.240	235.869	217.082	410.799	227.583	–1.6241	3100
3200	20.786	60.319	236.529	217.679	412.877	223.183	–1.5054	3200
3300	20.786	62.397	237.168	218.260	414.956	218.783	–1.3961	3300
3400	20.786	64.476	237.789	218.825	417.035	214.383	–1.2953	3400
3500	20.786	66.555	238.391	219.376	419.113	209.983	–1.2021	3500
3600	20.786	68.633	238.977	219.912	421.192	205.583	–1.1160	3600
3700	20.786	70.712	239.546	220.435	423.271	201.183	–1.0362	3700
3800	20.786	72.790	240.101	220.945	425.349	196.783	–0.9623	3800
3900	20.786	74.869	240.641	221.443	427.428	192.383	–0.8937	3900
4000	20.786	76.948	241.167	221.930	429.507	187.983	–0.8300	4000
4100	20.786	79.026	241.680	222.405	431.585	183.583	–0.7708	4100
4200	20.786	81.105	242.181	222.870	433.664	179.183	–0.7158	4200
4300	20.786	83.184	242.670	223.325	435.742	174.783	–0.6646	4300
4400	20.786	85.262	243.148	223.770	437.821	170.383	–0.6170	4400
4500	20.786	87.341	243.615	224.206	439.900	165.983	–0.5726	4500
4600	20.786	89.419	244.072	224.633	441.978	161.583	–0.5313	4600
4700	20.786	91.498	244.519	225.051	444.057	157.183	–0.4928	4700
4800	20.786	93.577	244.957	225.462	446.136	152.783	–0.4569	4800
4900	20.786	95.655	245.385	225.864	448.214	148.383	–0.4234	4900
5000	20.786	97.734	245.805	226.258	450.293	143.983	–0.3923	5000

TABLE A112.—THERMODYNAMIC PROPERTIES FOR Sc^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	246.217	226.646	452.371	139.583	–0.3632	5100
5200	20.786	101.891	246.620	227.026	454.450	135.183	–0.3362	5200
5300	20.786	103.970	247.016	227.399	456.529	130.783	–0.3109	5300
5400	20.786	106.048	247.405	227.766	458.607	126.383	–0.2875	5400
5500	20.786	108.127	247.786	228.127	460.686	121.983	–0.2656	5500
5600	20.786	110.206	248.161	228.481	462.765	117.583	–0.2453	5600
5700	20.786	112.284	248.529	228.830	464.843	113.183	–0.2264	5700
5800	20.786	114.363	248.890	229.173	466.922	108.783	–0.2089	5800
5900	20.786	116.442	249.246	229.510	469.000	104.383	–0.1926	5900
6000	20.786	118.520	249.595	229.842	471.079	99.983	–0.1776	6000
6200	20.786	122.677	250.277	230.490	475.236			6200
6400	20.786	126.835	250.937	231.119	479.394			6400
6600	20.786	130.992	251.576	231.729	483.551			6600
6800	20.786	135.149	252.197	232.322	487.708			6800
7000	20.786	139.306	252.799	232.898	491.865			7000
7200	20.786	143.464	253.385	233.459	496.023			7200
7400	20.786	147.621	253.954	234.006	500.180			7400
7600	20.786	151.778	254.509	234.538	504.337			7600
7800	20.786	155.936	255.049	235.057	508.494			7800
8000	20.786	160.093	255.575	235.563	512.652			8000
8500	20.786	170.486	256.835	236.778	523.045			8500
9000	20.786	180.879	258.023	237.925	533.438			9000
9500	20.786	191.272	259.147	239.013	543.831			9500
10000	20.786	201.665	260.213	240.047	554.224			10000
10500	20.786	212.058	261.227	241.031	564.617			10500
11000	20.786	222.452	262.194	241.971	575.010			11000
11500	20.786	232.845	263.118	242.871	585.404			11500
12000	20.786	243.238	264.003	243.733	595.797			12000
12500	20.786	253.631	264.851	244.561	606.190			12500
13000	20.786	264.024	265.667	245.357	616.583			13000
13500	20.786	274.417	266.451	246.124	626.976			13500
14000	20.786	284.810	267.207	246.864	637.369			14000
14500	20.786	295.204	267.937	247.578	647.762			14500
15000	20.786	305.597	268.641	248.268	658.156			15000
15500	20.786	315.990	269.323	248.936	668.549			15500
16000	20.786	326.383	269.983	249.584	678.942			16000
16500	20.786	336.776	270.622	250.212	689.335			16500
17000	20.786	347.169	271.243	250.821	699.728			17000
17500	20.786	357.562	271.845	251.413	710.121			17500
18000	20.786	367.956	272.431	251.989	720.514			18000
18500	20.786	378.349	273.001	252.549	730.907			18500
19000	20.786	388.742	273.555	253.095	741.301			19000
19500	20.786	399.135	274.095	253.626	751.694			19500
20000	20.786	409.528	274.621	254.145	762.087			20000

*Assigned reference element phase change at 1609 K and 1814 K

TABLE A113.—THERMODYNAMIC PROPERTIES FOR Si

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.550	----------	----------	442.450	445.667	----------	0
100	28.022	–4.809	140.888	188.982	445.191	448.141	–226.9199	100
200	23.796	–2.247	158.819	170.056	447.753	449.527	–109.7147	200
298.15	22.251	0.000	167.982	167.982	450.000	450.000	–71.0444	298.15
300	22.234	0.041	168.120	167.982	450.041	450.004	–70.5582	300
400	21.613	2.229	174.419	168.846	452.229	450.070	–50.9682	400
500	21.316	4.374	179.206	170.458	454.374	449.914	–39.2154	500
600	21.153	6.497	183.077	172.249	456.497	449.630	–31.3841	600
700	21.057	8.607	186.330	174.034	458.607	449.259	–25.7943	700
800	21.000	10.710	189.138	175.751	460.710	448.822	–21.6058	800
900	20.971	12.808	191.609	177.378	462.808	448.330	–18.3515	900
1000	20.968	14.905	193.818	178.914	464.905	447.791	–15.7510	1000
1100	20.989	17.002	195.818	180.361	467.002	447.211	–13.6260	1100
1200	21.033	19.103	197.646	181.726	469.103	446.595	–11.8575	1200
1300	21.099	21.210	199.332	183.016	471.210	445.947	–10.3632	1300
1400	21.183	23.324	200.898	184.238	473.324	445.269	–9.0843	1400
1500	21.283	25.447	202.363	185.398	475.447	444.564	–7.9777	1500
1600	21.394	27.581	203.740	186.502	477.581	443.833	–7.0109	1600
*1700	21.514	29.726	205.041	187.555	479.726	392.889	–6.1684	1700
1800	21.638	31.884	206.274	188.561	481.884	392.327	–5.4982	1800
1900	21.764	34.054	207.447	189.524	484.054	391.777	–4.8995	1900
2000	21.889	36.236	208.567	190.448	486.236	391.239	–4.3613	2000
2100	22.012	38.431	209.638	191.337	488.431	390.714	–3.8751	2100
2200	22.129	40.639	210.664	192.192	490.639	390.202	–3.4336	2200
2300	22.241	42.857	211.650	193.017	492.857	389.700	–3.0311	2300
2400	22.347	45.087	212.599	193.813	495.087	389.210	–2.6625	2400
2500	22.445	47.326	213.514	194.583	497.326	388.729	–2.3239	2500
2600	22.535	49.575	214.396	195.328	499.575	388.258	–2.0117	2600
2700	22.617	51.833	215.248	196.050	501.833	387.796	–1.7230	2700
2800	22.692	54.098	216.072	196.751	504.098	387.342	–1.4552	2800
2900	22.759	56.371	216.869	197.431	506.371	386.894	–1.2062	2900
3000	22.819	58.650	217.642	198.092	508.650	386.453	–0.9740	3000
3100	22.872	60.935	218.391	198.734	510.935	386.018	–0.7571	3100
3200	22.918	63.224	219.118	199.360	513.224	385.587	–0.5540	3200
3300	22.959	65.518	219.824	199.970	515.518	385.161	–0.3634	3300
3400	22.993	67.816	220.510	200.564	517.816	384.739	–0.1841	3400
3500	23.022	70.117	221.176	201.143	520.117	384.320	–0.0154	3500
3600	23.046	72.420	221.825	201.709	522.420	383.903	0.1439	3600
3700	23.066	74.726	222.457	202.261	524.726	383.489	0.2943	3700
3800	23.082	77.033	223.072	202.801	527.033	383.076	0.4367	3800
3900	23.094	79.342	223.672	203.328	529.342	382.665	0.5717	3900
4000	23.102	81.652	224.257	203.844	531.652	382.255	0.6997	4000
4100	23.108	83.962	224.827	204.349	533.962	381.845	0.8214	4100
4200	23.112	86.273	225.384	204.843	536.273	381.436	0.9372	4200
4300	23.113	88.585	225.928	205.327	538.585	381.028	1.0474	4300
4400	23.113	90.896	226.460	205.801	540.896	380.619	1.1526	4400
4500	23.111	93.207	226.979	206.266	543.207	380.210	1.2529	4500

TABLE A113.—THERMODYNAMIC PROPERTIES FOR Si (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	23.108	95.518	227.487	206.722	545.518	379.801	1.3488	4600
4700	23.104	97.829	227.984	207.169	547.829	379.392	1.4405	4700
4800	23.100	100.139	228.470	207.608	550.139	378.982	1.5283	4800
4900	23.096	102.449	228.946	208.039	552.449	378.572	1.6124	4900
5000	23.092	104.758	229.413	208.461	554.758	378.161	1.6931	5000
5100	23.089	107.067	229.870	208.877	557.067	377.750	1.7705	5100
5200	23.087	109.376	230.319	209.285	559.376	377.339	1.8449	5200
5300	23.086	111.685	230.758	209.686	561.685	376.928	1.9164	5300
5400	23.087	113.993	231.190	210.080	563.993	376.516	1.9851	5400
5500	23.089	116.302	231.614	210.468	566.302	376.105	2.0513	5500
5600	23.094	118.611	232.030	210.849	568.611	375.694	2.1151	5600
5700	23.102	120.921	232.438	211.224	570.921	375.284	2.1765	5700
5800	23.113	123.231	232.840	211.593	573.231	374.874	2.2358	5800
5900	23.126	125.543	233.235	211.957	575.543	374.466	2.2929	5900
6000	23.137	127.854	233.624	212.315	577.854	374.057	2.3482	6000
6200	23.209	132.491	234.384	213.014	582.491			6200
6400	23.270	137.139	235.122	213.694	587.139			6400
6600	23.335	141.799	235.839	214.354	591.799			6600
6800	23.417	146.474	236.537	214.996	596.474			6800
7000	23.524	151.168	237.217	215.621	601.168			7000
7200	23.661	155.886	237.881	216.231	605.886			7200
7400	23.830	160.634	238.532	216.825	610.634			7400
7600	24.032	165.420	239.170	217.404	615.420			7600
7800	24.266	170.249	239.797	217.971	620.249			7800
8000	24.531	175.128	240.415	218.524	625.128			8000
8500	25.314	187.583	241.925	219.856	637.583			8500
9000	26.235	200.465	243.397	221.123	650.465			9000
9500	27.246	213.833	244.842	222.334	663.833			9500
10000	28.303	227.719	246.267	223.495	677.719			10000
10500	29.367	242.136	247.673	224.613	692.136			10500
11000	30.406	257.082	249.064	225.693	707.082			11000
11500	31.396	272.534	250.437	226.739	722.534			11500
12000	32.317	288.467	251.793	227.754	738.467			12000
12500	33.156	304.838	253.130	228.743	754.838			12500
13000	33.905	321.608	254.445	229.706	771.608			13000
13500	34.559	338.727	255.737	230.646	788.727			13500
14000	35.116	356.150	257.004	231.565	806.150			14000
14500	35.579	373.828	258.245	232.464	823.828			14500
15000	35.951	391.715	259.458	233.344	841.715			15000
15500	36.235	409.763	260.642	234.205	859.763			15500
16000	36.437	427.935	261.795	235.049	877.935			16000
16500	36.562	446.187	262.919	235.877	896.187			16500
17000	36.617	464.485	264.011	236.688	914.485			17000
17500	36.605	482.794	265.073	237.484	932.794			17500
18000	36.533	501.081	266.103	238.265	951.081			18000
18500	36.402	519.316	267.102	239.031	969.316			18500
19000	36.215	537.472	268.071	239.783	987.472			19000
19500	35.973	555.521	269.008	240.520	1005.521			19500
20000	35.675	573.436	269.915	241.244	1023.436			20000

***Assigned reference element phase change at 1690 K**

TABLE A114.—THERMODYNAMIC PROPERTIES FOR Si^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.343	----------	----------	1235.165	1232.185	----------	0
298.15	24.336	0.000	163.429	163.429	1242.508	1242.508	–209.0270	298.15
300	24.303	0.045	163.580	163.430	1242.553	1242.555	–207.6846	300
400	22.942	2.400	170.365	164.364	1244.908	1244.866	–153.5521	400
500	22.200	4.654	175.397	166.089	1247.162	1246.897	–121.0154	500
600	21.772	6.851	179.403	167.985	1249.359	1248.766	–99.2901	600
700	21.509	9.014	182.738	169.861	1251.522	1250.527	–83.7493	700
800	21.337	11.155	185.598	171.654	1253.663	1252.207	–72.0776	800
900	21.219	13.283	188.104	173.345	1255.791	1253.823	–62.9877	900
1000	21.134	15.400	190.335	174.935	1257.908	1255.383	–55.7065	1000
1100	21.072	17.510	192.346	176.428	1260.019	1256.895	–49.7418	1100
1200	21.025	19.615	194.178	177.832	1262.123	1258.361	–44.7654	1200
1300	20.989	21.716	195.859	179.155	1264.224	1259.786	–40.5497	1300
1400	20.960	23.813	197.413	180.404	1266.321	1261.170	–36.9322	1400
1500	20.937	25.908	198.859	181.587	1268.416	1262.515	–33.7936	1500
1600	20.919	28.001	200.209	182.709	1270.509	1263.822	–31.0445	1600
*1700	20.903	30.092	201.477	183.776	1272.600	1214.902	–28.6255	1700
1800	20.890	32.182	202.672	184.793	1274.690	1216.351	–26.5504	1800
1900	20.879	34.270	203.801	185.764	1276.778	1217.798	–24.6916	1900
2000	20.870	36.358	204.871	186.693	1278.866	1219.244	–23.0167	2000
2100	20.862	38.444	205.889	187.583	1280.952	1220.689	–21.4995	2100
2200	20.855	40.530	206.860	188.437	1283.038	1222.133	–20.1186	2200
2300	20.849	42.615	207.787	189.258	1285.123	1223.577	–18.8563	2300
2400	20.844	44.700	208.674	190.049	1287.208	1225.021	–17.6978	2400
2500	20.839	46.784	209.525	190.811	1289.292	1226.463	–16.6307	2500
2600	20.835	48.868	210.342	191.547	1291.376	1227.906	–15.6446	2600
2700	20.832	50.951	211.128	192.257	1293.459	1229.348	–14.7304	2700
2800	20.828	53.034	211.886	192.945	1295.542	1230.789	–13.8806	2800
2900	20.825	55.117	212.617	193.611	1297.625	1232.231	–13.0884	2900
3000	20.823	57.199	213.323	194.256	1299.707	1233.672	–12.3481	3000
3100	20.820	59.281	214.005	194.882	1301.789	1235.112	–11.6548	3100
3200	20.818	61.363	214.666	195.490	1303.871	1236.553	–11.0041	3200
3300	20.816	63.445	215.307	196.081	1305.953	1237.993	–10.3921	3300
3400	20.815	65.527	215.928	196.656	1308.035	1239.434	–9.8155	3400
3500	20.813	67.608	216.532	197.215	1310.116	1240.874	–9.2711	3500
3600	20.812	69.689	217.118	197.760	1312.197	1242.313	–8.7564	3600
3700	20.810	71.770	217.688	198.291	1314.278	1243.753	–8.2690	3700
3800	20.809	73.851	218.243	198.809	1316.359	1245.193	–7.8067	3800
3900	20.808	75.932	218.784	199.314	1318.440	1246.632	–7.3675	3900
4000	20.807	78.013	219.310	199.807	1320.521	1248.072	–6.9499	4000
4100	20.807	80.094	219.824	200.289	1322.602	1249.511	–6.5522	4100
4200	20.806	82.174	220.326	200.760	1324.682	1250.950	–6.1729	4200
4300	20.806	84.255	220.815	201.221	1326.763	1252.390	–5.8109	4300
4400	20.806	86.335	221.294	201.672	1328.844	1253.829	–5.4650	4400
4500	20.806	88.416	221.761	202.113	1330.924	1255.268	–5.1340	4500
4600	20.806	90.497	222.218	202.545	1333.005	1256.707	–4.8171	4600
4700	20.807	92.577	222.666	202.969	1335.085	1258.146	–4.5133	4700
4800	20.808	94.658	223.104	203.383	1337.166	1259.586	–4.2218	4800
4900	20.809	96.739	223.533	203.790	1339.247	1261.025	–3.9419	4900
5000	20.811	98.820	223.953	204.189	1341.328	1262.465	–3.6729	5000

TABLE A114.—THERMODYNAMIC PROPERTIES FOR Si^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.813	100.901	224.366	204.581	1343.409	1263.905	–3.4142	5100
5200	20.816	102.983	224.770	204.965	1345.491	1265.345	–3.1651	5200
5300	20.819	105.064	225.166	205.343	1347.572	1266.785	–2.9252	5300
5400	20.823	107.146	225.555	205.714	1349.654	1268.226	–2.6938	5400
5500	20.827	109.229	225.938	206.078	1351.737	1269.667	–2.4707	5500
5600	20.832	111.312	226.313	206.436	1353.820	1271.109	–2.2552	5600
5700	20.838	113.395	226.682	206.788	1355.903	1272.551	–2.0471	5700
5800	20.845	115.479	227.044	207.134	1357.988	1273.994	–1.8459	5800
5900	20.852	117.564	227.401	207.474	1360.072	1275.437	–1.6514	5900
6000	20.861	119.650	227.751	207.809	1362.158	1276.881	–1.4631	6000
6200	20.881	123.824	228.435	208.464	1366.332			6200
6400	20.905	128.003	229.099	209.098	1370.511			6400
6600	20.934	132.186	229.742	209.714	1374.695			6600
6800	20.969	136.377	230.368	210.312	1378.885			6800
7000	21.010	140.575	230.976	210.894	1383.083			7000
7200	21.056	144.781	231.569	211.460	1387.289			7200
7400	21.109	148.997	232.146	212.012	1391.506			7400
7600	21.170	153.225	232.710	212.549	1395.733			7600
7800	21.237	157.466	233.261	213.073	1399.974			7800
8000	21.311	161.720	233.799	213.584	1404.228			8000
8500	21.532	172.429	235.098	214.812	1414.937			8500
9000	21.801	183.260	236.336	215.974	1425.768			9000
9500	22.121	194.239	237.523	217.077	1436.747			9500
10000	22.491	205.390	238.667	218.128	1447.898			10000
10500	22.910	216.738	239.774	219.132	1459.246			10500
11000	23.374	228.307	240.850	220.095	1470.815			11000
11500	23.884	240.119	241.901	221.021	1482.627			11500
12000	24.436	252.197	242.929	221.912	1494.706			12000
12500	25.027	264.561	243.938	222.773	1507.069			12500
13000	25.648	277.222	244.931	223.606	1519.730			13000
13500	26.304	290.200	245.910	224.414	1532.708			13500
14000	26.997	303.523	246.879	225.199	1546.031			14000
14500	27.717	317.201	247.839	225.963	1559.709			14500
15000	28.459	331.244	248.791	226.708	1573.752			15000
15500	29.219	345.662	249.737	227.436	1588.170			15500
16000	29.990	360.464	250.677	228.148	1602.972			16000
16500	30.769	375.654	251.611	228.844	1618.162			16500
17000	31.547	391.233	252.541	229.528	1633.742			17000
17500	32.320	407.201	253.467	230.198	1649.709			17500
18000	33.078	423.551	254.388	230.858	1666.059			18000
18500	33.816	440.275	255.305	231.506	1682.783			18500
19000	34.524	457.362	256.216	232.144	1699.870			19000
19500	35.195	474.793	257.122	232.773	1717.301			19500
20000	35.820	492.549	258.021	233.393	1735.057			20000

***Assigned reference element phase change at 1690 K**

TABLE A115.—THERMODYNAMIC PROPERTIES FOR Si^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	302.620	312.035	----------	0
298.15	20.786	0.000	161.979	161.979	308.818	308.818	–47.7198	298.15
300	20.786	0.038	162.108	161.980	308.856	308.781	–47.3862	300
400	20.786	2.117	168.088	162.795	310.935	306.658	–33.9865	400
500	20.786	4.196	172.726	164.334	313.013	304.357	–26.0052	500
600	20.787	6.274	176.516	166.058	315.092	301.950	–20.7256	600
700	20.789	8.353	179.720	167.787	317.171	299.470	–16.9849	700
800	20.798	10.432	182.497	169.456	319.250	296.930	–14.2029	800
900	20.825	12.513	184.948	171.044	321.331	294.342	–12.0578	900
1000	20.881	14.598	187.144	172.546	323.416	291.713	–10.3569	1000
1100	20.981	16.691	189.139	173.965	325.508	289.050	–8.9778	1100
1200	21.137	18.796	190.971	175.307	327.614	286.360	–7.8392	1200
1300	21.356	20.920	192.671	176.578	329.738	283.650	–6.8847	1300
1400	21.641	23.070	194.263	177.785	331.887	280.929	–6.0745	1400
1500	21.991	25.251	195.768	178.934	334.068	278.203	–5.3790	1500
1600	22.401	27.470	197.200	180.031	336.287	275.479	–4.7765	1600
*1700	22.862	29.733	198.572	181.082	338.550	222.574	–4.2591	1700
1800	23.366	32.044	199.892	182.090	340.861	220.086	–3.8813	1800
1900	23.899	34.407	201.170	183.061	343.224	217.651	–3.5470	1900
2000	24.453	36.824	202.410	183.998	345.642	215.270	–3.2494	2000
2100	25.015	39.298	203.616	184.903	348.115	212.944	–2.9831	2100
2200	25.575	41.827	204.793	185.781	350.645	210.675	–2.7437	2200
2300	26.124	44.412	205.942	186.632	353.230	208.462	–2.5273	2300
2400	26.655	47.051	207.065	187.460	355.869	206.302	–2.3311	2400
2500	27.159	49.742	208.164	188.267	358.560	204.195	–2.1524	2500
2600	27.633	52.482	209.238	189.053	361.300	202.136	–1.9891	2600
2700	28.072	55.268	210.289	189.820	364.085	200.123	–1.8394	2700
2800	28.472	58.095	211.318	190.569	366.913	198.152	–1.7019	2800
2900	28.832	60.961	212.323	191.302	369.778	196.219	–1.5750	2900
3000	29.151	63.860	213.306	192.019	372.678	194.320	–1.4578	3000
3100	29.430	66.790	214.267	192.722	375.607	192.450	–1.3491	3100
3200	29.668	69.745	215.205	193.410	378.563	190.607	–1.2483	3200
3300	29.866	72.722	216.121	194.084	381.540	188.785	–1.1545	3300
3400	30.028	75.717	217.015	194.745	384.535	186.982	–1.0670	3400
3500	30.153	78.726	217.887	195.394	387.544	185.192	–0.9853	3500
3600	30.246	81.747	218.738	196.031	390.564	183.414	–0.9089	3600
3700	30.307	84.774	219.568	196.656	393.592	181.643	–0.8373	3700
3800	30.340	87.807	220.377	197.269	396.625	179.877	–0.7702	3800
3900	30.346	90.842	221.165	197.872	399.659	178.113	–0.7071	3900
4000	30.329	93.875	221.933	198.464	402.693	176.348	–0.6477	4000
4100	30.291	96.907	222.681	199.046	405.724	174.581	–0.5918	4100
4200	30.234	99.933	223.411	199.617	408.751	172.809	–0.5392	4200
4300	30.160	102.953	224.121	200.179	411.770	171.030	–0.4894	4300
4400	30.071	105.965	224.814	200.731	414.782	169.243	–0.4425	4400
4500	29.969	108.967	225.488	201.273	417.784	167.446	–0.3980	4500
4600	29.857	111.958	226.146	201.807	420.776	165.639	–0.3560	4600
4700	29.734	114.938	226.787	202.332	423.755	163.820	–0.3162	4700
4800	29.604	117.905	227.411	202.848	426.722	161.988	–0.2785	4800
4900	29.467	120.858	228.020	203.355	429.676	160.143	–0.2427	4900
5000	29.325	123.798	228.614	203.855	432.615	158.284	–0.2088	5000

TABLE A115.—THERMODYNAMIC PROPERTIES FOR Si^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	29.179	126.723	229.193	204.346	435.541	156.411	–0.1766	5100
5200	29.029	129.634	229.759	204.829	438.451	154.523	–0.1459	5200
5300	28.876	132.529	230.310	205.305	441.346	152.619	–0.1168	5300
5400	28.723	135.409	230.848	205.773	444.226	150.701	–0.0891	5400
5500	28.568	138.273	231.374	206.233	447.091	148.767	–0.0628	5500
5600	28.413	141.122	231.887	206.687	449.940	146.817	–0.0377	5600
5700	28.258	143.956	232.389	207.133	452.773	144.852	–0.0139	5700
5800	28.103	146.774	232.879	207.573	455.591	142.871	0.0089	5800
5900	27.950	149.577	233.358	208.006	458.394	140.875	0.0305	5900
6000	27.798	152.364	233.827	208.433	461.181	138.864	0.0511	6000
6200	27.500	157.894	234.733	209.266	466.711			6200
6400	27.211	163.365	235.602	210.076	472.182			6400
6600	26.931	168.779	236.435	210.862	477.596			6600
6800	26.663	174.138	237.235	211.626	482.955			6800
7000	26.405	179.445	238.004	212.369	488.262			7000
7200	26.159	184.701	238.744	213.091	493.518			7200
7400	25.925	189.909	239.458	213.794	498.727			7400
7600	25.702	195.072	240.146	214.479	503.889			7600
7800	25.490	200.190	240.811	215.146	509.008			7800
8000	25.288	205.268	241.454	215.795	514.086			8000
8500	24.829	217.795	242.973	217.350	526.612			8500
9000	24.427	230.107	244.380	218.813	538.924			9000
9500	24.076	242.230	245.691	220.193	551.048			9500
10000	23.768	254.190	246.918	221.499	563.007			10000
10500	23.497	266.004	248.071	222.738	574.822			10500
11000	23.260	277.692	249.159	223.914	586.510			11000
11500	23.050	289.269	250.188	225.034	598.086			11500
12000	22.864	300.746	251.165	226.103	609.564			12000
12500	22.699	312.136	252.095	227.124	620.954			12500
13000	22.552	323.448	252.982	228.102	632.266			13000
13500	22.421	334.691	253.831	229.039	643.508			13500
14000	22.303	345.871	254.644	229.939	654.689			14000
14500	22.197	356.995	255.425	230.804	665.813			14500
15000	22.101	368.069	256.176	231.638	676.887			15000
15500	22.014	379.098	256.899	232.441	687.915			15500
16000	21.936	390.085	257.597	233.216	698.903			16000
16500	21.864	401.035	258.270	233.965	709.852			16500
17000	21.799	411.950	258.922	234.690	720.768			17000
17500	21.740	422.835	259.553	235.391	731.652			17500
18000	21.685	433.691	260.165	236.071	742.508			18000
18500	21.635	444.521	260.758	236.730	753.338			18500
19000	21.589	455.327	261.335	237.370	764.144			19000
19500	21.546	466.110	261.895	237.992	774.928			19500
20000	21.507	476.873	262.440	238.596	785.691			20000

*Assigned reference element phase change at 1690 K

TABLE A116.—THERMODYNAMIC PROPERTIES FOR Sn

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.215	----------	----------	294.985	301.308	----------	0
100	20.786	–4.136	145.722	187.083	297.064	302.069	–151.4237	100
200	20.805	–2.057	160.132	170.418	299.143	301.726	–72.5608	200
298.15	21.260	0.000	168.495	168.495	301.200	301.200	–46.6399	298.15
300	21.278	0.039	168.626	168.495	301.239	301.188	–46.3144	300
400	22.888	2.238	174.940	169.345	303.438	300.585	–33.2162	400
500	25.328	4.645	180.301	171.011	305.845	300.000	–25.3731	500
*600	27.881	7.307	185.147	172.969	308.507	292.556	–20.2699	600
700	30.058	10.208	189.616	175.032	311.408	292.614	–16.6315	700
800	31.653	13.299	193.740	177.117	314.499	292.891	–13.9011	800
900	32.641	16.519	197.531	179.177	317.719	293.312	–11.7748	900
1000	33.096	19.809	200.998	181.189	321.009	293.808	–10.0712	1000
1100	33.135	23.124	204.157	183.135	324.324	294.327	–8.6749	1100
1200	32.880	26.427	207.031	185.009	327.627	294.828	–7.5092	1200
1300	32.439	29.694	209.646	186.805	330.894	295.287	–6.5213	1300
1400	31.896	32.911	212.031	188.523	334.111	295.686	–5.6732	1400
1500	31.312	36.071	214.211	190.164	337.271	296.019	–4.9374	1500
1600	30.728	39.173	216.214	191.730	340.373	296.281	–4.2928	1600
1700	30.169	42.218	218.060	193.225	343.418	296.474	–3.7237	1700
1800	29.648	45.208	219.769	194.653	346.408	296.601	–3.2175	1800
1900	29.172	48.149	221.359	196.017	349.349	296.666	–2.7644	1900
2000	28.740	51.044	222.844	197.322	352.244	296.672	–2.3566	2000
2100	28.353	53.899	224.237	198.571	355.099	296.626	–1.9877	2100
2200	28.006	56.716	225.548	199.768	357.916	296.530	–1.6524	2200
2300	27.695	59.501	226.786	200.916	360.701	296.389	–1.3463	2300
2400	27.417	62.256	227.958	202.018	363.456	296.207	–1.0660	2400
2500	27.166	64.985	229.072	203.078	366.185	295.986	–0.8082	2500
2600	26.940	67.691	230.133	204.099	368.891	295.729	–0.5704	2600
2700	26.735	70.374	231.146	205.082	371.574	295.439	–0.3505	2700
2800	26.548	73.038	232.115	206.030	374.238	295.118	–0.1465	2800
2900	26.376	75.684	233.044	206.946	376.884	294.769	0.0432	2900
3000	26.218	78.314	233.935	207.831	379.514	294.391	0.2201	3000
3100	26.071	80.928	234.792	208.687	382.128	293.988	0.3853	3100
3200	25.934	83.528	235.618	209.515	384.728	293.560	0.5400	3200
3300	25.806	86.115	236.414	210.319	387.315	293.109	0.6851	3300
3400	25.685	88.690	237.183	211.097	389.890	292.636	0.8215	3400
3500	25.571	91.253	237.926	211.853	392.453	292.141	0.9498	3500
3600	25.463	93.804	238.644	212.588	395.004	291.626	1.0708	3600
3700	25.361	96.346	239.341	213.301	397.546	291.091	1.1851	3700
3800	25.263	98.877	240.016	213.995	400.077	290.538	1.2931	3800
3900	25.170	101.398	240.671	214.671	402.598	289.967	1.3954	3900
4000	25.081	103.911	241.307	215.329	405.111	289.379	1.4924	4000
4100	24.996	106.415	241.925	215.970	407.615	288.774	1.5845	4100
4200	24.916	108.910	242.526	216.595	410.110	288.154	1.6720	4200
4300	24.839	111.398	243.112	217.205	412.598	287.518	1.7552	4300
4400	24.766	113.878	243.682	217.801	415.078	286.868	1.8345	4400
4500	24.697	116.351	244.238	218.382	417.551	286.205	1.9101	4500

TABLE A116.—THERMODYNAMIC PROPERTIES FOR Sn (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	24.632	118.818	244.780	218.950	420.018	285.529	1.9822	4600
4700	24.571	121.278	245.309	219.505	422.478	284.840	2.0511	4700
4800	24.515	123.732	245.826	220.048	424.932			4800
4900	24.463	126.181	246.331	220.579	427.381			4900
5000	24.414	128.625	246.824	221.099	429.825			5000
5100	24.371	131.063	247.307	221.609	432.263			5100
5200	24.332	133.499	247.780	222.107	434.699			5200
5300	24.300	135.930	248.243	222.596	437.130			5300
5400	24.272	138.358	248.697	223.075	439.558			5400
5500	24.250	140.784	249.142	223.545	441.984			5500
5600	24.234	143.208	249.579	224.006	444.408			5600
5700	24.223	145.631	250.008	224.459	446.831			5700
5800	24.220	148.053	250.429	224.903	449.253			5800
5900	24.218	150.472	250.843	225.339	451.672			5900
6000	24.225	152.893	251.249	225.767	454.093			6000
6200	24.263	157.741	252.044	226.602	458.941			6200
6400	24.328	162.597	252.815	227.409	463.797			6400
6600	24.400	167.455	253.562	228.190	468.655			6600
6800	24.525	172.347	254.293	228.947	473.547			6800
7000	24.683	177.268	255.006	229.682	478.468			7000
7200	24.874	182.223	255.704	230.395	483.423			7200
7400	25.084	187.208	256.386	231.088	488.408			7400
7600	25.339	192.249	257.059	231.763	493.449			7600
7800	25.593	197.316	257.716	232.419	498.516			7800
8000	25.908	202.466	258.368	233.060	503.666			8000
8500	26.796	215.862	259.997	234.601	517.062			8500
9000	27.769	229.497	261.555	236.055	530.697			9000
9500	28.869	243.653	263.086	237.438	544.853			9500
10000	30.031	258.377	264.596	238.758	559.577			10000
10500	31.190	273.684	266.089	240.024	574.884			10500
11000	32.286	289.557	267.566	241.243	590.757			11000
11500	33.270	305.950	269.023	242.419	607.150			11500
12000	34.109	322.802	270.457	243.557	624.002			12000
12500	34.778	340.031	271.864	244.661	641.231			12500
13000	35.266	357.550	273.238	245.734	658.750			13000
13500	35.570	375.266	274.575	246.778	676.466			13500
14000	35.697	393.090	275.872	247.794	694.290			14000
14500	35.659	410.936	277.124	248.784	712.136			14500
15000	35.472	428.724	278.330	249.749	729.924			15000
15500	35.160	446.388	279.489	250.689	747.588			15500
16000	34.744	463.866	280.599	251.607	765.066			16000
16500	34.250	481.118	281.660	252.502	782.318			16500
17000	33.701	498.107	282.675	253.374	799.307			17000
17500	33.123	514.814	283.643	254.225	816.014			17500
18000	32.536	531.229	284.568	255.056	832.429			18000
18500	31.962	547.353	285.452	255.865	848.553			18500
19000	31.417	563.196	286.297	256.655	864.396			19000
19500	30.914	578.777	287.106	257.425	879.977			19500
20000	30.462	594.118	287.883	258.177	895.318			20000

***Assigned reference element phase change at 505.118 K**

TABLE A117.—THERMODYNAMIC PROPERTIES FOR Sn^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1009.753	1009.878	----------	0
298.15	20.786	0.000	174.193	174.193	1015.950	1015.950	–170.4645	298.15
300	20.786	0.038	174.321	174.193	1015.988	1015.976	–169.3668	300
400	20.787	2.117	180.301	175.009	1018.067	1017.331	–125.1164	400
500	20.798	4.196	184.941	176.548	1020.146	1018.497	–98.5325	500
*600	20.851	6.278	188.736	178.273	1022.228	1012.551	–80.9070	600
700	20.990	8.369	191.960	180.003	1024.319	1013.878	–68.3066	700
800	21.250	10.480	194.778	181.678	1026.430	1015.254	–58.8437	800
900	21.641	12.624	197.302	183.276	1028.574	1016.677	–51.4735	900
1000	22.146	14.812	199.607	184.795	1030.762	1018.150	–45.5689	1000
1100	22.734	17.056	201.745	186.240	1033.006	1019.676	–40.7307	1100
1200	23.364	19.360	203.750	187.617	1035.310	1021.258	–36.6928	1200
1300	24.000	21.729	205.646	188.931	1037.679	1022.897	–33.2706	1300
1400	24.610	24.160	207.447	190.190	1040.109	1024.588	–30.3326	1400
1500	25.169	26.649	209.164	191.398	1042.599	1026.328	–27.7821	1500
1600	25.664	29.191	210.805	192.560	1045.141	1028.109	–25.5465	1600
1700	26.084	31.779	212.373	193.680	1047.729	1029.924	–23.5704	1700
1800	26.427	34.405	213.874	194.760	1050.355	1031.766	–21.8109	1800
1900	26.694	37.062	215.311	195.804	1053.012	1033.625	–20.2337	1900
2000	26.891	39.742	216.685	196.814	1055.692	1035.495	–18.8116	2000
2100	27.022	42.438	218.001	197.792	1058.388	1037.369	–17.5227	2100
2200	27.096	45.144	219.260	198.740	1061.094	1039.240	–16.3488	2200
2300	27.120	47.856	220.465	199.658	1063.806	1041.105	–15.2751	2300
2400	27.102	50.567	221.619	200.549	1066.517	1042.957	–14.2890	2400
2500	27.048	53.275	222.724	201.414	1069.225	1044.793	–13.3803	2500
2600	26.966	55.976	223.784	202.254	1071.926	1046.611	–12.5400	2600
2700	26.860	58.667	224.799	203.071	1074.617	1048.408	–11.7606	2700
2800	26.737	61.347	225.774	203.864	1077.297	1050.182	–11.0356	2800
2900	26.599	64.014	226.710	204.636	1079.964	1051.931	–10.3595	2900
3000	26.451	66.667	227.609	205.387	1082.617	1053.655	–9.7274	3000
3100	26.297	69.304	228.474	206.118	1085.254	1055.354	–9.1352	3100
3200	26.137	71.926	229.306	206.830	1087.876	1057.026	–8.5791	3200
3300	25.976	74.532	230.108	207.523	1090.481	1058.672	–8.0558	3300
3400	25.814	77.121	230.881	208.199	1093.071	1060.293	–7.5626	3400
3500	25.652	79.694	231.627	208.857	1095.644	1061.887	–7.0968	3500
3600	25.493	82.252	232.348	209.500	1098.201	1063.456	–6.6563	3600
3700	25.336	84.793	233.044	210.127	1100.743	1065.001	–6.2390	3700
3800	25.183	87.319	233.718	210.739	1103.269	1066.521	–5.8430	3800
3900	25.033	89.830	234.370	211.336	1105.779	1068.017	–5.4669	3900
4000	24.888	92.326	235.002	211.920	1108.275	1069.491	–5.1090	4000
4100	24.747	94.807	235.614	212.491	1110.757	1070.943	–4.7682	4100
4200	24.611	97.275	236.209	213.048	1113.225	1072.373	–4.4431	4200
4300	24.480	99.730	236.787	213.594	1115.680	1073.783	–4.1328	4300
4400	24.353	102.171	237.348	214.127	1118.121	1075.174	–3.8361	4400
4500	24.232	104.601	237.894	214.649	1120.550	1076.545	–3.5523	4500
4600	24.115	107.018	238.425	215.161	1122.968	1077.898	–3.2805	4600
4700	24.003	109.424	238.943	215.661	1125.374	1079.234	–3.0199	4700
4800	23.895	111.818	239.447	216.151	1127.768			4800
4900	23.792	114.203	239.939	216.632	1130.153			4900
5000	23.693	116.577	240.418	217.103	1132.527			5000

TABLE A117.—THERMODYNAMIC PROPERTIES FOR Sn^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	23.599	118.942	240.886	217.565	1134.892			5100
5200	23.509	121.297	241.344	218.017	1137.247			5200
5300	23.422	123.643	241.791	218.462	1139.593			5300
5400	23.340	125.982	242.228	218.898	1141.931			5400
5500	23.262	128.312	242.655	219.326	1144.262			5500
5600	23.187	130.634	243.074	219.746	1146.584			5600
5700	23.116	132.949	243.484	220.159	1148.899			5700
5800	23.049	135.257	243.885	220.565	1151.207			5800
5900	22.985	137.559	244.278	220.963	1153.509			5900
6000	22.924	139.854	244.664	221.355	1155.804			6000
6200	22.813	144.428	245.414	222.119	1160.378			6200
6400	22.714	148.980	246.137	222.859	1164.930			6400
6600	22.628	153.514	246.834	223.575	1169.464			6600
6800	22.554	158.032	247.509	224.269	1173.982			6800
7000	22.492	162.537	248.162	224.942	1178.487			7000
7200	22.442	167.030	248.795	225.596	1182.980			7200
7400	22.403	171.514	249.409	226.231	1187.464			7400
7600	22.376	175.992	250.006	226.849	1191.942			7600
7800	22.361	180.466	250.587	227.450	1196.416			7800
8000	22.357	184.937	251.153	228.036	1200.887			8000
8500	22.400	196.124	252.509	229.436	1212.074			8500
9000	22.517	207.350	253.793	230.754	1223.300			9000
9500	22.711	218.654	255.015	231.999	1234.604			9500
10000	22.981	230.073	256.186	233.179	1246.023			10000
10500	23.330	241.647	257.316	234.302	1257.597			10500
11000	23.757	253.415	258.410	235.373	1269.365			11000
11500	24.263	265.416	259.477	236.398	1281.366			11500
12000	24.845	277.689	260.522	237.381	1293.639			12000
12500	25.499	290.268	261.549	238.327	1306.218			12500
13000	26.223	303.093	262.546	239.232	1319.043			13000
13500	27.028	316.403	263.551	240.114	1332.353			13500
14000	27.884	330.128	264.549	240.969	1346.078			14000
14500	28.780	344.293	265.543	241.799	1360.243			14500
15000	29.703	358.913	266.535	242.607	1374.863			15000
15500	30.641	373.999	267.524	243.395	1389.949			15500
16000	31.580	389.555	268.511	244.164	1405.505			16000
16500	32.509	405.577	269.497	244.917	1421.527			16500
17000	33.415	422.059	270.481	245.654	1438.009			17000
17500	34.285	438.986	271.463	246.378	1454.936			17500
18000	35.108	456.336	272.440	247.088	1472.286			18000
18500	35.873	474.084	273.413	247.787	1490.034			18500
19000	36.569	492.197	274.379	248.474	1508.147			19000
19500	37.188	510.640	275.337	249.150	1526.590			19500
20000	37.721	529.372	276.285	249.817	1545.322			20000

*Assigned reference element phase change at 505.118 K

TABLE A118.—THERMODYNAMIC PROPERTIES FOR Sn^-

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.490	----------	----------	173.006	185.526	----------	0
298.15	24.464	0.000	181.197	181.197	179.496	179.496	–25.7507	298.15
300	24.501	0.045	181.349	181.198	179.541	179.452	–25.5567	300
400	25.728	2.569	188.601	182.178	182.065	177.095	–17.7918	400
500	25.786	5.152	194.363	184.060	184.648	174.607	–13.1963	500
*600	25.313	7.709	199.027	186.179	187.205	164.979	–10.2938	600
700	24.702	10.210	202.883	188.298	189.706	162.559	–8.2563	700
800	24.118	12.650	206.143	190.330	192.146	160.107	–6.7510	800
900	23.612	15.036	208.954	192.247	194.532	157.615	–5.5981	900
1000	23.190	17.375	211.419	194.044	196.871	155.081	–4.6904	1000
1100	22.844	19.677	213.612	195.725	199.172	152.508	–3.9599	1100
1200	22.559	21.946	215.587	197.299	201.442	149.898	–3.3614	1200
1300	22.325	24.190	217.384	198.776	203.686	147.255	–2.8638	1300
1400	22.132	26.413	219.031	200.165	205.909	144.581	–2.4450	1400
1500	21.971	28.618	220.552	201.474	208.113	141.879	–2.0886	1500
1600	21.836	30.808	221.966	202.711	210.304	139.150	–1.7827	1600
1700	21.722	32.985	223.286	203.883	212.481	136.398	–1.5181	1700
1800	21.625	35.153	224.525	204.995	214.649	133.623	–1.2876	1800
1900	21.542	37.311	225.692	206.054	216.807	130.827	–1.0856	1900
2000	21.470	39.461	226.795	207.064	218.957	128.010	–0.9077	2000
2100	21.408	41.605	227.841	208.029	221.101	125.174	–0.7502	2100
2200	21.353	43.743	228.835	208.952	223.239	122.320	–0.6103	2200
2300	21.306	45.876	229.783	209.837	225.372	119.449	–0.4855	2300
2400	21.264	48.004	230.689	210.687	227.500	116.561	–0.3738	2400
2500	21.227	50.129	231.556	211.505	229.625	113.657	–0.2736	2500
2600	21.194	52.250	232.388	212.292	231.746	110.737	–0.1834	2600
2700	21.164	54.368	233.188	213.051	233.864	107.803	–0.1021	2700
2800	21.138	56.483	233.957	213.784	235.979	104.855	–0.0286	2800
2900	21.114	58.595	234.698	214.493	238.091	101.893	0.0379	2900
3000	21.092	60.706	235.414	215.178	240.202	98.918	0.0982	3000
3100	21.073	62.814	236.105	215.842	242.310	95.930	0.1529	3100
3200	21.055	64.920	236.774	216.486	244.416	92.929	0.2027	3200
3300	21.039	67.025	237.421	217.111	246.521	89.917	0.2479	3300
3400	21.024	69.128	238.049	217.717	248.624	86.894	0.2891	3400
3500	21.011	71.230	238.658	218.307	250.726	83.859	0.3265	3500
3600	20.998	73.330	239.250	218.881	252.826	80.815	0.3607	3600
3700	20.987	75.429	239.825	219.439	254.925	77.760	0.3918	3700
3800	20.976	77.528	240.385	219.983	257.024	74.695	0.4201	3800
3900	20.967	79.625	240.930	220.513	259.121	71.620	0.4459	3900
4000	20.958	81.721	241.460	221.030	261.217	68.537	0.4694	4000
4100	20.949	83.816	241.978	221.535	263.312	65.445	0.4907	4100
4200	20.942	85.911	242.482	222.027	265.407	62.345	0.5101	4200
4300	20.935	88.005	242.975	222.509	267.501	59.237	0.5277	4300
4400	20.928	90.098	243.456	222.979	269.594	56.122	0.5436	4400
4500	20.922	92.190	243.926	223.440	271.686	52.999	0.5580	4500
4600	20.916	94.282	244.386	223.890	273.778	49.870	0.5710	4600
4700	20.910	96.373	244.836	224.331	275.869	46.734	0.5827	4700
4800	20.905	98.464	245.276	224.763	277.960			4800
4900	20.900	100.554	245.707	225.186	280.050			4900
5000	20.896	102.644	246.129	225.601	282.140			5000

TABLE A118.—THERMODYNAMIC PROPERTIES FOR Sn^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.891	104.734	246.543	226.007	284.230			5100
5200	20.887	106.823	246.949	226.406	286.318			5200
5300	20.883	108.911	247.347	226.797	288.407			5300
5400	20.880	110.999	247.737	227.181	290.495			5400
5500	20.876	113.087	248.120	227.559	292.583			5500
5600	20.873	115.174	248.496	227.929	294.670			5600
5700	20.870	117.262	248.866	228.293	296.758			5700
5800	20.867	119.349	249.228	228.651	298.844			5800
5900	20.865	121.435	249.585	229.003	300.931			5900
6000	20.862	123.521	249.936	229.349	303.017			6000
6200	20.857	127.693	250.620	230.024	307.189			6200
6400	20.853	131.864	251.282	230.678	311.360			6400
6600	20.849	136.034	251.924	231.312	315.530			6600
6800	20.845	140.204	252.546	231.928	319.700			6800
7000	20.842	144.372	253.150	232.525	323.868			7000
7200	20.839	148.540	253.737	233.107	328.036			7200
7400	20.836	152.708	254.308	233.672	332.204			7400
7600	20.833	156.875	254.864	234.222	336.371			7600
7800	20.831	161.041	255.405	234.759	340.537			7800
8000	20.829	165.207	255.932	235.281	344.703			8000
8500	20.824	175.620	257.195	236.534	355.116			8500
9000	20.820	186.031	258.385	237.715	365.527			9000
9500	20.816	196.440	259.510	238.833	375.936			9500
10000	20.813	206.847	260.578	239.893	386.343			10000
10500	20.811	217.253	261.594	240.903	396.749			10500
11000	20.809	227.658	262.562	241.865	407.154			11000
11500	20.807	238.062	263.487	242.785	417.558			11500
12000	20.805	248.465	264.372	243.667	427.961			12000
12500	20.803	258.867	265.221	244.512	438.363			12500
13000	20.802	269.268	266.037	245.324	448.764			13000
13500	20.801	279.669	266.822	246.106	459.165			13500
14000	20.800	290.069	267.579	246.859	469.565			14000
14500	20.799	300.469	268.309	247.587	479.965			14500
15000	20.798	310.868	269.014	248.289	490.364			15000
15500	20.797	321.267	269.696	248.969	500.763			15500
16000	20.797	331.666	270.356	249.627	511.162			16000
16500	20.796	342.064	270.996	250.265	521.560			16500
17000	20.796	352.462	271.617	250.884	531.958			17000
17500	20.795	362.859	272.219	251.485	542.355			17500
18000	20.795	373.257	272.805	252.069	552.753			18000
18500	20.794	383.654	273.375	252.637	563.150			18500
19000	20.794	394.051	273.930	253.190	573.547			19000
19500	20.793	404.448	274.470	253.729	583.944			19500
20000	20.793	414.844	274.996	254.254	594.340			20000

*Assigned reference element phase change at 505.118 K

TABLE A119.—THERMODYNAMIC PROPERTIES FOR Sr

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	154.303	160.861	----------	0
100	20.786	–4.119	141.935	183.123	156.381	161.451	–78.3458	100
200	20.786	–2.040	156.343	166.544	158.460	161.040	–36.2172	200
298.15	20.786	0.000	164.642	164.642	160.500	160.500	–22.3912	298.15
300	20.786	0.038	164.771	164.643	160.538	160.489	–22.2178	300
400	20.786	2.117	170.751	165.458	162.617	159.831	–15.2447	400
500	20.786	4.196	175.389	166.998	164.696	159.083	–11.0793	500
600	20.786	6.274	179.179	168.722	166.774	158.258	–8.3161	600
700	20.786	8.353	182.383	170.450	168.853	157.365	–6.3531	700
800	20.786	10.432	185.159	172.119	170.932	156.410	–4.8895	800
*900	20.786	12.510	187.607	173.707	173.010	154.626	–3.7629	900
1000	20.786	14.589	189.797	175.208	175.089	153.670	–2.8682	1000
*1100	20.786	16.667	191.778	176.626	177.167	144.310	–2.1628	1100
1200	20.787	18.746	193.587	177.965	179.246	142.688	–1.5949	1200
1300	20.788	20.825	195.251	179.232	181.325	141.067	–1.1197	1300
1400	20.791	22.904	196.791	180.432	183.404	139.446	–0.7171	1400
1500	20.799	24.983	198.226	181.571	185.483	137.825	–0.3723	1500
1600	20.813	27.064	199.569	182.654	187.564	136.206	–0.0740	1600
1700	20.839	29.146	200.831	183.686	189.646	134.588	0.1860	1700
1800	20.882	31.232	202.024	184.672	191.732	132.974	0.4144	1800
1900	20.950	33.324	203.154	185.616	193.824	131.366	0.6163	1900
2000	21.050	35.423	204.231	186.520	195.923	129.765	0.7958	2000
2100	21.191	37.535	205.261	187.388	198.035	128.177	0.9562	2100
2200	21.384	39.663	206.252	188.223	200.163	126.605	1.1002	2200
2300	21.637	41.814	207.207	189.028	202.314	125.056	1.2301	2300
2400	21.960	43.993	208.135	189.804	204.493	123.535	1.3477	2400
2500	22.362	46.208	209.039	190.556	206.708	122.050	1.4546	2500
2600	22.850	48.468	209.925	191.284	208.968	120.610	1.5521	2600
2700	23.431	50.781	210.798	191.990	211.281	119.223	1.6414	2700
2800	24.110	53.157	211.662	192.678	213.657	117.900	1.7233	2800
2900	24.889	55.606	212.522	193.347	216.106	116.649	1.7987	2900
3000	25.770	58.139	213.380	194.001	218.639	115.481	1.8684	3000
3100	26.753	60.764	214.241	194.640	221.264	114.406	1.9330	3100
3200	27.833	63.492	215.107	195.266	223.992	113.434	1.9930	3200
3300	29.007	66.334	215.981	195.880	226.834	112.576	2.0488	3300
3400	30.268	69.297	216.866	196.484	229.797	111.839	2.1011	3400
3500	31.609	72.390	217.762	197.079	232.890	111.232	2.1500	3500
3600	33.018	75.621	218.672	197.667	236.121	110.763	2.1960	3600
3700	34.486	78.995	219.597	198.247	239.495	110.437	2.2394	3700
3800	36.000	82.519	220.536	198.821	243.019	110.261	2.2804	3800
3900	37.549	86.196	221.491	199.390	246.696	110.238	2.3193	3900
4000	39.119	90.029	222.462	199.955	250.529	110.372	2.3562	4000
4100	40.697	94.020	223.447	200.515	254.520	110.662	2.3914	4100
4200	42.259	98.164	224.446	201.073	258.664	111.107	2.4250	4200
4300	43.812	102.468	225.458	201.629	262.968	111.710	2.4572	4300
4400	45.337	106.925	226.483	202.182	267.425	112.467	2.4882	4400
4500	46.821	111.533	227.518	202.733	272.033	113.375	2.5179	4500

TABLE A119.—THERMODYNAMIC PROPERTIES FOR Sr (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	48.221	116.273	228.560	203.283	276.773	114.416	2.5467	4600
4700	49.592	121.165	229.612	203.832	281.665	115.607	2.5745	4700
4800	50.893	126.188	230.669	204.380	286.688	116.931	2.6014	4800
4900	52.124	131.340	231.732	204.928	291.840	118.382	2.6275	4900
5000	53.228	136.628	232.801	205.475	297.128	119.970	2.6529	5000
5100	54.341	142.008	233.866	206.021	302.508	121.650	2.6777	5100
5200	55.338	147.492	234.931	206.567	307.992	123.435	2.7018	5200
5300	56.225	153.071	235.993	207.112	313.571	125.314	2.7254	5300
5400	57.005	158.734	237.052	207.657	319.234	127.276	2.7484	5400
5500	57.682	164.469	238.104	208.201	324.969	129.311	2.7710	5500
5600	58.262	170.267	239.149	208.744	330.767	131.409	2.7931	5600
5700	58.748	176.119	240.185	209.287	336.619	133.561	2.8148	5700
5800	59.146	182.014	241.210	209.828	342.514	135.756	2.8360	5800
5900	59.461	187.945	242.224	210.369	348.445	137.987	2.8569	5900
6000	59.696	193.903	243.225	210.908	354.403	140.245	2.8775	6000
6200	59.950	205.872	245.187	211.982	366.372			6200
6400	59.944	217.866	247.091	213.050	378.366			6400
6600	59.712	229.835	248.933	214.109	390.335			6600
6800	59.286	241.738	250.710	215.160	402.238			6800
7000	58.695	253.538	252.420	216.200	414.038			7000
7200	57.967	265.207	254.064	217.229	425.707			7200
7400	57.127	276.718	255.641	218.246	437.218			7400
7600	56.195	288.051	257.152	219.250	448.551			7600
7800	55.192	299.191	258.599	220.241	459.691			7800
8000	54.136	310.124	259.983	221.217	470.624			8000
8500	51.357	336.503	263.182	223.594	497.003			8500
9000	48.528	361.474	266.037	225.874	521.974			9000
9500	45.784	385.046	268.587	228.056	545.546			9500
10000	43.211	407.286	270.869	230.141	567.786			10000
10500	40.857	428.293	272.920	232.130	588.793			10500
11000	38.746	448.184	274.771	234.027	608.684			11000
11500	36.876	467.079	276.451	235.835	627.579			11500
12000	35.234	485.098	277.985	237.560	645.598			12000
12500	33.796	502.348	279.393	239.205	662.848			12500
13000	32.531	518.923	280.694	240.776	679.423			13000
13500	31.407	534.903	281.900	242.277	695.403			13500
14000	30.392	550.348	283.024	243.713	710.848			14000
14500	29.454	565.307	284.073	245.087	725.807			14500
15000	28.568	579.811	285.057	246.403	740.311			15000
15500	27.714	593.880	285.980	247.665	754.380			15500
16000	26.879	607.528	286.846	248.876	768.028			16000
16500	26.059	620.762	287.661	250.039	781.262			16500
17000	25.257	633.590	288.427	251.157	794.090			17000
17500	24.488	646.024	289.148	252.232	806.524			17500
18000	23.778	658.089	289.827	253.267	818.589			18000
18500	23.163	669.819	290.470	254.264	830.319			18500
19000	22.691	681.275	291.081	255.225	841.775			19000
19500	22.422	692.544	291.667	256.152	853.044			19500
20000	22.429	703.744	292.234	257.047	864.244			20000

***Assigned reference element phase change at 820 K and 1041 K**

TABLE A120.—THERMODYNAMIC PROPERTIES FOR Sr^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	709.969	710.330	----------	0
298.15	20.786	0.000	170.405	170.405	716.166	716.166	–118.3423	298.15
300	20.786	0.038	170.534	170.406	716.205	716.194	–117.5686	300
400	20.786	2.117	176.514	171.221	718.283	717.614	–86.3660	400
500	20.786	4.196	181.152	172.761	720.362	718.945	–67.6080	500
600	20.786	6.274	184.942	174.485	722.441	720.199	–55.0800	600
700	20.786	8.353	188.146	176.213	724.519	721.385	–46.1162	700
800	20.786	10.432	190.922	177.882	726.598	722.508	–39.3825	800
*900	20.786	12.510	193.370	179.470	728.677	722.802	–34.1419	900
1000	20.786	14.589	195.560	180.971	730.755	723.925	–29.9438	1000
*1100	20.786	16.667	197.541	182.389	732.834	716.643	–26.5257	1100
1200	20.787	18.746	199.350	183.728	734.912	717.101	–23.6890	1200
1300	20.787	20.825	201.014	184.995	736.991	717.558	–21.2872	1300
1400	20.789	22.904	202.554	186.195	739.070	718.015	–19.2272	1400
1500	20.792	24.983	203.989	187.334	741.149	718.473	–17.4408	1500
1600	20.799	27.062	205.331	188.417	743.229	718.931	–15.8766	1600
1700	20.811	29.143	206.592	189.449	745.309	719.390	–14.4956	1700
1800	20.831	31.225	207.782	190.435	747.391	719.851	–13.2672	1800
1900	20.861	33.309	208.909	191.378	749.476	720.314	–12.1674	1900
2000	20.904	35.397	209.980	192.282	751.564	720.781	–11.1770	2000
2100	20.963	37.491	211.002	193.149	753.657	721.253	–10.2803	2100
2200	21.041	39.591	211.978	193.983	755.757	721.731	–9.4646	2200
2300	21.141	41.699	212.916	194.786	757.866	722.219	–8.7193	2300
2400	21.264	43.820	213.818	195.560	759.986	722.718	–8.0357	2400
2500	21.414	45.953	214.689	196.308	762.120	723.230	–7.4063	2500
2600	21.591	48.103	215.532	197.031	764.270	723.759	–6.8249	2600
2700	21.795	50.272	216.351	197.732	766.439	724.306	–6.2862	2700
2800	22.029	52.463	217.148	198.411	768.630	724.876	–5.7856	2800
2900	22.291	54.679	217.925	199.070	770.845	725.470	–5.3191	2900
3000	22.580	56.922	218.686	199.712	773.089	726.092	–4.8834	3000
3100	22.897	59.196	219.431	200.336	775.362	726.744	–4.4754	3100
3200	23.239	61.503	220.164	200.944	777.669	727.430	–4.0925	3200
3300	23.605	63.845	220.884	201.537	780.011	728.150	–3.7325	3300
3400	23.993	66.224	221.595	202.117	782.391	728.909	–3.3934	3400
3500	24.400	68.644	222.296	202.683	784.810	729.707	–3.0733	3500
3600	24.825	71.105	222.989	203.238	787.271	730.547	–2.7706	3600
3700	25.264	73.609	223.675	203.781	789.776	731.430	–2.4840	3700
3800	25.714	76.158	224.355	204.313	792.325	732.357	–2.2121	3800
3900	26.174	78.753	225.029	204.836	794.919	733.330	–1.9538	3900
4000	26.640	81.393	225.697	205.349	797.560	734.349	–1.7081	4000
4100	27.110	84.081	226.361	205.854	800.247	735.416	–1.4740	4100
4200	27.582	86.815	227.020	206.350	802.982	736.529	–1.2508	4200
4300	28.051	89.597	227.675	206.838	805.763	737.689	–1.0376	4300
4400	28.517	92.425	228.325	207.319	808.592	738.896	–0.8338	4400
4500	28.977	95.300	228.971	207.793	811.467	740.150	–0.6387	4500
4600	29.429	98.221	229.613	208.260	814.387	741.449	–0.4517	4600
4700	29.870	101.186	230.250	208.721	817.352	742.792	–0.2725	4700
4800	30.299	104.194	230.884	209.177	820.361	744.179	–0.1003	4800
4900	30.715	107.245	231.513	209.626	823.411	745.609	0.0651	4900
5000	31.116	110.337	232.137	210.070	826.503	747.079	0.2242	5000

TABLE A120.—THERMODYNAMIC PROPERTIES FOR Sr^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	31.501	113.468	232.757	210.509	829.634	748.589	0.3774	5100
5200	31.878	115.772	233.366	211.103	831.938	749.271	0.5334	5200
5300	32.232	118.977	233.977	211.528	835.144	750.856	0.6755	5300
5400	32.567	122.217	234.583	211.950	838.384	752.474	0.8127	5400
5500	32.880	125.490	235.183	212.367	841.656	754.125	0.9452	5500
5600	33.170	128.792	235.778	212.779	844.959	755.807	1.0732	5600
5700	33.438	132.123	236.368	213.188	848.290	757.516	1.1970	5700
5800	33.680	135.479	236.951	213.593	851.646	759.251	1.3169	5800
5900	33.898	138.859	237.529	213.994	855.025	761.009	1.4329	5900
6000	34.090	142.258	238.100	214.391	858.424	762.787	1.5453	6000
6200	34.445	149.112	239.224	215.174	865.279			6200
6400	34.740	156.032	240.322	215.942	872.198			6400
6600	34.975	163.004	241.395	216.698	879.171			6600
6800	35.151	170.018	242.442	217.439	886.184			6800
7000	35.272	177.061	243.463	218.168	893.227			7000
7200	35.344	184.123	244.458	218.885	900.289			7200
7400	35.372	191.195	245.426	219.589	907.362			7400
7600	35.362	198.269	246.370	220.282	914.436			7600
7800	35.320	205.338	247.288	220.962	921.504			7800
8000	35.252	212.396	248.181	221.632	928.562			8000
8500	35.006	229.963	250.311	223.257	946.130			8500
9000	34.710	247.393	252.304	224.816	963.559			9000
9500	34.425	264.676	254.173	226.312	980.842			9500
10000	34.194	281.828	255.933	227.750	997.994			10000
10500	34.044	298.883	257.597	229.132	1015.050			10500
11000	33.988	315.888	259.179	230.462	1032.054			11000
11500	34.028	332.888	260.690	231.743	1049.054			11500
12000	34.158	349.930	262.141	232.980	1066.097			12000
12500	34.366	367.059	263.539	234.175	1083.225			12500
13000	34.634	384.306	264.892	235.330	1100.473			13000
13500	34.943	401.699	266.205	236.449	1117.865			13500
14000	35.271	419.253	267.482	237.535	1135.419			14000
14500	35.598	436.969	268.725	238.589	1153.136			14500
15000	35.903	454.846	269.937	239.614	1171.013			15000
15500	36.169	472.867	271.119	240.611	1189.033			15500
16000	36.380	491.006	272.271	241.583	1207.173			16000
16500	36.524	509.236	273.393	242.530	1225.402			16500
17000	36.594	527.518	274.484	243.454	1243.684			17000
17500	36.587	545.815	275.545	244.355	1261.982			17500
18000	36.504	564.091	276.575	245.236	1280.257			18000
18500	36.352	582.309	277.573	246.097	1298.475			18500
19000	36.146	600.434	278.540	246.938	1316.600			19000
19500	35.903	618.447	279.476	247.760	1334.614			19500
20000	35.649	636.336	280.381	248.565	1352.503			20000

*Assigned reference element phase change at 820 K and 1041 K

TABLE A121.—THERMODYNAMIC PROPERTIES FOR Ta

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.200	----------	----------	776.319	782.000	----------	0
100	20.786	–4.121	162.506	203.716	778.398	783.084	–401.3856	100
200	20.788	–2.042	176.914	187.126	780.476	782.910	–196.8791	200
298.15	20.858	0.000	185.221	185.221	782.519	782.519	–129.5820	298.15
300	20.862	0.039	185.350	185.222	782.557	782.510	–128.7366	300
400	21.260	2.141	191.396	186.044	784.660	782.054	–94.6846	400
500	22.082	4.305	196.221	187.611	786.824	781.609	–74.2654	500
600	23.183	6.567	200.342	189.397	789.085	781.210	–60.6601	600
700	24.381	8.945	204.005	191.227	791.463	780.884	–50.9466	700
800	25.563	11.442	207.339	193.036	793.961	780.648	–43.6641	800
900	26.676	14.055	210.415	194.798	796.574	780.505	–38.0013	900
1000	27.702	16.775	213.279	196.505	799.293	780.445	–33.4718	1000
1100	28.634	19.592	215.964	198.153	802.111	780.452	–29.7658	1100
1200	29.470	22.498	218.492	199.743	805.017	780.510	–26.6774	1200
1300	30.213	25.483	220.881	201.278	808.002	780.612	–24.0639	1300
1400	30.866	28.538	223.144	202.760	811.056	780.755	–21.8234	1400
1500	31.438	31.654	225.294	204.191	814.172	780.945	–19.8812	1500
1600	31.938	34.823	227.339	205.575	817.342	781.178	–18.1813	1600
1700	32.378	38.039	229.289	206.913	820.558	781.439	–16.6809	1700
1800	32.769	41.297	231.151	208.208	823.815	781.707	–15.3468	1800
1900	33.120	44.592	232.932	209.463	827.110	781.962	–14.1527	1900
2000	33.442	47.920	234.639	210.679	830.438	782.198	–13.0777	2000
2100	33.741	51.279	236.278	211.859	833.798	782.412	–12.1048	2100
2200	34.022	54.667	237.854	213.005	837.186	782.602	–11.2201	2200
2300	34.292	58.083	239.372	214.119	840.602	782.765	–10.4121	2300
2400	34.552	61.525	240.837	215.202	844.044	782.893	–9.6714	2400
2500	34.806	64.993	242.253	216.256	847.512	782.980	–8.9898	2500
2600	35.055	68.486	243.623	217.282	851.005	783.017	–8.3606	2600
2700	35.300	72.004	244.951	218.282	854.523	782.993	–7.7779	2700
2800	35.543	75.546	246.239	219.258	858.065	782.895	–7.2370	2800
2900	35.785	79.113	247.490	220.210	861.631	782.707	–6.7334	2900
3000	36.026	82.703	248.707	221.140	865.222	782.414	–6.2636	3000
3100	36.267	86.318	249.893	222.048	868.837	781.997	–5.8243	3100
3200	36.509	89.957	251.048	222.936	872.475	781.434	–5.4126	3200
*3300	36.752	93.620	252.175	223.805	876.138	744.249	–5.0338	3300
3400	36.997	97.307	253.276	224.656	879.826	743.753	–4.6874	3400
3500	37.244	101.019	254.352	225.489	883.538	743.281	–4.3611	3500
3600	37.493	104.756	255.405	226.306	887.275	742.833	–4.0530	3600
3700	37.744	108.518	256.435	227.106	891.036	742.411	–3.7618	3700
3800	37.997	112.305	257.445	227.891	894.824	742.014	–3.4861	3800
3900	38.252	116.117	258.435	228.662	898.636	741.643	–3.2246	3900
4000	38.509	119.955	259.407	229.418	902.474	741.297	–2.9763	4000
4100	38.768	123.819	260.361	230.161	906.338	740.977	–2.7403	4100
4200	39.028	127.709	261.298	230.892	910.228	740.682	–2.5156	4200
4300	39.288	131.625	262.220	231.609	914.143	740.414	–2.3014	4300
4400	39.550	135.567	263.126	232.315	918.085	740.172	–2.0970	4400
4500	39.811	139.535	264.018	233.010	922.053	739.956	–1.9018	4500

TABLE A121.—THERMODYNAMIC PROPERTIES FOR Ta (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	40.072	143.529	264.896	233.694	926.047	739.766	–1.7151	4600
4700	40.333	147.549	265.760	234.367	930.068	739.602	–1.5364	4700
4800	40.593	151.595	266.612	235.030	934.114	739.465	–1.3652	4800
4900	40.851	155.667	267.452	235.683	938.186	739.353	–1.2010	4900
5000	41.108	159.765	268.280	236.327	942.284	739.267	–1.0433	5000
5100	41.364	163.889	269.096	236.961	946.408	739.206	–0.8919	5100
5200	41.618	168.037	269.902	237.587	950.556	739.171	–0.7463	5200
5300	41.871	172.212	270.697	238.204	954.731	739.161	–0.6062	5300
5400	42.124	176.412	271.482	238.813	958.930	739.177	–0.4713	5400
5500	42.374	180.636	272.257	239.414	963.155	739.217	–0.3413	5500
5600	42.622	184.885	273.023	240.007	967.403	739.282	–0.2160	5600
5700	42.871	189.159	273.779	240.593	971.678	739.373	-0.0950	5700
5800	43.118	193.458	274.527	241.172	975.976	739.487	0.0218	5800
5900	43.367	197.782	275.266	241.744	980.301	739.627	0.1347	5900
6000	43.611	202.128	275.996	242.308	984.647	739.790	0.2439	6000
6200	44.105	210.897	277.434	243.418	993.416			6200
6400	44.589	219.757	278.840	244.503	1002.276			6400
6600	45.094	228.725	280.220	245.565	1011.244			6600
6800	45.571	237.772	281.570	246.604	1020.290			6800
7000	46.064	246.923	282.896	247.621	1029.442			7000
7200	46.546	256.165	284.198	248.620	1038.684			7200
7400	47.047	265.526	285.480	249.598	1048.044			7400
7600	47.527	274.983	286.741	250.559	1057.502			7600
7800	47.977	284.534	287.982	251.503	1067.053			7800
8000	48.393	294.172	289.202	252.430	1076.690			8000
8500	49.247	318.594	292.163	254.681	1101.112			8500
9000	49.793	343.368	294.995	256.843	1125.886			9000
9500	50.001	368.330	297.694	258.922	1150.849			9500
10000	49.866	393.311	300.257	260.926	1175.830			10000
10500	49.402	418.141	302.680	262.857	1200.660			10500
11000	48.636	442.663	304.961	264.719	1225.182			11000
11500	47.605	466.734	307.101	266.516	1249.252			11500
12000	46.354	490.231	309.102	268.249	1272.750			12000
12500	44.931	513.059	310.966	269.921	1295.578			12500
13000	43.384	535.142	312.698	271.533	1317.660			13000
13500	41.762	556.431	314.305	273.088	1338.949			13500
14000	40.112	576.900	315.794	274.587	1359.418			14000
14500	38.475	596.544	317.173	276.032	1379.063			14500
15000	36.890	615.383	318.450	277.425	1397.902			15000
15500	35.388	633.448	319.635	278.768	1415.966			15500
16000	33.995	650.789	320.737	280.062	1433.308			16000
16500	32.730	667.465	321.763	281.311	1449.984			16500
17000	31.602	683.542	322.723	282.515	1466.061			17000
17500	30.613	699.090	323.624	283.676	1481.609			17500
18000	29.756	714.176	324.475	284.798	1496.695			18000
18500	29.016	728.865	325.279	285.881	1511.383			18500
19000	28.367	743.209	326.044	286.928	1525.727			19000
19500	27.773	757.242	326.774	287.941	1539.761			19500
20000	27.189	770.983	327.469	288.920	1553.501			20000

***Assigned reference element phase change at 3258 K**

TABLE A122.—THERMODYNAMIC PROPERTIES FOR Ta^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.338	----------	----------	1543.341	1542.825	----------	0
298.15	23.109	0.000	183.387	183.387	1549.679	1549.679	–262.9820	298.15
300	23.151	0.043	183.530	183.388	1549.722	1549.714	–261.3077	300
400	25.237	2.466	190.488	184.322	1552.146	1551.657	–193.8145	400
500	26.708	5.069	196.289	186.151	1554.748	1553.729	–153.2656	500
600	27.735	7.793	201.253	188.265	1557.472	1555.872	–126.1960	600
700	28.582	10.610	205.593	190.437	1560.289	1558.063	–106.8335	700
800	29.370	13.508	209.462	192.577	1563.187	1560.306	–92.2909	800
900	30.121	16.483	212.965	194.651	1566.162	1562.603	–80.9635	900
1000	30.819	19.530	216.175	196.645	1569.209	1564.950	–71.8881	1000
1100	31.442	22.644	219.142	198.557	1572.323	1567.332	–64.4515	1100
1200	31.972	25.815	221.902	200.389	1575.495	1569.734	–58.2448	1200
1300	32.400	29.035	224.478	202.144	1578.714	1572.149	–52.9849	1300
1400	32.726	32.292	226.892	203.826	1581.971	1574.573	–48.4695	1400
1500	32.957	35.577	229.158	205.440	1585.256	1577.011	–44.5502	1500
1600	33.105	38.880	231.290	206.990	1588.560	1579.456	–41.1154	1600
1700	33.184	42.195	233.300	208.479	1591.875	1581.895	–38.0800	1700
1800	33.210	45.515	235.198	209.911	1595.195	1584.305	–35.3777	1800
1900	33.197	48.836	236.993	211.290	1598.515	1586.664	–32.9562	1900
2000	33.159	52.154	238.695	212.618	1601.833	1588.969	–30.7737	2000
2100	33.107	55.467	240.311	213.898	1605.147	1591.215	–28.7962	2100
2200	33.049	58.775	241.850	215.134	1608.455	1593.403	–26.9960	2200
2300	32.993	62.077	243.318	216.328	1611.757	1595.531	–25.3500	2300
2400	32.943	65.374	244.721	217.482	1615.053	1597.592	–23.8393	2400
2500	32.902	68.666	246.065	218.599	1618.346	1599.582	–22.4476	2500
2600	32.872	71.955	247.355	219.680	1621.634	1601.493	–21.1615	2600
2700	32.854	75.241	248.595	220.728	1624.920	1603.316	–19.9692	2700
2800	32.848	78.526	249.790	221.745	1628.205	1605.040	–18.8608	2800
2900	32.852	81.811	250.943	222.732	1631.490	1606.649	–17.8278	2900
3000	32.865	85.097	252.057	223.691	1634.776	1608.130	–16.8628	3000
3100	32.887	88.384	253.135	224.623	1638.064	1609.464	–15.9592	3100
3200	32.914	91.674	254.179	225.531	1641.354	1610.631	–15.1114	3200
*3300	32.947	94.967	255.192	226.414	1644.647	1575.155	–14.3220	3300
3400	32.982	98.264	256.176	227.275	1647.943	1576.346	–13.5884	3400
3500	33.019	101.564	257.133	228.115	1651.243	1577.540	–12.8962	3500
3600	33.057	104.868	258.064	228.934	1654.547	1578.739	–12.2420	3600
3700	33.093	108.175	258.970	229.733	1657.854	1579.941	–11.6227	3700
3800	33.127	111.486	259.853	230.514	1661.166	1581.147	–11.0355	3800
3900	33.159	114.801	260.714	231.278	1664.480	1582.356	–10.4780	3900
4000	33.186	118.118	261.554	232.024	1667.797	1583.568	–9.9480	4000
4100	33.210	121.438	262.374	232.755	1671.117	1584.782	–9.4435	4100
4200	33.228	124.760	263.174	233.469	1674.439	1585.999	–8.9626	4200
4300	33.242	128.083	263.956	234.169	1677.763	1587.217	–8.5037	4300
4400	33.250	131.408	264.720	234.855	1681.087	1588.436	–8.0653	4400
4500	33.253	134.733	265.468	235.527	1684.412	1589.656	–7.6461	4500
4600	33.251	138.058	266.199	236.186	1687.738	1590.876	–7.2449	4600
4700	33.243	141.383	266.914	236.832	1691.062	1592.095	–6.8604	4700
4800	33.229	144.707	267.613	237.466	1694.386	1593.313	–6.4916	4800
4900	33.211	148.029	268.298	238.088	1697.708	1594.530	–6.1376	4900
5000	33.188	151.349	268.969	238.699	1701.028	1595.745	–5.7975	5000

TABLE A122.—THERMODYNAMIC PROPERTIES FOR Ta^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	33.161	154.666	269.626	239.299	1704.346	1596.957	–5.4705	5100
5200	33.129	157.981	270.270	239.889	1707.660	1598.166	–5.1559	5200
5300	33.093	161.292	270.900	240.468	1710.971	1599.372	–4.8529	5300
5400	33.054	164.599	271.519	241.037	1714.279	1600.574	–4.5609	5400
5500	33.012	167.903	272.125	241.597	1717.582	1601.772	–4.2793	5500
5600	32.967	171.202	272.719	242.147	1720.881	1602.965	–4.0075	5600
5700	32.919	174.496	273.302	242.689	1724.175	1604.154	–3.7451	5700
5800	32.869	177.785	273.874	243.222	1727.465	1605.338	–3.4916	5800
5900	32.817	181.070	274.436	243.746	1730.749	1606.517	–3.2465	5900
6000	32.763	184.349	274.987	244.262	1734.028	1607.691	–3.0093	6000
6200	32.654	190.890	276.059	245.271	1740.570			6200
6400	32.541	197.410	277.094	246.249	1747.089			6400
6600	32.429	203.907	278.094	247.199	1753.586			6600
6800	32.318	210.382	279.060	248.122	1760.061			6800
7000	32.211	216.834	279.996	249.019	1766.514			7000
7200	32.109	223.266	280.902	249.892	1772.946			7200
7400	32.014	229.679	281.780	250.742	1779.358			7400
7600	31.925	236.072	282.633	251.570	1785.752			7600
7800	31.844	242.449	283.461	252.378	1792.129			7800
8000	31.772	248.811	284.266	253.165	1798.490			8000
8500	31.633	264.660	286.188	255.051	1814.339			8500
9000	31.553	280.454	287.993	256.832	1830.133			9000
9500	31.533	296.223	289.699	258.517	1845.902			9500
10000	31.569	311.996	291.317	260.117	1861.676			10000
10500	31.656	327.801	292.859	261.640	1877.480			10500
11000	31.789	343.660	294.334	263.093	1893.339			11000
11500	31.960	359.596	295.751	264.482	1909.275			11500
12000	32.162	375.625	297.115	265.813	1925.304			12000
12500	32.390	391.762	298.433	267.092	1941.442			12500
13000	32.636	408.017	299.708	268.322	1957.697			13000
13500	32.895	424.399	300.944	269.507	1974.079			13500
14000	33.161	440.913	302.146	270.652	1990.593			14000
14500	33.429	457.561	303.314	271.758	2007.240			14500
15000	33.689	474.334	304.451	272.829	2024.013			15000
15500	33.946	491.243	305.560	273.867	2040.922			15500
16000	34.193	508.278	306.642	274.874	2057.957			16000
16500	34.426	525.433	307.697	275.853	2075.113			16500
17000	34.631	542.675	308.727	276.805	2092.354			17000
17500	34.828	560.040	309.733	277.731	2109.719			17500
18000	35.006	577.499	310.717	278.634	2127.179			18000
18500	35.163	595.042	311.678	279.514	2144.722			18500
19000	35.271	612.586	312.614	280.372	2162.265			19000
19500	35.381	630.250	313.531	281.211	2179.929			19500
20000	35.469	647.963	314.428	282.030	2197.643			20000

*Assigned reference element phase change at 3258 K

TABLE A123.—THERMODYNAMIC PROPERTIES FOR Ta^-

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.416	----------	----------	739.053	750.932	----------	0
298.15	24.561	0.000	174.563	174.563	745.469	745.469	–124.7438	298.15
300	24.635	0.046	174.715	174.563	745.515	745.429	–123.9385	300
400	28.552	2.708	182.349	175.577	748.178	743.455	–91.5317	400
500	31.607	5.726	189.068	177.617	751.195	741.784	–72.1359	500
600	33.601	8.994	195.022	180.032	754.464	740.314	–59.2329	600
700	34.681	12.415	200.294	182.558	757.885	738.953	–50.0340	700
800	35.012	15.906	204.954	185.072	761.375	737.630	–43.1475	800
900	34.772	19.399	209.068	187.514	764.868	736.289	–37.8008	900
1000	34.143	22.847	212.702	189.855	768.316	734.880	–33.5316	1000
1100	33.284	26.220	215.917	192.081	771.689	733.363	–30.0454	1100
1200	32.320	29.500	218.773	194.189	774.970	731.717	–27.1465	1200
1300	31.335	32.683	221.321	196.180	778.152	729.938	–24.6994	1300
1400	30.382	35.768	223.608	198.059	781.238	728.034	–22.6072	1400
1500	29.491	38.762	225.673	199.832	784.231	726.022	–20.7988	1500
1600	28.674	41.669	227.550	201.506	787.139	723.914	–19.2209	1600
1700	27.936	44.499	229.266	203.090	789.968	721.710	–17.8328	1700
1800	27.273	47.259	230.843	204.588	792.728	719.402	–16.6028	1800
1900	26.682	49.956	232.302	206.009	795.425	716.981	–15.5058	1900
2000	26.156	52.597	233.657	207.358	798.067	714.452	–14.5220	2000
2100	25.688	55.189	234.921	208.641	800.659	711.819	–13.6350	2100
2200	25.271	57.737	236.106	209.862	803.206	709.090	–12.8318	2200
2300	24.900	60.245	237.221	211.028	805.714	706.266	–12.1012	2300
2400	24.569	62.718	238.274	212.141	808.187	703.347	–11.4343	2400
2500	24.273	65.160	239.271	213.207	810.629	700.329	–10.8233	2500
2600	24.008	67.574	240.218	214.228	813.043	697.208	–10.2617	2600
2700	23.770	69.962	241.119	215.207	815.432	693.976	–9.7441	2700
2800	23.556	72.328	241.980	216.148	817.798	690.624	–9.2658	2800
2900	23.362	74.674	242.803	217.053	820.143	687.137	–8.8226	2900
3000	23.188	77.001	243.592	217.925	822.471	683.501	–8.4112	3000
3100	23.029	79.312	244.349	218.765	824.782	679.702	–8.0283	3100
3200	22.885	81.608	245.078	219.576	827.077	675.718	–7.6714	3200
*3300	22.754	83.890	245.780	220.359	829.359	635.072	–7.3457	3300
3400	22.634	86.159	246.458	221.117	831.628	631.079	–7.0510	3400
3500	22.525	88.417	247.112	221.851	833.886	627.074	–6.7748	3500
3600	22.424	90.664	247.746	222.561	836.134	623.059	–6.5157	3600
3700	22.332	92.902	248.359	223.250	838.371	619.034	–6.2722	3700
3800	22.247	95.131	248.953	223.919	840.600	615.001	–6.0429	3800
3900	22.169	97.352	249.530	224.568	842.821	610.959	–5.8269	3900
4000	22.097	99.565	250.090	225.199	845.034	606.909	–5.6230	4000
4100	22.030	101.771	250.635	225.813	847.241	602.853	–5.4303	4100
4200	21.968	103.971	251.165	226.410	849.440	598.790	–5.2481	4200
4300	21.910	106.165	251.681	226.992	851.634	594.721	–5.0755	4300
4400	21.856	108.353	252.185	227.559	853.823	590.647	–4.9118	4400
4500	21.806	110.536	252.675	228.112	856.006	586.568	–4.7566	4500
4600	21.760	112.715	253.154	228.651	858.184	582.483	–4.6091	4600
4700	21.716	114.888	253.621	229.177	860.358	578.394	–4.4688	4700
4800	21.675	117.058	254.078	229.691	862.527	574.301	–4.3354	4800
4900	21.637	119.223	254.525	230.193	864.693	570.204	–4.2083	4900
5000	21.601	121.385	254.961	230.684	866.855	566.104	–4.0872	5000

TABLE A123.—THERMODYNAMIC PROPERTIES FOR Ta^- (Concluded)

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.568	123.544	255.389	231.165	869.013	561.999	–3.9716	5100
5200	21.536	125.699	255.807	231.635	871.168	557.892	–3.8613	5200
5300	21.506	127.851	256.217	232.094	873.321	553.781	–3.7560	5300
5400	21.478	130.000	256.619	232.545	875.470	549.668	–3.6553	5400
5500	21.452	132.147	257.013	232.986	877.616	545.552	–3.5590	5500
5600	21.427	134.291	257.399	233.419	879.760	541.433	–3.4668	5600
5700	21.403	136.432	257.778	233.843	881.902	537.312	-3.3785	5700
5800	21.381	138.571	258.150	234.259	884.041	533.189	–3.2940	5800
5900	21.359	140.708	258.516	234.667	886.178	529.063	–3.2129	5900
6000	21.339	142.843	258.874	235.067	888.313	524.935	–3.1351	6000
6200	21.302	147.107	259.574	235.847	892.577			6200
6400	21.269	151.364	260.249	236.599	896.834			6400
6600	21.238	155.615	260.903	237.325	901.084			6600
6800	21.210	159.860	261.537	238.028	905.329			6800
7000	21.185	164.099	262.151	238.709	909.569			7000
7200	21.162	168.334	262.748	239.368	913.804			7200
7400	21.141	172.564	263.327	240.008	918.034			7400
7600	21.122	176.791	263.891	240.629	922.260			7600
7800	21.104	181.013	264.439	241.233	926.483			7800
8000	21.087	185.232	264.973	241.819	930.702			8000
8500	21.051	195.766	266.251	243.219	941.236			8500
9000	21.021	206.284	267.453	244.533	951.754			9000
9500	20.996	216.788	268.589	245.769	962.258			9500
10000	20.975	227.281	269.665	246.937	972.750			10000
10500	20.956	237.764	270.688	248.044	983.233			10500
11000	20.941	248.238	271.663	249.096	993.707			11000
11500	20.927	258.705	272.593	250.097	1004.174			11500
12000	20.915	269.165	273.484	251.053	1014.634			12000
12500	20.905	279.620	274.337	251.968	1025.089			12500
13000	20.895	290.070	275.157	252.844	1035.539			13000
13500	20.887	300.515	275.945	253.685	1045.985			13500
14000	20.880	310.957	276.705	254.494	1056.426			14000
14500	20.873	321.395	277.437	255.272	1066.865			14500
15000	20.867	331.830	278.145	256.023	1077.300			15000
15500	20.862	342.263	278.829	256.748	1087.732			15500
16000	20.857	352.692	279.491	257.448	1098.162			16000
16500	20.853	363.120	280.133	258.126	1108.589			16500
17000	20.849	373.545	280.756	258.782	1119.015			17000
17500	20.845	383.969	281.360	259.419	1129.438			17500
18000	20.842	394.391	281.947	260.037	1139.860			18000
18500	20.839	404.811	282.518	260.636	1150.280			18500
19000	20.836	415.230	283.074	261.220	1160.699			19000
19500	20.833	425.647	283.615	261.787	1171.116			19500
20000	20.831	436.063	284.142	262.339	1181.533			20000

*Assigned reference element phase change at 3258 K

TABLE A124.—THERMODYNAMIC PROPERTIES FOR Ti

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.539	----------	----------	465.461	470.285	----------	0
100	26.974	–5.214	151.245	203.383	467.786	472.051	–239.0978	100
200	26.487	–2.493	170.124	182.592	470.507	472.854	–115.7149	200
298.15	24.430	0.000	180.296	180.296	473.000	473.000	–75.0527	298.15
300	24.399	0.045	180.447	180.296	473.045	472.999	–74.5418	300
400	23.104	2.414	187.271	181.235	475.414	472.787	–53.9564	400
500	22.360	4.684	192.339	182.971	477.684	472.371	–41.6135	500
600	21.914	6.896	196.373	184.880	479.896	471.795	–33.3934	600
700	21.632	9.072	199.729	186.768	482.072	471.075	–27.5300	700
800	21.454	11.226	202.605	188.572	484.226	470.228	–23.1398	800
900	21.354	13.366	205.125	190.274	486.366	469.291	–19.7317	900
1000	21.323	15.499	207.373	191.874	488.499	468.278	–17.0108	1000
1100	21.362	17.633	209.406	193.377	490.633	466.860	–14.7903	1100
*1200	21.474	19.774	211.269	194.791	492.774	461.601	–12.9525	1200
1300	21.657	21.930	212.995	196.126	494.930	460.832	–11.4082	1300
1400	21.911	24.108	214.609	197.389	497.108	459.943	–10.0868	1400
1500	22.228	26.314	216.131	198.588	499.314	458.934	–8.9440	1500
1600	22.604	28.555	217.577	199.730	501.555	457.805	–7.9464	1600
1700	23.030	30.837	218.960	200.821	503.837	456.556	–7.0684	1700
1800	23.497	33.163	220.289	201.866	506.163	455.183	–6.2902	1800
1900	23.999	35.537	221.573	202.869	508.537	453.685	–5.5961	1900
*2000	24.529	37.963	222.818	203.836	510.963	437.131	–4.9847	2000
2100	25.080	40.444	224.028	204.769	513.444	434.931	–4.4424	2100
2200	25.648	42.980	225.207	205.671	515.980	432.787	–3.9519	2200
2300	26.229	45.574	226.360	206.546	518.574	430.701	–3.5062	2300
2400	26.819	48.226	227.489	207.395	521.226	428.673	–3.0996	2400
2500	27.417	50.938	228.596	208.221	523.938	426.705	–2.7272	2500
2600	28.020	53.710	229.683	209.025	526.710	424.797	–2.3851	2600
2700	28.627	56.542	230.752	209.810	529.542	422.949	–2.0697	2700
2800	29.236	59.435	231.804	210.577	532.435	421.162	–1.7781	2800
2900	29.846	62.389	232.841	211.327	535.389	419.437	–1.5077	2900
3000	30.456	65.404	233.863	212.061	538.404	417.772	–1.2564	3000
3100	31.065	68.480	234.871	212.781	541.480	416.168	–1.0222	3100
3200	31.672	71.617	235.867	213.487	544.617	414.625	–0.8035	3200
3300	32.274	74.815	236.851	214.180	547.815	413.142	–0.5988	3300
3400	32.871	78.072	237.823	214.861	551.072	411.719	–0.4068	3400
3500	33.461	81.389	238.785	215.531	554.389	410.356	–0.2263	3500
3600	34.043	84.764	239.735	216.190	557.764	409.051	–0.0565	3600
3700	34.616	88.197	240.676	216.839	561.197	407.804	0.1037	3700
3800	35.177	91.687	241.607	217.479	564.687	406.614	0.2549	3800
3900	35.726	95.232	242.528	218.109	568.232	405.479	0.3981	3900
4000	36.261	98.831	243.439	218.731	571.831	404.399	0.5336	4000
4100	36.782	102.484	244.341	219.345	575.484	403.371	0.6623	4100
4200	37.287	106.187	245.233	219.950	579.187	402.395	0.7845	4200
4300	37.775	109.940	246.116	220.549	582.940	401.468	0.9007	4300
4400	38.247	113.742	246.990	221.140	586.742	400.589	1.0114	4400
4500	38.701	117.589	247.855	221.724	590.589	399.756	1.1170	4500

TABLE A124.—THERMODYNAMIC PROPERTIES FOR Ti (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	39.138	121.481	248.710	222.301	594.481	398.968	1.2178	4600
4700	39.557	125.416	249.556	222.872	598.416	398.223	1.3141	4700
4800	39.958	129.391	250.393	223.437	602.391	397.519	1.4062	4800
4900	40.341	133.406	251.221	223.995	606.406	396.853	1.4944	4900
5000	40.707	137.458	252.040	224.548	610.458	396.226	1.5789	5000
5100	41.058	141.547	252.849	225.095	614.547	395.634	1.6600	5100
5200	41.388	145.668	253.649	225.636	618.668	395.075	1.7379	5200
5300	41.705	149.821	254.441	226.172	622.821	394.549	1.8127	5300
5400	42.005	154.006	255.223	226.703	627.006	394.053	1.8847	5400
5500	42.290	158.219	255.996	227.229	631.219	393.586	1.9540	5500
5600	42.560	162.460	256.760	227.749	635.460	393.147	2.0207	5600
5700	42.817	166.726	257.515	228.265	639.726	392.733	2.0850	5700
5800	43.059	171.017	258.261	228.775	644.017	392.344	2.1470	5800
5900	43.278	175.348	259.000	229.280	648.348	391.995	2.2068	5900
6000	43.484	179.685	259.729	229.781	652.685	391.653	2.2646	6000
6200	43.894	188.424	261.161	230.770	661.424			6200
6400	44.261	197.240	262.561	231.742	670.240			6400
6600	44.572	206.125	263.928	232.697	679.125			6600
6800	44.819	215.065	265.262	233.635	688.065			6800
7000	44.998	224.048	266.564	234.557	697.048			7000
7200	45.109	233.060	267.834	235.464	706.060			7200
7400	45.153	242.087	269.070	236.356	715.087			7400
7600	45.133	251.116	270.274	237.233	724.116			7600
7800	45.053	260.137	271.446	238.095	733.137			7800
8000	44.918	269.134	272.585	238.943	742.134			8000
8500	44.371	291.468	275.293	241.003	764.468			8500
9000	43.588	313.466	277.808	242.978	786.466			9000
9500	42.644	335.030	280.140	244.874	808.030			9500
10000	41.603	356.093	282.301	246.692	829.093			10000
10500	40.515	376.624	284.305	248.436	849.624			10500
11000	39.419	396.607	286.164	250.109	869.607			11000
11500	38.345	416.047	287.892	251.714	889.047			11500
12000	37.310	434.959	289.502	253.256	907.959			12000
12500	36.326	453.365	291.005	254.736	926.365			12500
13000	35.398	471.295	292.412	256.158	944.295			13000
13500	34.526	488.773	293.731	257.526	961.773			13500
14000	33.706	505.829	294.972	258.841	978.829			14000
14500	32.932	522.487	296.141	260.107	995.487			14500
15000	32.200	538.768	297.245	261.327	1011.768			15000
15500	31.500	554.692	298.289	262.503	1027.692			15500
16000	30.826	570.271	299.279	263.637	1043.271			16000
16500	30.173	585.521	300.217	264.731	1058.521			16500
17000	29.538	600.448	301.108	265.788	1073.448			17000
17500	28.917	615.062	301.956	266.809	1088.062			17500
18000	28.312	629.368	302.762	267.797	1102.368			18000
18500	27.727	643.376	303.530	268.752	1116.376			18500
19000	27.170	657.099	304.262	269.677	1130.099			19000
19500	26.650	670.553	304.960	270.573	1143.553			19500
20000	26.184	683.759	305.629	271.441	1156.759			20000

***Assigned reference element phase change at 1156 K and 1944 K**

TABLE A125.—THERMODYNAMIC PROPERTIES FOR Ti^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.900	----------	----------	1129.724	1128.351	----------	0
298.15	26.186	0.000	183.591	183.591	1137.624	1137.624	–190.2212	298.15
300	26.184	0.048	183.753	183.591	1137.672	1137.665	–188.9922	300
400	26.131	2.665	191.280	184.618	1140.289	1139.779	–139.4301	400
500	25.845	5.266	197.086	186.554	1142.890	1141.773	–109.6385	500
600	25.357	7.827	201.757	188.711	1145.451	1143.625	–89.7436	600
700	24.818	10.336	205.625	190.859	1147.960	1145.316	–75.5107	700
800	24.321	12.792	208.906	192.915	1150.416	1146.850	–64.8210	800
900	23.903	15.203	211.746	194.853	1152.827	1148.262	–56.4961	900
1000	23.571	17.576	214.246	196.670	1155.200	1149.568	–49.8281	1000
1100	23.319	19.920	216.480	198.371	1157.544	1150.438	–44.3672	1100
*1200	23.135	22.242	218.501	199.966	1159.866	1147.439	–39.8201	1200
1300	23.011	24.549	220.347	201.464	1162.173	1148.900	–35.9758	1300
1400	22.936	26.846	222.050	202.874	1164.470	1150.208	–32.6766	1400
1500	22.904	29.137	223.631	204.206	1166.761	1151.363	–29.8143	1500
1600	22.909	31.428	225.109	205.467	1169.052	1152.362	–27.3073	1600
1700	22.946	33.720	226.499	206.663	1171.344	1153.203	–25.0936	1700
1800	23.012	36.018	227.812	207.802	1173.642	1153.880	–23.1245	1800
1900	23.101	38.324	229.059	208.888	1175.948	1154.392	–21.3618	1900
*2000	23.212	40.639	230.246	209.927	1178.263	1139.806	–19.7859	2000
2100	23.341	42.967	231.382	210.922	1180.591	1139.532	–18.3685	2100
2200	23.485	45.308	232.471	211.877	1182.932	1139.272	–17.0803	2200
2300	23.641	47.664	233.518	212.795	1185.288	1139.026	–15.9044	2300
2400	23.807	50.036	234.528	213.679	1187.660	1138.797	–14.8267	2400
2500	23.981	52.426	235.503	214.533	1190.050	1138.585	–13.8354	2500
2600	24.159	54.833	236.447	215.358	1192.457	1138.391	–12.9205	2600
2700	24.340	57.258	237.363	216.156	1194.882	1138.215	–12.0736	2700
2800	24.522	59.701	238.251	216.929	1197.325	1138.056	–11.2872	2800
2900	24.704	62.162	239.115	217.679	1199.786	1137.916	–10.5552	2900
3000	24.883	64.642	239.955	218.408	1202.266	1137.794	–9.8720	3000
3100	25.059	67.139	240.774	219.116	1204.763	1137.690	–9.2330	3100
3200	25.231	69.653	241.572	219.806	1207.277	1137.603	–8.6340	3200
3300	25.397	72.185	242.351	220.477	1209.809	1137.533	–8.0713	3300
3400	25.557	74.732	243.112	221.132	1212.356	1137.480	–7.5418	3400
3500	25.710	77.296	243.855	221.770	1214.920	1137.442	–7.0425	3500
3600	25.856	79.874	244.581	222.394	1217.498	1137.419	–6.5710	3600
3700	25.995	82.467	245.292	223.003	1220.091	1137.410	–6.1250	3700
3800	26.126	85.073	245.987	223.599	1222.697	1137.415	–5.7024	3800
3900	26.250	87.692	246.667	224.182	1225.316	1137.432	–5.3015	3900
4000	26.366	90.323	247.333	224.752	1227.947	1137.462	–4.9207	4000
4100	26.475	92.965	247.985	225.311	1230.589	1137.502	–4.5584	4100
4200	26.577	95.617	248.625	225.859	1233.242	1137.554	–4.2133	4200
4300	26.671	98.280	249.251	226.395	1235.904	1137.615	–3.8843	4300
4400	26.759	100.952	249.865	226.922	1238.576	1137.685	–3.5702	4400
4500	26.841	103.632	250.468	227.438	1241.256	1137.764	–3.2701	4500
4600	26.916	106.320	251.058	227.945	1243.944	1137.850	–2.9830	4600
4700	26.986	109.015	251.638	228.443	1246.639	1137.944	–2.7081	4700
4800	27.050	111.717	252.207	228.932	1249.341	1138.045	–2.4446	4800
4900	27.110	114.425	252.765	229.413	1252.049	1138.151	–2.1919	4900
5000	27.164	117.138	253.313	229.886	1254.762	1138.264	–1.9492	5000

TABLE A125.—THERMODYNAMIC PROPERTIES FOR Ti^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	27.215	119.857	253.852	230.350	1257.481	1138.381	–1.7160	5100
5200	27.261	122.581	254.381	230.807	1260.205	1138.504	–1.4918	5200
5300	27.304	125.309	254.900	231.257	1262.933	1138.631	–1.2760	5300
5400	27.344	128.042	255.411	231.700	1265.666	1138.762	–1.0682	5400
5500	27.381	130.778	255.913	232.135	1268.402	1138.897	–0.8679	5500
5600	27.416	133.518	256.407	232.564	1271.142	1139.035	–0.6748	5600
5700	27.448	136.261	256.892	232.987	1273.885	1139.177	–0.4884	5700
5800	27.478	139.008	257.370	233.403	1276.632	1139.322	–0.3084	5800
5900	27.506	141.757	257.840	233.813	1279.381	1139.470	–0.1344	5900
6000	27.533	144.509	258.303	234.218	1282.133	1139.620	0.0337	6000
6200	27.582	150.020	259.206	235.009	1287.644			6200
6400	27.629	155.541	260.083	235.779	1293.165			6400
6600	27.672	161.072	260.933	236.529	1298.696			6600
6800	27.715	166.610	261.760	237.259	1304.234			6800
7000	27.757	172.157	262.564	237.970	1309.782			7000
7200	27.800	177.713	263.347	238.664	1315.337			7200
7400	27.844	183.278	264.109	239.342	1320.902			7400
7600	27.890	188.851	264.852	240.003	1326.475			7600
7800	27.937	194.434	265.577	240.650	1332.058			7800
8000	27.987	200.026	266.285	241.282	1337.650			8000
8500	28.122	214.052	267.986	242.803	1351.676			8500
9000	28.275	228.151	269.598	244.247	1365.775			9000
9500	28.447	242.331	271.131	245.622	1379.955			9500
10000	28.639	256.601	272.595	246.935	1394.225			10000
10500	28.850	270.973	273.997	248.190	1408.597			10500
11000	29.082	285.455	275.344	249.394	1423.079			11000
11500	29.335	300.057	276.643	250.551	1437.681			11500
12000	29.607	314.790	277.897	251.664	1452.414			12000
12500	29.898	329.663	279.111	252.738	1467.287			12500
13000	30.209	344.687	280.289	253.775	1482.311			13000
13500	30.532	359.863	281.435	254.778	1497.487			13500
14000	30.866	375.198	282.550	255.750	1512.822			14000
14500	31.222	390.720	283.639	256.693	1528.344			14500
15000	31.571	406.391	284.702	257.609	1544.015			15000
15500	31.919	422.226	285.740	258.499	1559.850			15500
16000	32.290	438.278	286.759	259.367	1575.902			16000
16500	32.629	454.444	287.753	260.211	1592.068			16500
17000	32.953	470.756	288.727	261.035	1608.380			17000
17500	33.285	487.271	289.684	261.840	1624.895			17500
18000	33.594	503.916	290.621	262.625	1641.540			18000
18500	33.857	520.617	291.535	263.393	1658.241			18500
19000	34.130	537.532	292.436	264.145	1675.156			19000
19500	34.367	554.520	293.317	264.881	1692.144			19500
20000	34.541	571.468	294.173	265.600	1709.092			20000

*Assigned reference element phase change at 1156 K and 1944 K

TABLE A126.—THERMODYNAMIC PROPERTIES FOR Ti^-

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.563	----------	----------	451.641	462.663	----------	0
298.15	22.835	0.000	183.714	183.714	459.204	459.204	–73.5530	298.15
300	22.813	0.042	183.855	183.714	459.246	459.162	–73.0570	300
400	21.996	2.278	190.292	184.597	461.482	456.737	–53.1176	400
500	21.580	4.454	195.151	186.242	463.658	454.149	–41.2202	500
600	21.345	6.600	199.062	188.063	465.803	451.428	–33.3350	600
700	21.199	8.726	202.341	189.875	467.930	448.580	–27.7374	700
800	21.104	10.841	205.165	191.614	470.045	445.615	–23.5665	800
900	21.038	12.948	207.647	193.260	472.152	442.567	–20.3443	900
1000	20.990	15.049	209.861	194.811	474.253	439.443	–17.7844	1000
1100	20.955	17.146	211.859	196.272	476.350	435.910	–15.7057	1100
*1200	20.928	19.241	213.682	197.648	478.444	428.525	–13.9945	1200
1300	20.907	21.332	215.356	198.946	480.536	425.613	–12.5644	1300
1400	20.890	23.422	216.905	200.175	482.626	422.558	–11.3471	1400
1500	20.877	25.510	218.345	201.338	484.714	419.352	–10.3000	1500
1600	20.866	27.598	219.692	202.444	486.801	415.991	–9.3908	1600
1700	20.857	29.684	220.957	203.496	488.888	412.467	–8.5953	1700
1800	20.849	31.769	222.149	204.500	490.973	408.775	–7.8943	1800
1900	20.843	33.854	223.276	205.458	493.057	404.909	–7.2728	1900
*2000	20.837	35.938	224.345	206.376	495.141	385.934	–6.7301	2000
2100	20.833	38.021	225.362	207.256	497.225	381.258	–6.2530	2100
2200	20.828	40.104	226.331	208.102	499.308	376.583	–5.8245	2200
2300	20.825	42.187	227.256	208.914	501.391	371.907	–5.4382	2300
2400	20.822	44.269	228.143	209.697	503.473	367.231	–5.0884	2400
2500	20.819	46.351	228.993	210.452	505.555	362.554	–4.7708	2500
2600	20.816	48.433	229.809	211.181	507.637	357.877	–4.4813	2600
2700	20.814	50.514	230.595	211.886	509.718	353.200	–4.2167	2700
2800	20.812	52.596	231.352	212.567	511.800	348.523	–3.9743	2800
2900	20.811	54.677	232.082	213.228	513.881	343.845	–3.7516	2900
3000	20.809	56.758	232.787	213.868	515.962	339.168	–3.5465	3000
3100	20.807	58.839	233.470	214.489	518.042	334.490	–3.3573	3100
3200	20.806	60.919	234.130	215.093	520.123	329.812	–3.1824	3200
3300	20.805	63.000	234.770	215.680	522.204	325.134	–3.0204	3300
3400	20.804	65.080	235.392	216.250	524.284	320.456	–2.8701	3400
3500	20.803	67.161	235.995	216.806	526.365	315.777	–2.7305	3500
3600	20.802	69.241	236.581	217.347	528.445	311.099	–2.6005	3600
3700	20.801	71.321	237.151	217.875	530.525	306.420	–2.4795	3700
3800	20.800	73.401	237.705	218.389	532.605	301.742	–2.3665	3800
3900	20.800	75.481	238.246	218.891	534.685	297.063	–2.2609	3900
4000	20.799	77.561	238.772	219.382	536.765	292.385	–2.1623	4000
4100	20.798	79.641	239.286	219.861	538.845	287.706	–2.0699	4100
4200	20.798	81.721	239.787	220.330	540.925	283.027	–1.9833	4200
4300	20.797	83.801	240.276	220.788	543.004	278.348	–1.9021	4300
4400	20.797	85.880	240.754	221.236	545.084	273.669	–1.8259	4400
4500	20.796	87.960	241.222	221.675	547.164	268.990	–1.7543	4500
4600	20.796	90.040	241.679	222.105	549.243	264.311	–1.6870	4600
4700	20.795	92.119	242.126	222.526	551.323	259.632	–1.6238	4700
4800	20.795	94.199	242.564	222.939	553.402	254.953	–1.5642	4800
4900	20.795	96.278	242.993	223.344	555.482	250.274	–1.5081	4900
5000	20.794	98.358	243.413	223.741	557.561	245.595	–1.4552	5000

TABLE A126.—THERMODYNAMIC PROPERTIES FOR Ti^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.794	100.437	243.825	224.131	559.641	240.916	–1.4054	5100
5200	20.794	102.516	244.228	224.514	561.720	236.236	–1.3584	5200
5300	20.794	104.596	244.624	224.889	563.800	231.557	–1.3141	5300
5400	20.793	106.675	245.013	225.258	565.879	226.878	–1.2722	5400
5500	20.793	108.754	245.395	225.621	567.958	222.198	–1.2327	5500
5600	20.793	110.834	245.769	225.978	570.037	217.519	–1.1954	5600
5700	20.793	112.913	246.137	226.328	572.117	212.840	–1.1602	5700
5800	20.792	114.992	246.499	226.673	574.196	208.160	–1.1270	5800
5900	20.792	117.071	246.854	227.012	576.275	203.481	–1.0955	5900
6000	20.792	119.151	247.204	227.345	578.354	198.802	–1.0659	6000
6200	20.792	123.309	247.886	227.997	582.513			6200
6400	20.791	127.467	248.546	228.629	586.671			6400
6600	20.791	131.625	249.185	229.242	590.829			6600
6800	20.791	135.784	249.806	229.838	594.987			6800
7000	20.790	139.942	250.409	230.417	599.146			7000
7200	20.790	144.100	250.994	230.981	603.304			7200
7400	20.790	148.258	251.564	231.529	607.462			7400
7600	20.790	152.416	252.119	232.064	611.620			7600
7800	20.790	156.574	252.659	232.585	615.778			7800
8000	20.789	160.732	253.185	233.093	619.935			8000
8500	20.789	171.126	254.445	234.313	630.330			8500
9000	20.789	181.521	255.633	235.465	640.725			9000
9500	20.789	191.915	256.757	236.556	651.119			9500
10000	20.788	202.309	257.824	237.593	661.513			10000
10500	20.788	212.703	258.838	238.581	671.907			10500
11000	20.788	223.097	259.805	239.524	682.301			11000
11500	20.788	233.491	260.729	240.426	692.695			11500
12000	20.788	243.885	261.614	241.290	703.089			12000
12500	20.788	254.279	262.462	242.120	713.483			12500
13000	20.787	264.673	263.278	242.918	723.877			13000
13500	20.787	275.066	264.062	243.687	734.270			13500
14000	20.787	285.460	264.818	244.428	744.664			14000
14500	20.787	295.854	265.548	245.144	755.058			14500
15000	20.787	306.247	266.252	245.836	765.451			15000
15500	20.787	316.641	266.934	246.506	775.845			15500
16000	20.787	327.034	267.594	247.154	786.238			16000
16500	20.787	337.428	268.234	247.783	796.632			16500
17000	20.787	347.822	268.854	248.394	807.025			17000
17500	20.787	358.215	269.457	248.987	817.419			17500
18000	20.787	368.608	270.042	249.564	827.812			18000
18500	20.787	379.002	270.612	250.125	838.206			18500
19000	20.787	389.395	271.166	250.672	848.599			19000
19500	20.787	399.789	271.706	251.204	858.993			19500
20000	20.787	410.182	272.232	251.723	869.386			20000

*Assigned reference element phase change at 1156 K and 1944 K

TABLE A127.—THERMODYNAMIC PROPERTIES FOR V

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.907	----------	----------	509.360	514.000	----------	0
100	28.040	–5.485	151.833	206.688	511.782	515.933	–261.9333	100
200	27.961	–2.649	171.500	184.743	514.618	516.933	–127.0693	200
298.15	26.012	0.000	182.301	182.301	517.267	517.267	–82.6100	298.15
300	25.979	0.048	182.462	182.302	517.315	517.269	–82.0512	300
400	24.648	2.571	189.730	183.302	519.838	517.227	–59.5354	400
500	24.196	5.007	195.168	185.153	522.274	517.003	–46.0296	500
600	24.283	7.428	199.582	187.201	524.696	516.703	–37.0304	600
700	24.582	9.871	203.346	189.245	527.138	516.370	–30.6064	700
800	24.890	12.345	206.649	191.218	529.612	516.010	–25.7916	800
900	25.117	14.846	209.595	193.099	532.113	515.609	–22.0495	900
1000	25.238	17.365	212.249	194.884	534.632	515.156	–19.0583	1000
1100	25.262	19.891	214.656	196.574	537.158	514.635	–16.6132	1100
1200	25.214	22.415	216.852	198.173	539.682	514.026	–14.5779	1200
1300	25.117	24.932	218.867	199.689	542.199	513.317	–12.8580	1300
1400	24.995	27.437	220.724	201.126	544.705	512.495	–11.3859	1400
1500	24.864	29.930	222.444	202.490	547.197	511.557	–10.1123	1500
1600	24.739	32.411	224.045	203.788	549.678	510.505	–9.0000	1600
1700	24.631	34.879	225.541	205.024	552.146	509.329	–8.0207	1700
1800	24.545	37.337	226.946	206.203	554.604	508.027	–7.1524	1800
1900	24.487	39.789	228.272	207.330	557.056	506.592	–6.3776	1900
2000	24.461	42.236	229.527	208.409	559.503	505.018	–5.6823	2000
2100	24.468	44.682	230.720	209.443	561.949	503.297	–5.0552	2100
*2200	24.511	47.131	231.860	210.437	564.398	478.544	–4.4897	2200
2300	24.589	49.585	232.951	211.392	566.852	476.378	–3.9969	2300
2400	24.705	52.050	233.999	212.312	569.317	474.222	–3.5471	2400
2500	24.856	54.527	235.011	213.200	571.795	472.079	–3.1352	2500
2600	25.044	57.022	235.989	214.058	574.289	469.954	–2.7567	2600
2700	25.268	59.538	236.939	214.888	576.805	467.849	–2.4078	2700
2800	25.527	62.077	237.862	215.692	579.344	465.768	–2.0852	2800
2900	25.819	64.644	238.763	216.472	581.911	463.714	–1.7863	2900
3000	26.143	67.242	239.644	217.230	584.509	461.692	–1.5085	3000
3100	26.497	69.874	240.506	217.967	587.141	459.703	–1.2497	3100
3200	26.880	72.542	241.354	218.684	589.809	457.751	–1.0082	3200
3300	27.290	75.250	242.187	219.384	592.518	455.839	–0.7822	3300
3400	27.723	78.001	243.008	220.067	595.268	453.969	–0.5704	3400
3500	28.179	80.796	243.818	220.734	598.063	452.144	–0.3716	3500
3600	28.655	83.637	244.619	221.386	600.905	450.365	–0.1845	3600
3700	29.149	86.528	245.411	222.025	603.795	448.635	–0.0082	3700
3800	29.657	89.468	246.195	222.651	606.735	446.954	0.1581	3800
3900	30.179	92.459	246.972	223.264	609.726	445.326	0.3154	3900
4000	30.712	95.504	247.742	223.867	612.771	443.750	0.4642	4000
4100	31.255	98.602	248.508	224.458	615.869	442.228	0.6053	4100
4200	31.805	101.755	249.267	225.040	619.022	440.760	0.7392	4200
4300	32.361	104.963	250.022	225.612	622.230	439.348	0.8665	4300
4400	32.921	108.227	250.772	226.175	625.494	437.992	0.9876	4400
4500	33.485	111.547	251.519	226.730	628.815	436.691	1.1030	4500

TABLE A127.—THERMODYNAMIC PROPERTIES FOR V (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	34.051	114.924	252.261	227.277	632.191	435.448	1.2130	4600
4700	34.619	118.357	252.999	227.817	635.624	434.261	1.3181	4700
4800	35.188	121.848	253.734	228.349	639.115	433.131	1.4185	4800
4900	35.757	125.395	254.465	228.874	642.662	432.057	1.5146	4900
5000	36.325	128.998	255.193	229.394	646.265	431.040	1.6066	5000
5100	36.892	132.658	255.918	229.907	649.925	430.080	1.6948	5100
5200	37.461	136.376	256.640	230.414	653.643	429.177	1.7794	5200
5300	38.027	140.149	257.358	230.915	657.416	428.330	1.8606	5300
5400	38.595	143.980	258.075	231.412	661.247	427.540	1.9387	5400
5500	39.151	147.862	258.787	231.903	665.129	426.802	2.0139	5500
5600	39.716	151.806	259.497	232.389	669.073	426.125	2.0862	5600
5700	40.281	155.806	260.205	232.871	673.073	425.505	2.1559	5700
5800	40.837	159.857	260.910	233.348	677.125	424.936	2.2230	5800
5900	41.386	163.962	261.611	233.821	681.229	424.420	2.2879	5900
6000	41.933	168.122	262.310	234.290	685.389	423.959	2.3504	6000
6200	43.029	176.610	263.702	235.216	693.877			6200
6400	44.079	185.293	265.080	236.128	702.560			6400
6600	45.127	194.197	266.449	237.026	711.464			6600
6800	46.098	203.267	267.802	237.910	720.534			6800
7000	47.065	212.553	269.148	238.783	729.820			7000
7200	47.913	221.957	270.471	239.643	739.225			7200
7400	48.760	231.574	271.787	240.493	748.841			7400
7600	49.515	241.315	273.085	241.333	758.582			7600
7800	50.215	251.209	274.368	242.162	768.476			7800
8000	50.787	261.774	275.716	242.994	779.041			8000
8500	51.593	287.398	278.823	245.011	804.665			8500
9000	51.754	313.260	281.779	246.973	830.527			9000
9500	51.370	339.060	284.569	248.879	856.328			9500
10000	50.553	364.557	287.185	250.729	881.824			10000
10500	49.410	389.560	289.625	252.524	906.827			10500
11000	48.040	413.930	291.893	254.263	931.197			11000
11500	46.525	437.576	293.995	255.945	954.843			11500
12000	44.935	460.443	295.942	257.572	977.710			12000
12500	43.324	482.508	297.743	259.143	999.775			12500
13000	41.736	503.770	299.412	260.660	1021.038			13000
13500	40.200	524.252	300.958	262.124	1041.519			13500
14000	38.739	543.984	302.393	263.537	1061.251			14000
14500	37.366	563.005	303.728	264.900	1080.273			14500
15000	36.087	581.365	304.973	266.215	1098.632			15000
15500	34.904	599.108	306.137	267.485	1116.375			15500
16000	33.813	616.284	307.227	268.710	1133.551			16000
16500	32.809	632.935	308.252	269.893	1150.202			16500
17000	31.882	649.105	309.218	271.035	1166.372			17000
17500	31.024	664.829	310.130	272.139	1182.096			17500
18000	30.224	680.139	310.992	273.207	1197.406			18000
18500	29.472	695.062	311.810	274.239	1212.329			18500
19000	28.758	709.617	312.586	275.238	1226.884			19000
19500	28.073	723.823	313.324	276.205	1241.090			19500
20000	27.411	737.693	314.027	277.142	1254.960			20000

***Assigned reference element phase change at 2190 K**

TABLE A128.—THERMODYNAMIC PROPERTIES FOR V^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.898	----------	----------	1165.848	1164.290	----------	0
298.15	23.150	0.000	183.378	183.378	1173.745	1173.745	–196.4673	298.15
300	23.125	0.043	183.521	183.379	1173.788	1173.781	–195.1992	300
400	22.253	2.305	190.036	184.273	1176.051	1175.557	–144.0714	400
500	22.004	4.514	194.965	185.938	1178.259	1177.184	–113.3499	500
600	22.180	6.720	198.987	187.787	1180.466	1178.747	–92.8410	600
700	22.632	8.959	202.438	189.639	1182.704	1180.289	–78.1724	700
800	23.222	11.251	205.498	191.434	1184.996	1181.826	–67.1565	800
900	23.837	13.604	208.268	193.153	1187.350	1183.356	–58.5775	900
1000	24.400	16.017	210.810	194.793	1189.762	1184.875	–51.7054	1000
1100	24.872	18.481	213.158	196.357	1192.226	1186.371	–46.0755	1100
1200	25.238	20.987	215.339	197.849	1194.733	1187.823	–41.3782	1200
1300	25.502	23.525	217.370	199.274	1197.271	1189.213	–37.3988	1300
1400	25.678	26.085	219.267	200.635	1199.830	1190.524	–33.9839	1400
1500	25.782	28.658	221.042	201.937	1202.404	1191.746	–31.0212	1500
1600	25.834	31.240	222.708	203.183	1204.985	1192.873	–28.4263	1600
1700	25.851	33.824	224.275	204.378	1207.569	1193.892	–26.1346	1700
1800	25.847	36.409	225.752	205.525	1210.154	1194.795	–24.0959	1800
1900	25.834	38.993	227.150	206.627	1212.739	1195.571	–22.2705	1900
2000	25.823	41.576	228.474	207.686	1215.321	1196.211	–20.6267	2000
2100	25.821	44.158	229.734	208.707	1217.903	1196.705	–19.1386	2100
*2200	25.834	46.741	230.936	209.690	1220.486	1174.165	–17.7879	2200
2300	25.864	49.325	232.085	210.639	1223.071	1174.208	–16.5759	2300
2400	25.916	51.914	233.186	211.555	1225.660	1174.255	–15.4647	2400
2500	25.989	54.509	234.246	212.442	1228.255	1174.308	–14.4425	2500
2600	26.084	57.113	235.267	213.300	1230.858	1174.370	–13.4988	2600
2700	26.201	59.727	236.253	214.132	1233.472	1174.442	–12.6249	2700
2800	26.339	62.354	237.209	214.940	1236.099	1174.527	–11.8135	2800
2900	26.497	64.995	238.136	215.723	1238.741	1174.627	–11.0579	2900
3000	26.673	67.654	239.037	216.486	1241.399	1174.743	–10.3526	3000
3100	26.864	70.330	239.915	217.227	1244.076	1174.878	–9.6928	3100
3200	27.070	73.027	240.771	217.950	1246.772	1175.033	–9.0742	3200
3300	27.288	75.745	241.607	218.654	1249.490	1175.209	–8.4929	3300
3400	27.516	78.485	242.425	219.341	1252.230	1175.408	–7.9457	3400
3500	27.752	81.248	243.226	220.012	1254.994	1175.629	–7.4298	3500
3600	27.994	84.036	244.011	220.668	1257.781	1175.875	–6.9424	3600
3700	28.239	86.847	244.781	221.309	1260.593	1176.144	–6.4812	3700
3800	28.487	89.683	245.538	221.937	1263.429	1176.439	–6.0442	3800
3900	28.735	92.545	246.281	222.552	1266.290	1176.758	–5.6295	3900
4000	28.981	95.430	247.012	223.154	1269.176	1177.102	–5.2354	4000
4100	29.225	98.341	247.730	223.745	1272.086	1177.471	–4.8605	4100
4200	29.465	101.275	248.437	224.324	1275.021	1177.864	–4.5033	4200
4300	29.700	104.234	249.133	224.893	1277.979	1178.280	–4.1625	4300
4400	29.929	107.215	249.819	225.452	1280.961	1178.720	–3.8372	4400
4500	30.151	110.219	250.494	226.001	1283.965	1179.182	–3.5262	4500
4600	30.366	113.245	251.159	226.541	1286.991	1179.667	–3.2286	4600
4700	30.572	116.292	251.814	227.071	1290.038	1180.172	–2.9435	4700
4800	30.770	119.360	252.460	227.594	1293.105	1180.697	–2.6702	4800
4900	30.959	122.446	253.097	228.108	1296.192	1181.242	–2.4079	4900
5000	31.138	125.551	253.724	228.614	1299.296	1181.805	–2.1560	5000

TABLE A128.—THERMODYNAMIC PROPERTIES FOR V^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	31.308	128.673	254.342	229.112	1302.419	1182.386	–1.9139	5100
5200	31.468	131.812	254.952	229.603	1305.558	1182.983	–1.6810	5200
5300	31.619	134.967	255.553	230.087	1308.712	1183.596	–1.4567	5300
5400	31.761	138.136	256.145	230.564	1311.881	1184.223	–1.2406	5400
5500	31.893	141.319	256.729	231.035	1315.064	1184.864	–1.0323	5500
5600	32.017	144.514	257.305	231.499	1318.260	1185.518	–0.8313	5600
5700	32.132	147.722	257.872	231.956	1321.467	1186.183	–0.6373	5700
5800	32.238	150.940	258.432	232.408	1324.686	1186.860	–0.4498	5800
5900	32.337	154.169	258.984	232.854	1327.914	1187.547	–0.2686	5900
6000	32.428	157.407	259.528	233.294	1331.153	1188.244	–0.0933	6000
6200	32.589	163.909	260.594	234.157	1337.655			6200
6400	32.725	170.441	261.631	235.000	1344.187			6400
6600	32.839	176.998	262.640	235.822	1350.743			6600
6800	32.934	183.576	263.622	236.625	1357.321			6800
7000	33.015	190.171	264.578	237.410	1363.916			7000
7200	33.085	196.781	265.509	238.178	1370.526			7200
7400	33.146	203.404	266.416	238.929	1377.150			7400
7600	33.202	210.039	267.301	239.664	1383.784			7600
7800	33.255	216.685	268.164	240.384	1390.430			7800
8000	33.307	223.341	269.007	241.089	1397.086			8000
8500	33.448	240.029	271.030	242.791	1413.774			8500
9000	33.625	256.795	272.946	244.414	1430.540			9000
9500	33.853	273.662	274.770	245.964	1447.408			9500
10000	34.144	290.659	276.514	247.448	1464.404			10000
10500	34.500	307.817	278.188	248.872	1481.562			10500
11000	34.919	325.168	279.802	250.242	1498.914			11000
11500	35.399	342.745	281.365	251.561	1516.490			11500
12000	35.930	360.573	282.882	252.835	1534.318			12000
12500	36.503	378.676	284.360	254.066	1552.421			12500
13000	37.112	397.078	285.804	255.259	1570.824			13000
13500	37.732	415.775	287.215	256.417	1589.521			13500
14000	38.369	434.796	288.598	257.541	1608.541			14000
14500	39.001	454.127	289.955	258.636	1627.872			14500
15000	39.622	473.775	291.287	259.702	1647.520			15000
15500	40.192	493.671	292.591	260.741	1667.417			15500
16000	40.744	513.875	293.874	261.757	1687.621			16000
16500	41.261	534.357	295.134	262.749	1708.102			16500
17000	41.704	555.019	296.367	263.719	1728.764			17000
17500	42.101	575.906	297.577	264.668	1749.651			17500
18000	42.419	596.911	298.760	265.598	1770.657			18000
18500	42.706	618.140	299.923	266.510	1791.886			18500
19000	42.867	639.286	301.048	267.402	1813.032			19000
19500	43.023	660.683	302.159	268.278	1834.428			19500
20000	43.094	682.041	303.239	269.137	1855.786			20000

*Assigned reference element phase change at 2190 K

TABLE A129.—THERMODYNAMIC PROPERTIES FOR V^-

T	C_p°	$H^\circ - H^\circ(298.15)$	S°	$-[G^\circ - H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10} K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.878	----------	----------	452.508	463.345	----------	0
298.15	23.049	0.000	183.438	183.438	460.386	460.386	–73.6813	298.15
300	23.025	0.043	183.581	183.439	460.429	460.344	–73.1840	300
400	22.119	2.294	190.065	184.329	462.680	457.952	–53.1924	400
500	21.660	4.481	194.946	185.984	464.867	455.400	–41.2629	500
600	21.399	6.633	198.870	187.815	467.019	452.751	–33.3554	600
700	21.239	8.764	202.156	189.636	469.150	450.029	–27.7407	700
800	21.134	10.882	204.985	191.382	471.268	447.235	–23.5555	800
900	21.061	12.992	207.469	193.034	473.378	444.364	–20.3210	900
1000	21.009	15.095	209.685	194.590	475.481	441.417	–17.7502	1000
1100	20.971	17.194	211.686	196.055	477.580	438.390	–15.6611	1100
1200	20.941	19.290	213.509	197.435	479.676	435.274	–13.9323	1200
1300	20.918	21.383	215.185	198.736	481.769	432.062	–12.4801	1300
1400	20.900	23.474	216.734	199.967	483.860	428.746	–11.2447	1400
1500	20.885	25.563	218.176	201.134	485.949	425.327	–10.1824	1500
1600	20.873	27.651	219.523	202.241	488.037	421.803	–9.2605	1600
1700	20.863	29.737	220.788	203.296	490.124	418.167	–8.4539	1700
1800	20.855	31.823	221.980	204.301	492.209	414.415	–7.7432	1800
1900	20.848	33.909	223.108	205.261	494.295	410.534	–7.1131	1900
2000	20.842	35.993	224.177	206.180	496.379	406.519	–6.5516	2000
2100	20.837	38.077	225.194	207.062	498.463	402.357	–6.0485	2100
*2200	20.832	40.160	226.163	207.908	500.546	375.160	–5.5985	2200
2300	20.828	42.243	227.089	208.722	502.629	370.544	–5.2136	2300
2400	20.825	44.326	227.975	209.506	504.712	365.928	–4.8651	2400
2500	20.822	46.408	228.825	210.262	506.794	361.311	–4.5485	2500
2600	20.819	48.490	229.642	210.992	508.876	356.694	–4.2600	2600
2700	20.817	50.572	230.428	211.697	510.958	352.077	–3.9963	2700
2800	20.815	52.654	231.185	212.380	513.040	347.459	–3.7546	2800
2900	20.813	54.735	231.915	213.041	515.121	342.842	–3.5326	2900
3000	20.811	56.816	232.621	213.682	517.202	338.224	–3.3281	3000
3100	20.809	58.897	233.303	214.304	519.283	333.606	–3.1394	3100
3200	20.808	60.978	233.964	214.908	521.364	328.988	–2.9650	3200
3300	20.807	63.059	234.604	215.495	523.445	324.369	–2.8034	3300
3400	20.805	65.139	235.225	216.066	525.526	319.751	–2.6534	3400
3500	20.804	67.220	235.828	216.622	527.606	315.132	–2.5141	3500
3600	20.803	69.300	236.414	217.164	529.686	310.514	–2.3844	3600
3700	20.802	71.381	236.984	217.692	531.767	305.895	–2.2635	3700
3800	20.802	73.461	237.539	218.207	533.847	301.276	–2.1507	3800
3900	20.801	75.541	238.079	218.710	535.927	296.657	–2.0453	3900
4000	20.800	77.621	238.606	219.200	538.007	292.038	–1.9468	4000
4100	20.799	79.701	239.119	219.680	540.087	287.419	–1.8545	4100
4200	20.799	81.781	239.621	220.149	542.167	282.800	–1.7680	4200
4300	20.798	83.861	240.110	220.607	544.247	278.181	–1.6869	4300
4400	20.798	85.941	240.588	221.056	546.327	273.562	–1.6107	4400
4500	20.797	88.020	241.055	221.495	548.406	268.942	–1.5392	4500
4600	20.797	90.100	241.513	221.926	550.486	264.323	–1.4719	4600
4700	20.796	92.180	241.960	222.347	552.566	259.704	–1.4086	4700
4800	20.796	94.259	242.398	222.760	554.645	255.084	–1.3490	4800
4900	20.795	96.339	242.826	223.165	556.725	250.465	–1.2928	4900
5000	20.795	98.418	243.247	223.563	558.804	245.845	–1.2399	5000

TABLE A129.—THERMODYNAMIC PROPERTIES FOR V^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.795	100.498	243.658	223.953	560.884	241.226	–1.1900	5100
5200	20.794	102.577	244.062	224.336	562.963	236.606	–1.1430	5200
5300	20.794	104.657	244.458	224.712	565.043	231.987	–1.0986	5300
5400	20.794	106.736	244.847	225.081	567.122	227.367	–1.0566	5400
5500	20.794	108.815	245.228	225.444	569.202	222.747	–1.0171	5500
5600	20.793	110.895	245.603	225.800	571.281	218.128	–0.9797	5600
5700	20.793	112.974	245.971	226.151	573.360	213.508	–0.9444	5700
5800	20.793	115.053	246.333	226.496	575.440	208.888	–0.9110	5800
5900	20.793	117.133	246.688	226.835	577.519	204.268	–0.8795	5900
6000	20.792	119.212	247.038	227.169	579.598	199.649	–0.8497	6000
6200	20.792	123.370	247.719	227.821	583.756			6200
6400	20.792	127.529	248.380	228.453	587.915			6400
6600	20.791	131.687	249.019	229.067	592.073			6600
6800	20.791	135.845	249.640	229.663	596.231			6800
7000	20.791	140.003	250.243	230.242	600.390			7000
7200	20.791	144.162	250.828	230.806	604.548			7200
7400	20.790	148.320	251.398	231.355	608.706			7400
7600	20.790	152.478	251.952	231.890	612.864			7600
7800	20.790	156.636	252.493	232.411	617.022			7800
8000	20.790	160.794	253.019	232.920	621.180			8000
8500	20.789	171.188	254.279	234.139	631.575			8500
9000	20.789	181.583	255.467	235.292	641.969			9000
9500	20.789	191.977	256.591	236.383	652.364			9500
10000	20.788	202.372	257.658	237.421	662.758			10000
10500	20.788	212.766	258.672	238.409	673.152			10500
11000	20.788	223.160	259.639	239.352	683.546			11000
11500	20.788	233.554	260.563	240.254	693.940			11500
12000	20.788	243.948	261.448	241.119	704.334			12000
12500	20.788	254.342	262.297	241.949	714.728			12500
13000	20.788	264.736	263.112	242.748	725.122			13000
13500	20.787	275.129	263.896	243.516	735.516			13500
14000	20.787	285.523	264.652	244.258	745.909			14000
14500	20.787	295.917	265.382	244.974	756.303			14500
15000	20.787	306.310	266.087	245.666	766.697			15000
15500	20.787	316.704	266.768	246.336	777.090			15500
16000	20.787	327.098	267.428	246.984	787.484			16000
16500	20.787	337.491	268.068	247.614	797.877			16500
17000	20.787	347.885	268.688	248.225	808.271			17000
17500	20.787	358.278	269.291	248.818	818.664			17500
18000	20.787	368.672	269.876	249.395	829.058			18000
18500	20.787	379.065	270.446	249.956	839.451			18500
19000	20.787	389.459	271.000	250.503	849.845			19000
19500	20.787	399.852	271.540	251.035	860.238			19500
20000	20.787	410.246	272.067	251.554	870.632			20000

*Assigned reference element phase change at 2190 K

TABLE A130.—THERMODYNAMIC PROPERTIES FOR W

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.217	----------	----------	845.027	850.000	----------	0
100	20.786	–4.138	151.177	192.556	847.106	851.427	–437.3340	100
200	20.808	–2.059	165.587	175.882	849.185	851.498	–214.9492	200
298.15	21.306	0.000	173.957	173.957	851.244	851.244	–141.7502	298.15
300	21.326	0.039	174.088	173.957	851.283	851.238	–140.8305	300
400	23.164	2.252	180.440	174.811	853.495	850.986	–103.7833	400
500	26.345	4.718	185.929	176.494	855.961	850.938	–81.5597	500
600	30.337	7.548	191.079	178.499	858.791	851.211	–66.7422	600
700	34.382	10.787	196.063	180.654	862.030	851.849	–56.1527	700
800	37.766	14.402	200.886	182.883	865.645	852.819	–48.2031	800
900	40.071	18.303	205.478	185.141	869.547	854.032	–42.0121	900
1000	41.236	22.378	209.770	187.392	873.621	855.372	–37.0518	1000
1100	41.439	26.518	213.716	189.609	877.762	856.734	–32.9870	1100
1200	40.952	30.643	217.305	191.770	881.886	858.034	–29.5943	1200
1300	40.037	34.695	220.549	193.861	885.938	859.216	–26.7194	1300
1400	38.901	38.643	223.475	195.873	889.886	860.247	–24.2519	1400
1500	37.687	42.472	226.118	197.803	893.716	861.115	–22.1112	1500
1600	36.488	46.181	228.512	199.649	897.424	861.813	–20.2363	1600
1700	35.360	49.772	230.689	201.412	901.016	862.348	–18.5808	1700
1800	34.331	53.256	232.681	203.094	904.499	862.726	–17.1084	1800
1900	33.417	56.642	234.512	204.700	907.886	862.961	–15.7906	1900
2000	32.622	59.943	236.205	206.234	911.187	863.061	–14.6043	2000
2100	31.944	63.171	237.780	207.699	914.414	863.038	–13.5310	2100
2200	31.379	66.336	239.253	209.100	917.579	862.904	–12.5553	2200
2300	30.922	69.450	240.637	210.441	920.693	862.669	–11.6646	2300
2400	30.566	72.524	241.945	211.727	923.767	862.345	–10.8485	2400
2500	30.304	75.566	243.187	212.961	926.810	861.940	–10.0979	2500
2600	30.129	78.587	244.372	214.146	929.831	861.465	–9.4055	2600
2700	30.034	81.595	245.507	215.287	932.838	860.903	–8.7647	2700
2800	30.013	84.597	246.599	216.386	935.840	860.227	–8.1701	2800
2900	30.058	87.600	247.653	217.446	938.843	859.403	–7.6170	2900
3000	30.164	90.610	248.673	218.470	941.854	858.412	–7.1013	3000
3100	30.324	93.634	249.665	219.460	944.878	857.216	–6.6195	3100
3200	30.533	96.677	250.631	220.419	947.920	855.788	–6.1685	3200
3300	30.785	99.742	251.574	221.349	950.986	854.109	–5.7456	3300
3400	31.075	102.835	252.497	222.252	954.078	852.145	–5.3484	3400
3500	31.399	105.958	253.403	223.129	957.202	849.839	–4.9749	3500
3600	31.751	109.116	254.292	223.982	960.359	847.089	–4.6231	3600
*3700	32.128	112.309	255.167	224.813	963.553	809.062	–4.2943	3700
3800	32.526	115.542	256.029	225.623	966.785	808.738	–3.9938	3800
3900	32.942	118.815	256.879	226.414	970.059	808.455	–3.7088	3900
4000	33.372	122.131	257.719	227.186	973.374	808.214	–3.4381	4000
4100	33.814	125.490	258.548	227.941	976.733	808.017	–3.1807	4100
4200	34.266	128.894	259.368	228.679	980.137	807.864	–2.9357	4200
4300	34.727	132.343	260.180	229.403	983.587	807.757	–2.7020	4300
4400	35.194	135.839	260.984	230.111	987.083	807.697	–2.4790	4400
4500	35.668	139.383	261.780	230.806	990.626	807.684	–2.2660	4500

TABLE A130.—THERMODYNAMIC PROPERTIES FOR W (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	36.147	142.973	262.569	231.488	994.217	807.718	–2.0622	4600
4700	36.632	146.612	263.352	232.158	997.856	807.800	–1.8670	4700
4800	37.121	150.300	264.128	232.816	1001.543	807.931	–1.6800	4800
4900	37.617	154.036	264.899	233.463	1005.280	808.112	–1.5005	4900
5000	38.118	157.823	265.664	234.099	1009.067	808.342	–1.3282	5000
5100	38.627	161.660	266.424	234.725	1012.904	808.623	–1.1626	5100
5200	39.143	165.549	267.179	235.342	1016.792	808.955	–1.0033	5200
5300	39.667	169.489	267.929	235.950	1020.733	809.339	-0.8499	5300
5400	40.199	173.482	268.675	236.549	1024.725	809.775	–0.7022	5400
5500	40.743	177.528	269.418	237.140	1028.772	810.266	–0.5597	5500
5600	41.298	181.630	270.157	237.723	1032.874	810.811	–0.4223	5600
5700	41.866	185.789	270.893	238.298	1037.032	811.413	–0.2896	5700
5800	42.446	190.004	271.626	238.867	1041.247	812.072	–0.1613	5800
5900	43.040	194.278	272.357	239.428	1045.522	812.790	-0.0373	5900
6000	43.639	198.608	273.084	239.983	1049.852	813.563	0.0827	6000
6200	44.894	207.461	274.536	241.074	1058.704			6200
6400	46.205	216.569	275.981	242.143	1067.813			6400
6600	47.543	225.931	277.422	243.190	1077.175			6600
6800	48.943	235.579	278.862	244.218	1086.823			6800
7000	50.372	245.509	280.301	245.228	1096.753			7000
7200	51.765	255.687	281.734	246.222	1106.930			7200
7400	53.200	266.181	283.171	247.201	1117.425			7400
7600	54.611	276.957	284.608	248.166	1128.200			7600
7800	55.900	287.933	286.032	249.118	1139.177			7800
8000	57.203	299.240	287.463	250.059	1150.483			8000
8500	59.936	328.394	290.995	252.361	1179.637			8500
9000	61.871	358.635	294.448	254.600	1209.879			9000
9500	62.862	389.473	297.776	256.779	1240.716			9500
10000	63.170	420.965	301.006	258.909	1272.208			10000
10500	62.397	451.716	303.994	260.974	1302.959			10500
11000	60.932	481.722	306.770	262.977	1332.965			11000
11500	58.928	510.546	309.309	264.914	1361.789			11500
12000	56.613	538.117	311.628	266.785	1389.361			12000
12500	54.118	564.190	313.720	268.585	1415.434			12500
13000	51.806	590.284	315.758	270.352	1441.527			13000
13500	49.322	613.720	317.481	272.020	1464.963			13500
14000	46.924	635.516	319.006	273.612	1486.760			14000
14500	44.711	656.354	320.411	275.145	1507.597			14500
15000	42.655	675.852	321.664	276.607	1527.095			15000
15500	40.763	694.046	322.775	277.998	1545.289			15500
16000	39.055	711.373	323.790	279.330	1562.617			16000
16500	37.584	729.793	324.899	280.670	1581.036			16500
17000	36.175	745.243	325.717	281.879	1596.486			17000
17500	34.903	759.678	326.432	283.022	1610.921			17500
18000	33.758	773.066	327.044	284.096	1624.310			18000
18500	32.738	786.091	327.616	285.125	1637.334			18500
19000	31.828	798.730	328.148	286.109	1649.973			19000
19500	31.036	813.556	328.881	287.160	1664.799			19500
20000	30.294	824.908	329.284	288.039	1676.151			20000

***Assigned reference element phase change at 3680 K**

TABLE A131.—THERMODYNAMIC PROPERTIES FOR W^+

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.221	---------	----------	1621.620	1620.395	----------	0
298.15	21.372	0.000	179.739	179.739	1627.841	1627.841	–276.4056	298.15
300	21.392	0.040	179.871	179.739	1627.881	1627.874	–274.6469	300
400	22.891	2.247	186.212	180.594	1630.088	1629.696	–203.7536	400
500	24.828	4.632	191.526	182.261	1632.473	1631.646	–161.1681	500
600	26.695	7.210	196.221	184.204	1635.051	1633.746	–132.7424	600
700	28.295	9.962	200.460	186.228	1637.803	1635.975	–112.4113	700
800	29.616	12.860	204.327	188.252	1640.701	1638.306	–97.1416	800
900	30.703	15.878	207.880	190.238	1643.719	1640.714	–85.2480	900
1000	31.603	18.994	211.163	192.169	1646.835	1643.175	–75.7189	1000
1100	32.348	22.193	214.211	194.036	1650.034	1645.674	–67.9106	1100
1200	32.956	25.459	217.053	195.837	1653.300	1648.194	–61.3937	1200
1300	33.442	28.780	219.711	197.572	1656.621	1650.724	–55.8709	1300
1400	33.814	32.144	222.203	199.243	1659.985	1653.249	–51.1299	1400
1500	34.083	35.540	224.546	200.853	1663.380	1655.761	–47.0147	1500
1600	34.261	38.957	226.752	202.403	1666.798	1658.248	–43.4084	1600
1700	34.363	42.389	228.832	203.897	1670.230	1660.701	–40.2217	1700
1800	34.402	45.828	230.798	205.338	1673.669	1663.114	–37.3849	1800
1900	34.393	49.268	232.658	206.727	1677.109	1665.480	–34.8431	1900
2000	34.351	52.705	234.421	208.068	1680.546	1667.795	–32.5522	2000
2100	34.289	56.137	236.095	209.363	1683.978	1670.056	–30.4767	2100
2200	34.218	59.563	237.689	210.615	1687.404	1672.261	–28.5873	2200
2300	34.148	62.981	239.208	211.825	1690.822	1674.409	–26.8599	2300
2400	34.087	66.393	240.660	212.997	1694.234	1676.501	–25.2746	2400
2500	34.041	69.799	242.051	214.131	1697.640	1678.538	–23.8142	2500
2600	34.014	73.202	243.385	215.231	1701.043	1680.523	–22.4645	2600
2700	34.008	76.603	244.669	216.298	1704.444	1682.434	–21.2134	2700
2800	34.026	80.004	245.906	217.333	1707.845	1684.236	–20.0504	2800
2900	34.067	83.409	247.101	218.339	1711.250	1685.892	–18.9664	2900
3000	34.131	86.818	248.257	219.317	1714.659	1687.379	–17.9538	3000
3100	34.216	90.235	249.377	220.269	1718.076	1688.654	–17.0057	3100
3200	34.321	93.662	250.465	221.196	1721.503	1689.690	–16.1163	3200
3300	34.442	97.100	251.523	222.099	1724.941	1690.461	–15.2803	3300
3400	34.578	100.551	252.553	222.979	1728.392	1690.935	–14.4932	3400
3500	34.726	104.016	253.558	223.839	1731.857	1691.049	–13.7510	3500
3600	34.882	107.496	254.538	224.678	1735.337	1690.701	–13.0500	3600
*3700	35.044	110.993	255.496	225.498	1738.834	1655.054	–12.3898	3700
3800	35.209	114.505	256.433	226.300	1742.346	1657.089	–11.7746	3800
3900	35.375	118.035	257.349	227.084	1745.876	1659.141	–11.1902	3900
4000	35.539	121.580	258.247	227.852	1749.421	1661.209	–10.6343	4000
4100	35.698	125.142	259.127	228.604	1752.983	1663.293	–10.1049	4100
4200	35.851	128.720	259.989	229.341	1756.561	1665.392	–9.6001	4200
4300	35.996	132.312	260.834	230.064	1760.153	1667.507	–9.1181	4300
4400	36.131	135.919	261.663	230.773	1763.760	1669.636	–8.6575	4400
4500	36.256	139.538	262.477	231.468	1767.379	1671.777	–8.2167	4500
4600	36.368	143.169	263.275	232.151	1771.010	1673.931	–7.7946	4600
4700	36.468	146.811	264.058	232.821	1774.652	1676.095	–7.3899	4700
4800	36.554	150.462	264.827	233.480	1778.303	1678.268	–7.0016	4800
4900	36.626	154.122	265.581	234.128	1781.963	1680.450	–6.6287	4900

TABLE A131.—THERMODYNAMIC PROPERTIES FOR W^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5000	36.685	157.787	266.322	234.764	1785.628	1682.638	–6.2702	5000
5100	36.730	161.458	267.049	235.390	1789.299	1684.831	–5.9253	5100
5200	36.760	165.133	267.762	236.006	1792.974	1687.028	–5.5932	5200
5300	36.777	168.810	268.462	236.612	1796.651	1689.227	–5.2733	5300
5400	36.781	172.488	269.150	237.208	1800.329	1691.427	–4.9648	5400
5500	36.772	176.165	269.825	237.795	1804.006	1693.627	–4.6671	5500
5600	36.751	179.842	270.487	238.373	1807.683	1695.826	–4.3797	5600
5700	36.718	183.515	271.137	238.942	1811.356	1698.021	–4.1020	5700
5800	36.674	187.185	271.776	239.502	1815.026	1700.213	–3.8336	5800
5900	36.620	190.850	272.402	240.055	1818.691	1702.400	–3.5739	5900
6000	36.557	194.509	273.017	240.599	1822.350	1704.581	–3.3225	6000
6200	36.405	201.805	274.213	241.664	1829.646			6200
6400	36.224	209.069	275.366	242.699	1836.910			6400
6600	36.022	216.294	276.478	243.706	1844.135			6600
6800	35.803	223.476	277.550	244.686	1851.317			6800
7000	35.573	230.614	278.585	245.640	1858.455			7000
7200	35.337	237.705	279.584	246.569	1865.546			7200
7400	35.101	244.749	280.549	247.474	1872.590			7400
7600	34.867	251.746	281.481	248.357	1879.586			7600
7800	34.640	258.696	282.384	249.218	1886.537			7800
8000	34.423	265.602	283.258	250.058	1893.443			8000
8500	33.937	282.688	285.330	252.073	1910.529			8500
9000	33.557	299.557	287.259	253.975	1927.398			9000
9500	33.298	316.266	289.066	255.775	1944.107			9500
10000	33.167	332.877	290.770	257.482	1960.718			10000
10500	33.163	349.454	292.387	259.106	1977.295			10500
11000	33.281	366.060	293.932	260.654	1993.901			11000
11500	33.510	382.753	295.416	262.134	2010.594			11500
12000	33.839	399.587	296.849	263.550	2027.427			12000
12500	34.255	416.607	298.239	264.910	2044.448			12500
13000	34.744	433.853	299.592	266.218	2061.694			13000
13500	35.289	451.358	300.913	267.479	2079.199			13500
14000	35.880	469.149	302.207	268.696	2096.990			14000
14500	36.500	487.243	303.476	269.874	2115.084			14500
15000	37.137	505.652	304.725	271.014	2133.493			15000
15500	37.770	524.369	305.952	272.122	2152.210			15500
16000	38.402	543.413	307.161	273.198	2171.254			16000
16500	39.014	562.768	308.352	274.245	2190.609			16500
17000	39.600	582.423	309.526	275.266	2210.264			17000
17500	40.151	602.362	310.682	276.261	2230.203			17500
18000	40.635	622.514	311.817	277.233	2250.355			18000
18500	41.093	642.948	312.936	278.183	2270.789			18500
19000	41.501	663.598	314.038	279.112	2291.439			19000
19500	41.855	684.440	315.121	280.021	2312.281			19500
20000	42.107	705.312	316.177	280.911	2333.153			20000

*Assigned reference element phase change at 3680 K

TABLE A132.—THERMODYNAMIC PROPERTIES FOR W^-

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	760.194	771.365	----------	0
298.15	20.786	0.000	188.782	188.782	766.392	766.392	–127.2062	298.15
300	20.786	0.038	188.911	188.783	766.430	766.347	–126.3783	300
400	20.786	2.117	194.891	189.598	768.509	763.883	–93.0691	400
500	20.786	4.196	199.529	191.138	770.587	761.369	–73.1494	500
600	20.786	6.274	203.319	192.862	772.666	758.812	–59.9140	600
700	20.786	8.353	206.523	194.590	774.744	756.211	–50.4924	700
800	20.786	10.432	209.299	196.259	776.823	753.566	–43.4506	800
900	20.786	12.510	211.747	197.847	778.902	750.877	–37.9932	900
1000	20.786	14.589	213.937	199.348	780.980	748.143	–33.6429	1000
1100	20.786	16.667	215.918	200.766	783.059	745.364	–30.0967	1100
1200	20.786	18.746	217.727	202.105	785.138	742.540	–27.1527	1200
1300	20.786	20.825	219.391	203.372	787.216	739.670	–24.6711	1300
1400	20.786	22.903	220.931	204.571	789.295	736.753	–22.5523	1400
1500	20.786	24.982	222.365	205.710	791.374	733.791	–20.7234	1500
1600	20.786	27.061	223.707	206.794	793.452	730.781	–19.1296	1600
1700	20.786	29.139	224.967	207.826	795.531	727.724	–17.7291	1700
1800	20.786	31.218	226.155	208.812	797.609	724.619	–16.4895	1800
1900	20.786	33.296	227.279	209.754	799.688	721.467	–15.3852	1900
2000	20.786	35.375	228.345	210.657	801.767	718.266	–14.3956	2000
2100	20.786	37.454	229.359	211.524	803.845	715.016	–13.5043	2100
2200	20.786	39.532	230.326	212.357	805.924	711.717	–12.6978	2200
2300	20.786	41.611	231.250	213.158	808.003	708.368	–11.9648	2300
2400	20.786	43.690	232.135	213.931	810.081	704.970	–11.2961	2400
2500	20.786	45.768	232.983	214.676	812.160	701.522	–10.6838	2500
2600	20.786	47.847	233.799	215.396	814.238	698.026	–10.1215	2600
2700	20.786	49.926	234.583	216.092	816.317	694.457	–9.6034	2700
2800	20.786	52.004	235.339	216.766	818.396	690.779	–9.1249	2800
2900	20.786	54.083	236.068	217.419	820.474	686.952	–8.6817	2900
3000	20.786	56.161	236.773	218.053	822.553	682.950	–8.2704	3000
3100	20.786	58.240	237.455	218.668	824.632	678.730	–7.8880	3100
3200	20.786	60.319	238.115	219.265	826.710	674.260	–7.5318	3200
3300	20.786	62.397	238.754	219.846	828.789	669.515	–7.1994	3300
3400	20.786	64.476	239.375	220.411	830.867	664.459	–6.8889	3400
3500	20.786	66.555	239.977	220.962	832.946	659.029	–6.5984	3500
3600	20.786	68.633	240.563	221.498	835.025	653.122	–6.3264	3600
*3700	20.786	70.712	241.132	222.021	837.103	611.900	–6.0742	3700
3800	20.786	72.790	241.687	222.531	839.182	608.344	–5.8476	3800
3900	20.786	74.869	242.227	223.029	841.261	604.787	–5.6338	3900
4000	20.786	76.948	242.753	223.516	843.339	601.231	–5.4319	4000
4100	20.786	79.026	243.266	223.991	845.418	597.675	–5.2409	4100
4200	20.786	81.105	243.767	224.456	847.496	594.118	–5.0602	4200
4300	20.786	83.184	244.256	224.911	849.575	590.562	–4.8888	4300
4400	20.786	85.262	244.734	225.356	851.654	587.005	–4.7263	4400
4500	20.786	87.341	245.201	225.792	853.732	583.449	–4.5719	4500
4600	20.786	89.419	245.658	226.219	855.811	579.893	–4.4251	4600
4700	20.786	91.498	246.105	226.637	857.890	576.336	–4.2855	4700
4800	20.786	93.577	246.543	227.048	859.968	572.780	–4.1524	4800
4900	20.786	95.655	246.971	227.450	862.047	569.223	–4.0256	4900
5000	20.786	97.734	247.391	227.844	864.125	565.667	–3.9046	5000

TABLE A132.—THERMODYNAMIC PROPERTIES FOR W^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.786	99.813	247.803	228.232	866.204	562.111	–3.7891	5100
5200	20.786	101.891	248.206	228.612	868.283	558.554	–3.6788	5200
5300	20.786	103.970	248.602	228.985	870.361	554.998	–3.5732	5300
5400	20.786	106.048	248.991	229.352	872.440	551.441	–3.4723	5400
5500	20.786	108.127	249.372	229.713	874.519	547.885	–3.3756	5500
5600	20.786	110.206	249.747	230.067	876.597	544.329	–3.2830	5600
5700	20.786	112.284	250.115	230.416	878.676	540.772	–3.1942	5700
5800	20.786	114.363	250.476	230.759	880.754	537.216	–3.1090	5800
5900	20.786	116.442	250.832	231.096	882.833	533.659	–3.0273	5900
6000	20.786	118.520	251.181	231.428	884.912	530.103	–2.9488	6000
6200	20.786	122.677	251.863	232.076	889.069			6200
6400	20.786	126.835	252.523	232.705	893.226			6400
6600	20.786	130.992	253.162	233.315	897.384			6600
6800	20.786	135.149	253.783	233.908	901.541			6800
7000	20.786	139.306	254.385	234.484	905.698			7000
7200	20.786	143.464	254.971	235.045	909.855			7200
7400	20.786	147.621	255.540	235.592	914.013			7400
7600	20.786	151.778	256.095	236.124	918.170			7600
7800	20.786	155.936	256.635	236.643	922.327			7800
8000	20.786	160.093	257.161	237.149	926.484			8000
8500	20.786	170.486	258.421	238.364	936.877			8500
9000	20.786	180.879	259.609	239.511	947.271			9000
9500	20.786	191.272	260.733	240.599	957.664			9500
10000	20.786	201.665	261.799	241.633	968.057			10000
10500	20.786	212.058	262.813	242.617	978.450			10500
11000	20.786	222.452	263.780	243.557	988.843			11000
11500	20.786	232.845	264.704	244.457	999.236			11500
12000	20.786	243.238	265.589	245.319	1009.629			12000
12500	20.786	253.631	266.437	246.147	1020.023			12500
13000	20.786	264.024	267.253	246.943	1030.416			13000
13500	20.786	274.417	268.037	247.710	1040.809			13500
14000	20.786	284.810	268.793	248.450	1051.202			14000
14500	20.786	295.204	269.523	249.164	1061.595			14500
15000	20.786	305.597	270.227	249.854	1071.988			15000
15500	20.786	315.990	270.909	250.522	1082.381			15500
16000	20.786	326.383	271.569	251.170	1092.774			16000
16500	20.786	336.776	272.208	251.798	1103.168			16500
17000	20.786	347.169	272.829	252.407	1113.561			17000
17500	20.786	357.562	273.431	252.999	1123.954			17500
18000	20.786	367.956	274.017	253.575	1134.347			18000
18500	20.786	378.349	274.587	254.135	1144.740			18500
19000	20.786	388.742	275.141	254.681	1155.133			19000
19500	20.786	399.135	275.681	255.212	1165.526			19500
20000	20.786	409.528	276.207	255.731	1175.920			20000

*Assigned reference element phase change at 3680 K

TABLE A133.—THERMODYNAMIC PROPERTIES FOR Xe

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	–6.197	0	----------	0
100	20.786	–4.119	146.978	188.166	–4.119	0	0	100
200	20.786	–2.040	161.386	171.587	–2.040	0	0	200
298.15	20.786	0.000	169.686	169.686	0.000	0	0	298.15
300	20.786	0.038	169.815	169.686	0.038	0	0	300
400	20.786	2.117	175.794	170.502	2.117	0	0	400
500	20.786	4.196	180.433	172.041	4.196	0	0	500
600	20.786	6.274	184.222	173.765	6.274	0	0	600
700	20.786	8.353	187.427	175.494	8.353	0	0	700
800	20.786	10.432	190.202	177.163	10.432	0	0	800
900	20.786	12.510	192.651	178.750	12.510	0	0	900
1000	20.786	14.589	194.841	180.252	14.589	0	0	1000
1100	20.786	16.667	196.822	181.670	16.667	0	0	1100
1200	20.786	18.746	198.630	183.009	18.746	0	0	1200
1300	20.786	20.825	200.294	184.275	20.825	0	0	1300
1400	20.786	22.903	201.835	185.475	22.903	0	0	1400
1500	20.786	24.982	203.269	186.614	24.982	0	0	1500
1600	20.786	27.061	204.610	187.697	27.061	0	0	1600
1700	20.786	29.139	205.870	188.730	29.139	0	0	1700
1800	20.786	31.218	207.059	189.715	31.218	0	0	1800
1900	20.786	33.296	208.182	190.658	33.296	0	0	1900
2000	20.786	35.375	209.249	191.561	35.375	0	0	2000
2100	20.786	37.454	210.263	192.428	37.454	0	0	2100
2200	20.786	39.532	211.230	193.260	39.532	0	0	2200
2300	20.786	41.611	212.154	194.062	41.611	0	0	2300
2400	20.786	43.690	213.038	194.834	43.690	0	0	2400
2500	20.786	45.768	213.887	195.580	45.768	0	0	2500
2600	20.786	47.847	214.702	196.300	47.847	0	0	2600
2700	20.786	49.926	215.487	196.996	49.926	0	0	2700
2800	20.786	52.004	216.243	197.670	52.004	0	0	2800
2900	20.786	54.083	216.972	198.323	54.083	0	0	2900
3000	20.786	56.161	217.677	198.956	56.161	0	0	3000
3100	20.786	58.240	218.358	199.571	58.240	0	0	3100
3200	20.786	60.319	219.018	200.169	60.319	0	0	3200
3300	20.786	62.397	219.658	200.750	62.397	0	0	3300
3400	20.786	64.476	220.278	201.315	64.476	0	0	3400
3500	20.786	66.555	220.881	201.865	66.555	0	0	3500
3600	20.786	68.633	221.466	202.402	68.633	0	0	3600
3700	20.786	70.712	222.036	202.925	70.712	0	0	3700
3800	20.786	72.790	222.590	203.435	72.790	0	0	3800
3900	20.786	74.869	223.130	203.933	74.869	0	0	3900
4000	20.786	76.948	223.657	204.420	76.948	0	0	4000
4100	20.786	79.026	224.170	204.895	79.026	0	0	4100
4200	20.786	81.105	224.671	205.360	81.105	0	0	4200
4300	20.786	83.184	225.160	205.815	83.184	0	0	4300
4400	20.786	85.262	225.638	206.260	85.262	0	0	4400
4500	20.786	87.341	226.105	206.696	87.341	0	0	4500

TABLE A133.—THERMODYNAMIC PROPERTIES FOR Xe (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	20.786	89.419	226.562	207.123	89.419	0	0	4600
4700	20.786	91.498	227.009	207.541	91.498	0	0	4700
4800	20.786	93.577	227.446	207.951	93.577	0	0	4800
4900	20.786	95.655	227.875	208.353	95.655	0	0	4900
5000	20.786	97.734	228.295	208.748	97.734	0	0	5000
5100	20.786	99.813	228.706	209.135	99.813	0	0	5100
5200	20.787	101.891	229.110	209.516	101.891	0	0	5200
5300	20.787	103.970	229.506	209.889	103.970	0	0	5300
5400	20.787	106.049	229.895	210.256	106.049	0	0	5400
5500	20.787	108.127	230.276	210.617	108.127	0	0	5500
5600	20.787	110.206	230.651	210.971	110.206	0	0	5600
5700	20.788	112.285	231.019	211.319	112.285	0	0	5700
5800	20.788	114.364	231.380	211.662	114.364	0	0	5800
5900	20.789	116.442	231.735	211.999	116.442	0	0	5900
6000	20.790	118.521	232.085	212.331	118.521	0	0	6000
6200	20.791	122.679	232.767	212.980	122.679	0	0	6200
6400	20.795	126.838	233.427	213.608	126.838	0	0	6400
6600	20.799	130.997	234.067	214.219	130.997	0	0	6600
6800	20.806	135.158	234.688	214.812	135.158	0	0	6800
7000	20.816	139.320	235.291	215.388	139.320	0	0	7000
7200	20.830	143.484	235.877	215.949	143.484	0	0	7200
7400	20.848	147.652	236.448	216.495	147.652	0	0	7400
7600	20.872	151.824	237.005	217.028	151.824	0	0	7600
7800	20.905	156.001	237.547	217.547	156.001	0	0	7800
8000	20.946	160.185	238.077	218.054	160.185	0	0	8000
8500	21.024	169.599	239.093	219.140	169.599	0	0	8500
9000	21.221	180.140	240.298	220.283	180.140	0	0	9000
9500	21.744	190.873	241.459	221.367	190.873	0	0	9500
10000	22.411	201.908	242.591	222.400	201.908	0	0	10000
10500	23.181	213.302	243.702	223.388	213.302	0	0	10500
11000	24.081	225.110	244.801	224.336	225.110	0	0	11000
11500	25.160	237.412	245.894	225.250	237.412	0	0	11500
12000	26.469	250.309	246.992	226.133	250.309	0	0	12000
12500	28.045	263.925	248.103	226.989	263.925	0	0	12500
13000	29.908	278.402	249.239	227.823	278.402	0	0	13000
13500	32.058	293.882	250.407	228.638	293.882	0	0	13500
14000	34.474	310.504	251.616	229.437	310.504	0	0	14000
14500	37.122	328.395	252.871	230.223	328.395	0	0	14500
15000	39.954	347.658	254.177	230.999	347.658	0	0	15000
15500	42.909	368.370	255.535	231.769	368.370	0	0	15500
16000	45.921	390.576	256.944	232.533	390.576	0	0	16000
16500	48.921	414.288	258.404	233.295	414.288	0	0	16500
17000	51.837	439.483	259.908	234.056	439.483	0	0	17000
17500	54.601	466.100	261.451	234.816	466.100	0	0	17500
18000	57.147	494.047	263.025	235.578	494.047	0	0	18000
18500	59.418	523.201	264.622	236.341	523.201	0	0	18500
19000	61.364	553.411	266.234	237.107	553.411	0	0	19000
19500	62.946	584.503	267.849	237.874	584.503	0	0	19500
20000	64.139	616.292	269.458	238.644	616.292	0	0	20000

TABLE A134.—THERMODYNAMIC PROPERTIES FOR Xe^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1170.355	1170.355	----------	0
298.15	20.786	0.000	181.212	181.212	1176.552	1176.552	–204.4240	298.15
300	20.786	0.038	181.341	181.213	1176.591	1176.591	–203.1529	300
400	20.786	2.117	187.321	182.028	1178.669	1178.669	–151.8976	400
500	20.786	4.196	191.959	183.568	1180.748	1180.748	–121.0896	500
600	20.786	6.274	195.749	185.292	1182.827	1182.827	–100.5145	600
700	20.786	8.353	198.953	187.020	1184.905	1184.905	–85.7920	700
800	20.786	10.432	201.729	188.689	1186.984	1186.984	–74.7306	800
900	20.786	12.510	204.177	190.277	1189.062	1189.062	–66.1123	900
1000	20.787	14.589	206.367	191.778	1191.141	1191.141	–59.2055	1000
1100	20.787	16.668	208.348	193.196	1193.220	1193.220	–53.5446	1100
1200	20.788	18.746	210.157	194.535	1195.299	1195.299	–48.8189	1200
1300	20.791	20.825	211.821	195.802	1197.378	1197.378	–44.8133	1300
1400	20.796	22.905	213.362	197.001	1199.457	1199.457	–41.3740	1400
1500	20.804	24.985	214.797	198.141	1201.537	1201.537	–38.3881	1500
1600	20.815	27.065	216.140	199.224	1203.618	1203.618	–35.7708	1600
1700	20.831	29.148	217.402	200.257	1205.700	1205.700	–33.4575	1700
1800	20.851	31.232	218.593	201.242	1207.784	1207.784	–31.3977	1800
1900	20.877	33.318	219.721	202.186	1209.870	1209.870	–29.5515	1900
2000	20.908	35.407	220.793	203.089	1211.960	1211.960	–27.8870	2000
2100	20.945	37.500	221.814	203.957	1214.052	1214.052	–26.3785	2100
2200	20.987	39.596	222.789	204.791	1216.149	1216.149	–25.0047	2200
2300	21.034	41.697	223.723	205.594	1218.250	1218.250	–23.7483	2300
2400	21.085	43.803	224.620	206.368	1220.356	1220.356	–22.5945	2400
2500	21.141	45.915	225.481	207.116	1222.467	1222.467	–21.5312	2500
2600	21.200	48.032	226.312	207.838	1224.584	1224.584	–20.5480	2600
2700	21.262	50.155	227.113	208.537	1226.707	1226.707	–19.6361	2700
2800	21.326	52.284	227.887	209.214	1228.836	1228.836	–18.7878	2800
2900	21.393	54.420	228.637	209.871	1230.972	1230.972	–17.9966	2900
3000	21.460	56.563	229.363	210.509	1233.115	1233.115	–17.2569	3000
3100	21.528	58.712	230.068	211.129	1235.264	1235.264	–16.5638	3100
3200	21.597	60.868	230.753	211.731	1237.421	1237.421	–15.9128	3200
3300	21.665	63.031	231.418	212.318	1239.584	1239.584	–15.3002	3300
3400	21.732	65.201	232.066	212.889	1241.753	1241.753	–14.7226	3400
3500	21.798	67.378	232.697	213.446	1243.930	1243.930	–14.1771	3500
3600	21.863	69.561	233.312	213.989	1246.113	1246.113	–13.6610	3600
3700	21.927	71.750	233.912	214.520	1248.303	1248.303	–13.1719	3700
3800	21.989	73.946	234.497	215.038	1250.498	1250.498	–12.7077	3800
3900	22.048	76.148	235.069	215.544	1252.700	1252.700	–12.2666	3900
4000	22.106	78.356	235.628	216.039	1254.908	1254.908	–11.8468	4000
4100	22.161	80.569	236.175	216.524	1257.121	1257.121	–11.4468	4100
4200	22.213	82.788	236.709	216.998	1259.340	1259.340	–11.0651	4200
4300	22.263	85.012	237.233	217.463	1261.564	1261.564	–10.7006	4300
4400	22.311	87.240	237.745	217.918	1263.793	1263.793	–10.3520	4400
4500	22.356	89.474	238.247	218.364	1266.026	1266.026	–10.0183	4500
4600	22.399	91.712	238.739	218.802	1268.264	1268.264	–9.6986	4600
4700	22.439	93.953	239.221	219.231	1270.506	1270.506	–9.3919	4700
4800	22.476	96.199	239.694	219.652	1272.751	1272.751	–9.0975	4800
4900	22.511	98.449	240.158	220.066	1275.001	1275.001	–8.8146	4900
5000	22.543	100.701	240.613	220.472	1277.253	1277.253	–8.5425	5000

TABLE A134.—THERMODYNAMIC PROPERTIES FOR Xe^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	22.573	102.957	241.059	220.872	1279.509	1279.509	–8.2806	5100
5200	22.601	105.216	241.498	221.264	1281.768	1281.768	–8.0284	5200
5300	22.627	107.477	241.929	221.650	1284.029	1284.029	–7.7853	5300
5400	22.650	109.741	242.352	222.029	1286.293	1286.293	–7.5507	5400
5500	22.671	112.007	242.768	222.403	1288.559	1288.559	–7.3243	5500
5600	22.690	114.275	243.176	222.770	1290.827	1290.827	–7.1056	5600
5700	22.707	116.545	243.578	223.132	1293.097	1293.097	–6.8942	5700
5800	22.722	118.817	243.973	223.488	1295.369	1295.369	–6.6897	5800
5900	22.736	121.090	244.362	223.838	1297.642	1297.642	–6.4918	5900
6000	22.748	123.364	244.744	224.183	1299.916	1299.916	–6.3002	6000
6200	22.766	127.915	245.490	224.859	1304.467	1304.467	–5.9345	6200
6400	22.779	132.470	246.213	225.515	1309.022	1309.021	–5.5905	6400
6600	22.786	137.026	246.914	226.153	1313.579	1313.577	–5.2662	6600
6800	22.788	141.584	247.595	226.773	1318.136	1318.134	–4.9599	6800
7000	22.786	146.141	248.255	227.378	1322.694	1322.689	–4.6701	7000
7200	22.781	150.698	248.897	227.967	1327.250	1327.243	–4.3955	7200
7400	22.772	155.253	249.521	228.541	1331.806	1331.795	–4.1348	7400
7600	22.760	159.807	250.128	229.101	1336.359	1336.342	–3.8870	7600
7800	22.745	164.357	250.719	229.648	1340.909	1340.883	–3.6511	7800
8000	22.729	168.905	251.295	230.182	1345.457	1345.417	–3.4262	8000
8500	22.680	180.257	252.671	231.465	1356.809	1356.710	–2.9074	8500
9000	22.626	191.584	253.966	232.679	1368.136	1367.908	–2.4423	9000
9500	22.570	202.883	255.188	233.832	1379.435	1378.955	–2.0228	9500
10000	22.517	214.154	256.344	234.929	1390.707	1389.769	–1.6423	10000
10500	22.472	225.401	257.442	235.975	1401.953	1400.231	–1.2953	10500
11000	22.440	236.628	258.486	236.975	1413.181	1410.186	–0.9775	11000
11500	22.427	247.844	259.483	237.932	1424.397	1419.431	–0.6855	11500
12000	22.442	259.060	260.438	238.850	1435.612	1427.721	–0.4160	12000
12500	22.491	270.292	261.355	239.732	1446.844	1434.768	–0.1668	12500
13000	22.585	281.558	262.239	240.581	1458.110	1440.247	0.0642	13000
13500	22.734	292.885	263.094	241.399	1469.437	1443.814	0.2788	13500
14000	22.951	304.302	263.924	242.188	1480.854	1445.122	0.4785	14000
14500	23.247	315.846	264.734	242.952	1492.398	1443.846	0.6643	14500
15000	23.637	327.559	265.528	243.691	1504.111	1439.709	0.8375	15000
15500	24.140	339.497	266.311	244.408	1516.049	1432.521	0.9988	15500
16000	24.759	351.706	267.086	245.105	1528.258	1422.183	1.1492	16000
16500	25.511	364.251	267.858	245.783	1540.803	1408.738	1.2892	16500
17000	26.408	377.199	268.631	246.443	1553.751	1392.366	1.4197	17000
17500	27.457	390.621	269.409	247.088	1567.173	1373.389	1.5411	17500
18000	28.663	404.584	270.196	247.719	1581.136	1352.253	1.6541	18000
18500	30.061	419.216	270.997	248.337	1595.768	1329.567	1.7593	18500
19000	31.615	434.539	271.814	248.943	1611.092	1305.909	1.8572	19000
19500	33.309	450.605	272.648	249.540	1627.157	1281.921	1.9483	19500
20000	35.166	467.534	273.504	250.127	1644.086	1258.317	2.0333	20000

TABLE A135.—THERMODYNAMIC PROPERTIES FOR Zn

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	124.203	129.860	----------	0
100	20.786	–4.119	138.285	179.473	126.281	130.942	–62.0353	100
200	20.786	–2.040	152.693	162.894	128.360	130.787	–27.8430	200
298.15	20.786	0.000	160.993	160.993	130.400	130.400	–16.6103	298.15
300	20.786	0.038	161.121	160.993	130.438	130.391	–16.4694	300
400	20.786	2.117	167.101	161.808	132.517	129.886	–10.8034	400
500	20.786	4.196	171.739	163.348	134.596	129.297	–7.4181	500
600	20.786	6.274	175.529	165.072	136.674	128.579	–5.1725	600
*700	20.786	8.353	178.733	166.801	138.753	120.362	–3.5843	700
800	20.786	10.432	181.509	168.470	140.832	119.301	–2.4664	800
900	20.786	12.510	183.957	170.057	142.910	118.240	–1.6046	900
1000	20.786	14.589	186.147	171.558	144.989	117.178	–0.9214	1000
1100	20.786	16.667	188.128	172.976	147.067	116.117	–0.3674	1100
1200	20.786	18.746	189.937	174.315	149.146	115.056	0.0901	1200
1300	20.786	20.825	191.601	175.582	151.225	113.994	0.4736	1300
1400	20.786	22.903	193.141	176.782	153.303	112.933	0.7992	1400
1500	20.786	24.982	194.575	177.921	155.382	111.871	1.0789	1500
1600	20.786	27.061	195.917	179.004	157.461	110.810	1.3212	1600
1700	20.786	29.139	197.177	180.036	159.539	109.749	1.5330	1700
1800	20.786	31.218	198.365	181.022	161.618	108.687	1.7194	1800
1900	20.786	33.296	199.489	181.965	163.696	107.626	1.8846	1900
2000	20.786	35.375	200.555	182.868	165.775	106.565	2.0319	2000
2100	20.786	37.454	201.569	183.734	167.854	105.503	2.1637	2100
2200	20.786	39.532	202.536	184.567	169.932	104.442	2.2824	2200
2300	20.786	41.611	203.460	185.369	172.011	103.380	2.3897	2300
2400	20.786	43.690	204.345	186.141	174.090	102.319	2.4870	2400
2500	20.786	45.768	205.194	186.886	176.168	101.258	2.5757	2500
2600	20.787	47.847	206.009	187.606	178.247	100.196	2.6566	2600
2700	20.787	49.926	206.793	188.302	180.326	99.135	2.7308	2700
2800	20.787	52.004	207.549	188.976	182.404	98.074	2.7989	2800
2900	20.788	54.083	208.279	189.629	184.483	97.013	2.8616	2900
3000	20.789	56.162	208.984	190.263	186.562	95.951	2.9196	3000
3100	20.791	58.241	209.665	190.878	188.641	94.890	2.9732	3100
3200	20.793	60.320	210.325	191.475	190.720	93.830	3.0229	3200
3300	20.796	62.400	210.965	192.056	192.800	92.769	3.0690	3300
3400	20.800	64.479	211.586	192.622	194.879	91.709	3.1120	3400
3500	20.806	66.560	212.189	193.172	196.960	90.649	3.1520	3500
3600	20.813	68.641	212.775	193.709	199.041	89.590	3.1893	3600
3700	20.823	70.722	213.346	194.232	201.122	88.532	3.2243	3700
3800	20.835	72.805	213.901	194.742	203.205	87.475	3.2570	3800
3900	20.850	74.889	214.443	195.240	205.289	86.419	3.2876	3900
4000	20.868	76.975	214.971	195.727	207.375	85.365	3.3164	4000
4100	20.890	79.063	215.486	196.203	209.463	84.313	3.3434	4100
4200	20.916	81.153	215.990	196.668	211.553	83.263	3.3688	4200
4300	20.947	83.246	216.482	197.123	213.646	82.216	3.3927	4300
4400	20.983	85.343	216.964	197.568	215.743	81.172	3.4153	4400
4500	21.025	87.443	217.436	198.005	217.843	80.133	3.4366	4500

TABLE A135.—THERMODYNAMIC PROPERTIES FOR Zn (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	21.073	89.548	217.899	198.432	219.948	79.098	3.4567	4600
4700	21.128	91.658	218.353	198.851	222.058	78.068	3.4757	4700
4800	21.191	93.774	218.798	199.262	224.174	77.043	3.4936	4800
4900	21.261	95.896	219.236	199.665	226.296	76.026	3.5106	4900
5000	21.340	98.026	219.666	200.061	228.426	75.016	3.5267	5000
5100	21.427	100.165	220.090	200.450	230.565	74.014	3.5420	5100
5200	21.524	102.312	220.507	200.831	232.712	73.022	3.5565	5200
5300	21.630	104.470	220.918	201.206	234.870	72.039	3.5702	5300
5400	21.747	106.639	221.323	201.575	237.039	71.068	3.5833	5400
5500	21.874	108.820	221.723	201.938	239.220	70.109	3.5957	5500
5600	22.011	111.014	222.119	202.295	241.414	69.163	3.6075	5600
5700	22.161	113.222	222.509	202.646	243.622	68.232	3.6187	5700
5800	22.321	115.446	222.896	202.992	245.846	67.316	3.6294	5800
5900	22.494	117.687	223.279	203.332	248.087	66.416	3.6396	5900
6000	22.678	119.945	223.659	203.668	250.345	65.535	3.6494	6000
6200	23.085	124.521	224.409	204.325	254.921			6200
6400	23.532	129.178	225.148	204.964	259.578			6400
6600	24.032	133.931	225.879	205.587	264.331			6600
6800	24.586	138.791	226.605	206.194	269.191			6800
7000	25.188	143.765	227.326	206.788	274.165			7000
7200	25.847	148.868	228.044	207.368	279.268			7200
7400	26.558	154.107	228.762	207.937	284.507			7400
7600	27.321	159.494	229.480	208.494	289.894			7600
7800	28.135	165.039	230.200	209.042	295.439			7800
8000	28.999	170.752	230.924	209.580	301.152			8000
8500	31.364	185.827	232.751	210.889	316.227			8500
9000	33.968	202.126	234.613	212.155	332.526			9000
9500	36.398	219.924	236.533	213.383	350.324			9500
10000	38.682	238.697	238.458	214.589	369.097			10000
10500	40.855	258.587	240.399	215.771	388.987			10500
11000	42.885	279.529	242.347	216.935	409.929			11000
11500	44.743	301.443	244.295	218.082	431.843			11500
12000	46.403	324.238	246.235	219.215	454.638			12000
12500	47.843	347.809	248.159	220.334	478.209			12500
13000	49.042	372.041	250.060	221.441	502.441			13000
13500	49.983	396.808	251.929	222.536	527.208			13500
14000	50.653	421.979	253.760	223.618	552.379			14000
14500	51.043	447.415	255.545	224.689	577.815			14500
15000	51.149	472.975	257.278	225.746	603.375			15000
15500	50.970	498.517	258.953	226.790	628.917			15500
16000	50.511	523.898	260.565	227.821	654.298			16000
16500	49.781	548.982	262.108	228.837	679.382			16500
17000	48.798	573.638	263.581	229.837	704.038			17000
17500	47.583	597.741	264.978	230.821	728.141			17500
18000	46.162	621.185	266.299	231.789	751.585			18000
18500	44.569	643.875	267.542	232.738	774.275			18500
19000	42.845	665.733	268.708	233.670	796.133			19000
19500	41.036	686.705	269.798	234.582	817.105			19500
20000	39.195	706.763	270.814	235.476	837.163			20000

***Assigned reference element phase change at 692.73 K**

TABLE A136.—THERMODYNAMIC PROPERTIES FOR Zn^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.197	----------	----------	1036.803	1036.262	----------	0
298.15	20.786	0.000	166.756	166.756	1043.000	1043.000	–175.0931	298.15
300	20.786	0.038	166.884	166.756	1043.039	1043.030	–173.9663	300
400	20.786	2.117	172.864	167.571	1045.117	1044.603	–128.5343	400
500	20.786	4.196	177.502	169.111	1047.196	1046.093	–101.2345	500
600	20.786	6.274	181.292	170.835	1049.274	1047.454	–83.0095	600
*700	20.786	8.353	184.496	172.564	1051.353	1041.316	–69.9815	700
800	20.786	10.432	187.272	174.233	1053.432	1042.333	–60.2642	800
900	20.786	12.510	189.720	175.820	1055.510	1043.350	–52.6989	900
1000	20.786	14.589	191.910	177.322	1057.589	1044.367	–46.6408	1000
1100	20.786	16.667	193.892	178.739	1059.668	1045.385	–41.6793	1100
1200	20.786	18.746	195.700	180.078	1061.746	1046.402	–37.5407	1200
1300	20.786	20.825	197.364	181.345	1063.825	1047.419	–34.0354	1300
1400	20.786	22.903	198.904	182.545	1065.903	1048.436	–31.0279	1400
1500	20.786	24.982	200.339	183.684	1067.982	1049.454	–28.4189	1500
1600	20.786	27.061	201.680	184.767	1070.061	1050.471	–26.1338	1600
1700	20.786	29.139	202.940	185.799	1072.139	1051.488	–24.1155	1700
1800	20.786	31.218	204.128	186.785	1074.218	1052.505	–22.3198	1800
1900	20.786	33.296	205.252	187.728	1076.297	1053.523	–20.7116	1900
2000	20.786	35.375	206.318	188.631	1078.375	1054.540	–19.2628	2000
2100	20.786	37.454	207.333	189.497	1080.454	1055.557	–17.9507	2100
2200	20.786	39.532	208.299	190.330	1082.533	1056.574	–16.7567	2200
2300	20.786	41.611	209.223	191.132	1084.611	1057.592	–15.6655	2300
2400	20.786	43.690	210.108	191.904	1086.690	1058.609	–14.6643	2400
2500	20.787	45.768	210.957	192.649	1088.768	1059.626	–13.7423	2500
2600	20.787	47.847	211.772	193.369	1090.847	1060.643	–12.8904	2600
2700	20.787	49.926	212.556	194.065	1092.926	1061.661	–12.1008	2700
2800	20.788	52.004	213.312	194.739	1095.005	1062.678	–11.3669	2800
2900	20.789	54.083	214.042	195.393	1097.083	1063.696	–10.6830	2900
3000	20.791	56.162	214.747	196.026	1099.162	1064.713	–10.0441	3000
3100	20.793	58.241	215.428	196.641	1101.241	1065.731	–9.4458	3100
3200	20.797	60.321	216.089	197.238	1103.321	1066.749	–8.8844	3200
3300	20.802	62.401	216.729	197.819	1105.401	1067.768	–8.3565	3300
3400	20.809	64.481	217.350	198.385	1107.481	1068.787	–7.8592	3400
3500	20.818	66.563	217.953	198.935	1109.563	1069.807	–7.3898	3500
3600	20.830	68.645	218.540	199.472	1111.645	1070.828	–6.9461	3600
3700	20.846	70.729	219.111	199.995	1113.729	1071.850	–6.5260	3700
3800	20.867	72.814	219.667	200.505	1115.814	1072.874	–6.1276	3800
3900	20.892	74.902	220.209	201.004	1117.902	1073.901	–5.7493	3900
4000	20.924	76.993	220.739	201.490	1119.993	1074.930	–5.3896	4000
4100	20.963	79.087	221.256	201.966	1122.087	1075.963	–5.0470	4100
4200	21.010	81.186	221.761	202.431	1124.186	1077.000	–4.7205	4200
4300	21.067	83.290	222.256	202.887	1126.290	1078.043	–4.4089	4300
4400	21.134	85.400	222.741	203.332	1128.400	1079.091	–4.1111	4400
4500	21.212	87.517	223.217	203.769	1130.517	1080.147	–3.8263	4500
4600	21.302	89.642	223.684	204.197	1132.642	1081.211	–3.5536	4600
4700	21.407	91.778	224.144	204.617	1134.778	1082.285	–3.2923	4700
4800	21.526	93.924	224.596	205.028	1136.924	1083.371	–3.0416	4800
4900	21.661	96.083	225.041	205.432	1139.084	1084.468	–2.8008	4900
5000	21.814	98.257	225.480	205.829	1141.257	1085.581	–2.5695	5000

TABLE A136.—THERMODYNAMIC PROPERTIES FOR Zn^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	21.984	100.447	225.914	206.218	1143.447	1086.709	–2.3470	5100
5200	22.173	102.654	226.342	206.601	1145.655	1087.855	–2.1329	5200
5300	22.383	104.882	226.767	206.977	1147.882	1089.022	–1.9266	5300
5400	22.613	107.132	227.187	207.348	1150.132	1090.210	–1.7277	5400
5500	22.864	109.405	227.604	207.712	1152.405	1091.422	–1.5359	5500
5600	23.138	111.705	228.019	208.071	1154.705	1092.661	–1.3507	5600
5700	23.434	114.034	228.431	208.425	1157.034	1093.928	–1.1718	5700
5800	23.754	116.393	228.841	208.773	1159.393	1095.225	–0.9989	5800
5900	24.097	118.785	229.250	209.117	1161.785	1096.556	–0.8316	5900
6000	24.464	121.213	229.658	209.456	1164.213	1097.923	–0.6697	6000
6200	25.268	126.185	230.473	210.121	1169.185			6200
6400	26.167	131.327	231.289	210.769	1174.327			6400
6600	27.157	136.658	232.109	211.404	1179.658			6600
6800	28.233	142.195	232.936	212.025	1185.195			6800
7000	29.389	147.956	233.771	212.634	1190.956			7000
7200	30.616	153.956	234.616	213.233	1196.956			7200
7400	31.903	160.206	235.472	213.822	1203.207			7400
7600	33.240	166.720	236.340	214.404	1209.720			7600
7800	34.613	173.505	237.222	214.977	1216.505			7800
8000	36.008	180.567	238.115	215.545	1223.567			8000
8500	39.505	199.447	240.404	216.939	1242.448			8500
9000	42.837	220.044	242.757	218.308	1263.044			9000
9500	45.811	242.224	245.155	219.658	1285.225			9500
10000	48.277	265.770	247.570	220.993	1308.770			10000
10500	50.147	290.402	249.973	222.316	1333.402			10500
11000	51.391	315.812	252.337	223.627	1358.812			11000
11500	52.035	341.692	254.638	224.925	1384.692			11500
12000	52.138	367.756	256.856	226.210	1410.756			12000
12500	51.787	393.754	258.979	227.479	1436.754			12500
13000	51.075	419.479	260.997	228.729	1462.479			13000
13500	50.099	444.780	262.907	229.960	1487.781			13500
14000	48.942	469.544	264.708	231.169	1512.544			14000
14500	47.678	493.698	266.403	232.355	1536.698			14500
15000	46.368	517.207	267.997	233.517	1560.207			15000
15500	45.060	540.062	269.496	234.654	1583.062			15500
16000	43.784	562.267	270.906	235.765	1605.267			16000
16500	42.570	583.852	272.235	236.850	1626.852			16500
17000	41.418	604.825	273.487	237.909	1647.825			17000
17500	40.337	625.218	274.669	238.942	1668.218			17500
18000	39.319	645.044	275.786	239.950	1688.044			18000
18500	38.427	664.477	276.851	240.933	1707.477			18500
19000	37.614	683.467	277.863	241.892	1726.467			19000
19500	36.862	702.017	278.827	242.826	1745.017			19500
20000	36.213	720.282	279.752	243.738	1763.283			20000

*Assigned reference element phase change at 692.73 K

TABLE A137.—THERMODYNAMIC PROPERTIES FOR Zr

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–6.816	----------	----------	592.503	598.000	----------	0
100	21.000	–4.734	155.849	203.192	594.584	599.195	–305.5732	100
200	24.030	–2.501	171.207	183.711	596.818	599.236	–149.0751	200
298.15	26.642	0.000	181.346	181.346	599.319	599.319	–97.5535	298.15
300	26.674	0.049	181.510	181.346	599.368	599.321	–96.9059	300
400	27.664	2.778	189.353	182.408	602.097	599.491	–70.8157	400
500	27.590	5.547	195.532	184.439	604.865	599.634	–55.1571	500
600	27.045	8.280	200.518	186.717	607.599	599.677	–44.7163	600
700	26.424	10.953	204.639	188.992	610.272	599.583	–37.2588	700
800	25.935	13.570	208.134	191.171	612.888	599.350	–31.6672	800
900	25.660	16.148	211.170	193.228	615.466	598.980	–27.3203	900
1000	25.610	18.709	213.869	195.160	618.028	598.486	–23.8453	1000
1100	25.754	21.276	216.316	196.974	620.595	597.882	–21.0048	1100
*1200	26.048	23.865	218.568	198.681	623.184	593.469	–18.6499	1200
1300	26.443	26.489	220.668	200.292	625.808	593.224	–16.6631	1300
1400	26.895	29.156	222.644	201.819	628.474	592.980	–14.9610	1400
1500	27.371	31.869	224.516	203.270	631.188	592.730	–13.4864	1500
1600	27.845	34.630	226.298	204.654	633.948	592.463	–12.1966	1600
1700	28.299	37.437	227.999	205.978	636.756	592.170	–11.0591	1700
1800	28.726	40.289	229.629	207.247	639.607	591.836	–10.0486	1800
1900	29.121	43.181	231.193	208.466	642.500	591.448	–9.1450	1900
2000	29.486	46.112	232.696	209.640	645.430	590.991	–8.3323	2000
2100	29.824	49.078	234.143	210.773	648.396	590.454	–7.5977	2100
*2200	30.141	52.076	235.538	211.867	651.395	568.500	–6.9481	2200
2300	30.441	55.105	236.884	212.926	654.424	567.345	–6.3619	2300
2400	30.731	58.164	238.186	213.951	657.482	566.219	–5.8256	2400
2500	31.015	61.251	239.446	214.946	660.570	565.123	–5.3331	2500
2600	31.298	64.367	240.668	215.912	663.686	564.055	–4.8794	2600
2700	31.583	67.511	241.855	216.851	666.830	563.015	–4.4601	2700
2800	31.872	70.684	243.009	217.765	670.002	562.003	–4.0714	2800
2900	32.166	73.885	244.132	218.654	673.204	561.021	–3.7102	2900
3000	32.467	77.117	245.228	219.522	676.436	560.069	–3.3737	3000
3100	32.774	80.379	246.297	220.369	679.698	559.147	–3.0594	3100
3200	33.088	83.672	247.343	221.195	682.991	558.256	–2.7652	3200
3300	33.406	86.997	248.366	222.003	686.315	557.396	–2.4893	3300
3400	33.729	90.353	249.368	222.793	689.672	556.569	–2.2300	3400
3500	34.055	93.743	250.350	223.567	693.061	555.774	–1.9859	3500
3600	34.381	97.164	251.314	224.324	696.483	555.012	–1.7556	3600
3700	34.708	100.619	252.261	225.066	699.938	554.283	–1.5381	3700
3800	35.034	104.106	253.191	225.794	703.425	553.586	–1.3323	3800
3900	35.356	107.626	254.105	226.509	706.944	552.921	–1.1373	3900
4000	35.674	111.177	255.004	227.210	710.496	552.289	–0.9523	4000
4100	35.987	114.760	255.889	227.898	714.079	551.688	–0.7765	4100
4200	36.294	118.374	256.760	228.575	717.693	551.118	–0.6093	4200
4300	36.593	122.019	257.617	229.241	721.337	550.578	–0.4499	4300
4400	36.885	125.693	258.462	229.895	725.011	550.068	–0.2980	4400
4500	37.169	129.395	259.294	230.539	728.714	549.587	–0.1530	4500

TABLE A137.—THERMODYNAMIC PROPERTIES FOR Zr (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
4600	37.444	133.126	260.114	231.173	732.445	549.134	–0.0143	4600
4700	37.710	136.884	260.922	231.798	736.202	548.707	0.1183	4700
4800	37.968	140.668	261.719	232.413	739.986	548.307	0.2453	4800
4900	38.216	144.477	262.504	233.019	743.796	547.933	0.3670	4900
5000	38.454	148.310	263.278	233.616	747.629	547.582	0.4838	5000
5100	38.685	152.167	264.042	234.205	751.486	547.255	0.5959	5100
5200	38.907	156.047	264.796	234.787	755.365	546.950	0.7037	5200
5300	39.119	159.947	265.538	235.360	759.265	546.666	0.8073	5300
5400	39.324	163.869	266.272	235.925	763.188	546.405	0.9070	5400
5500	39.523	167.812	266.995	236.484	767.130	546.163	1.0031	5500
5600	39.714	171.773	267.709	237.035	771.092	545.941	1.0957	5600
5700	39.892	175.751	268.413	237.579	775.069	545.734	1.1850	5700
5800	40.064	179.747	269.102	238.111	779.066	545.547	1.2710	5800
5900	40.229	183.762	269.788	238.642	783.081	545.378	1.3542	5900
6000	40.388	187.793	270.466	239.167	787.111	545.224	1.4347	6000
6200	40.653	195.897	271.794	240.198	795.215			6200
6400	40.926	204.055	273.089	241.206	803.373			6400
6600	41.192	212.267	274.353	242.191	811.585			6600
6800	41.441	220.530	275.586	243.155	819.849			6800
7000	41.665	228.841	276.791	244.099	828.160			7000
7200	41.858	237.194	277.967	245.024	836.513			7200
7400	42.018	245.583	279.117	245.930	844.901			7400
7600	42.143	253.999	280.239	246.818	853.318			7600
7800	42.231	262.437	281.335	247.689	861.756			7800
8000	42.282	270.889	282.405	248.544	870.208			8000
8500	42.252	292.032	284.968	250.612	891.350			8500
9000	42.012	313.106	287.377	252.588	912.425			9000
9500	41.588	334.013	289.638	254.479	933.332			9500
10000	41.007	354.668	291.757	256.291	953.986			10000
10500	40.298	374.999	293.741	258.027	974.317			10500
11000	39.487	394.949	295.598	259.693	994.268			11000
11500	38.599	414.473	297.334	261.292	1013.792			11500
12000	37.654	433.538	298.957	262.828	1032.857			12000
12500	36.672	452.120	300.474	264.304	1051.439			12500
13000	35.669	470.207	301.893	265.723	1069.525			13000
13500	34.661	487.789	303.220	267.087	1087.108			13500
14000	33.660	504.869	304.462	268.400	1104.188			14000
14500	32.678	521.452	305.626	269.664	1120.771			14500
15000	31.725	537.552	306.718	270.881	1136.871			15000
15500	30.810	553.185	307.743	272.054	1152.503			15500
16000	29.941	568.370	308.708	273.184	1167.689			16000
16500	29.127	583.135	309.616	274.275	1182.453			16500
17000	28.374	597.506	310.474	275.327	1196.825			17000
17500	27.690	611.519	311.287	276.343	1210.838			17500
18000	27.083	625.210	312.058	277.324	1224.528			18000
18500	26.558	638.616	312.793	278.273	1237.934			18500
19000	26.123	651.782	313.495	279.191	1251.100			19000
19500	25.785	664.755	314.169	280.079	1264.074			19500
20000	25.553	677.585	314.819	280.940	1276.904			20000

***Assigned reference element phase change at 1135 K and 2125 K**

TABLE A138.—THERMODYNAMIC PROPERTIES FOR Zr^+

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.472	----------	----------	1238.774	1238.074	----------	0
298.15	28.283	0.000	183.642	183.642	1246.246	1246.246	–209.6739	298.15
300	28.289	0.052	183.817	183.643	1246.299	1246.290	–208.3274	300
400	28.281	2.886	191.968	184.754	1249.132	1248.643	–154.0327	400
500	27.905	5.696	198.242	186.849	1251.943	1250.907	–121.3947	500
600	27.513	8.466	203.293	189.182	1254.713	1253.065	–99.5972	600
700	27.268	11.204	207.514	191.508	1257.450	1255.114	–84.0013	700
800	27.189	13.926	211.148	193.741	1260.172	1257.065	–72.2856	800
900	27.235	16.646	214.352	195.856	1262.892	1258.916	–63.1595	900
1000	27.357	19.375	217.227	197.852	1265.621	1260.668	–55.8482	1000
1100	27.516	22.119	219.842	199.734	1268.365	1262.319	–49.8581	1100
*1200	27.685	24.879	222.244	201.511	1271.125	1260.156	–44.8696	1200
1300	27.849	27.656	224.466	203.193	1273.902	1262.143	–40.6470	1300
1400	27.998	30.448	226.535	204.787	1276.694	1264.104	–37.0220	1400
1500	28.129	33.254	228.472	206.302	1279.501	1266.025	–33.8755	1500
1600	28.242	36.073	230.291	207.745	1282.319	1267.895	–31.1181	1600
1700	28.336	38.902	232.006	209.122	1285.149	1269.702	–28.6815	1700
1800	28.414	41.740	233.628	210.439	1287.986	1271.433	–26.5128	1800
1900	28.476	44.584	235.166	211.700	1290.831	1273.075	–24.5697	1900
2000	28.525	47.435	236.628	212.910	1293.681	1274.617	–22.8187	2000
2100	28.561	50.289	238.020	214.073	1296.535	1276.047	–21.2327	2100
*2200	28.588	53.147	239.350	215.192	1299.393	1256.030	–19.8069	2200
2300	28.605	56.006	240.621	216.270	1302.252	1256.784	–18.5100	2300
2400	28.614	58.867	241.838	217.310	1305.113	1257.540	–17.3204	2400
2500	28.616	61.729	243.007	218.315	1307.975	1258.296	–16.2253	2500
2600	28.612	64.590	244.129	219.286	1310.836	1259.052	–15.2138	2600
2700	28.603	67.451	245.209	220.227	1313.697	1259.808	–14.2767	2700
2800	28.588	70.311	246.249	221.138	1316.557	1260.562	–13.4061	2800
2900	28.570	73.169	247.251	222.021	1319.415	1261.315	–12.5949	2900
3000	28.547	76.024	248.220	222.878	1322.271	1262.065	–11.8374	3000
3100	28.522	78.878	249.155	223.711	1325.124	1262.813	–11.1284	3100
3200	28.493	81.729	250.060	224.520	1327.975	1263.559	–10.4633	3200
3300	28.461	84.576	250.937	225.307	1330.823	1264.301	–9.8381	3300
3400	28.427	87.421	251.786	226.074	1333.667	1265.040	–9.2493	3400
3500	28.390	90.262	252.609	226.820	1336.508	1265.775	–8.6939	3500
3600	28.352	93.099	253.408	227.548	1339.345	1266.507	–8.1690	3600
3700	28.312	95.932	254.185	228.257	1342.178	1267.235	–7.6722	3700
3800	28.270	98.761	254.939	228.950	1345.007	1267.959	–7.2013	3800
3900	28.227	101.586	255.673	229.625	1347.832	1268.678	–6.7543	3900
4000	28.184	104.406	256.387	230.286	1350.653	1269.393	–6.3294	4000
4100	28.140	107.223	257.083	230.931	1353.469	1270.104	–5.9250	4100
4200	28.095	110.034	257.760	231.561	1356.281	1270.811	–5.5396	4200
4300	28.050	112.842	258.421	232.178	1359.088	1271.512	–5.1720	4300
4400	28.005	115.644	259.065	232.782	1361.891	1272.210	–4.8208	4400
4500	27.960	118.443	259.694	233.373	1364.689	1272.903	–4.4851	4500
4600	27.916	121.236	260.308	233.952	1367.483	1273.591	–4.1639	4600
4700	27.873	124.026	260.908	234.519	1370.272	1274.275	–3.8561	4700
4800	27.830	126.811	261.494	235.075	1373.057	1274.955	–3.5610	4800
4900	27.788	129.592	262.068	235.620	1375.838	1275.630	–3.2777	4900
5000	27.747	132.369	262.629	236.155	1378.615	1276.302	–3.0057	5000

TABLE A138.—THERMODYNAMIC PROPERTIES FOR Zr^+ (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	27.708	135.141	263.178	236.679	1381.388	1276.969	–2.7442	5100
5200	27.670	137.910	263.715	237.194	1384.156	1277.633	–2.4926	5200
5300	27.633	140.675	264.242	237.699	1386.922	1278.292	–2.2504	5300
5400	27.598	143.437	264.758	238.196	1389.683	1278.949	–2.0171	5400
5500	27.565	146.195	265.264	238.683	1392.441	1279.601	–1.7921	5500
5600	27.534	148.950	265.761	239.162	1395.196	1280.251	–1.5750	5600
5700	27.504	151.702	266.248	239.633	1397.948	1280.897	–1.3655	5700
5800	27.477	154.451	266.726	240.096	1400.697	1281.541	–1.1631	5800
5900	27.451	157.197	267.195	240.552	1403.444	1282.182	–0.9674	5900
6000	27.428	159.941	267.657	241.000	1406.188	1282.821	–0.7782	6000
6200	27.387	165.423	268.555	241.874	1411.669			6200
6400	27.354	170.896	269.424	242.722	1417.143			6400
6600	27.329	176.365	270.265	243.544	1422.611			6600
6800	27.311	181.828	271.081	244.342	1428.075			6800
7000	27.302	187.290	271.873	245.117	1433.536			7000
7200	27.299	192.750	272.642	245.871	1438.996			7200
7400	27.303	198.210	273.390	246.604	1444.456			7400
7600	27.314	203.671	274.118	247.319	1449.918			7600
7800	27.331	209.136	274.828	248.015	1455.382			7800
8000	27.352	214.604	275.520	248.694	1460.850			8000
8500	27.428	228.298	277.180	250.322	1474.544			8500
9000	27.529	242.037	278.751	251.858	1488.283			9000
9500	27.650	255.830	280.242	253.313	1502.077			9500
10000	27.785	269.688	281.664	254.695	1515.935			10000
10500	27.933	283.617	283.023	256.012	1529.863			10500
11000	28.090	297.622	284.326	257.269	1543.868			11000
11500	28.254	311.706	285.578	258.473	1557.953			11500
12000	28.425	325.874	286.784	259.628	1572.120			12000
12500	28.600	340.126	287.948	260.737	1586.372			12500
13000	28.781	354.469	289.073	261.806	1600.716			13000
13500	28.961	368.895	290.161	262.836	1615.142			13500
14000	29.144	383.412	291.217	263.831	1629.659			14000
14500	29.322	398.009	292.241	264.793	1644.255			14500
15000	29.506	412.707	293.238	265.724	1658.953			15000
15500	29.674	427.465	294.205	266.627	1673.712			15500
16000	29.842	442.312	295.148	267.503	1688.558			16000
16500	30.011	457.254	296.067	268.355	1703.500			16500
17000	30.149	472.214	296.960	269.183	1718.461			17000
17500	30.287	487.550	297.852	269.992	1733.796			17500
18000	30.408	502.725	298.707	270.778	1748.971			18000
18500	30.512	517.957	299.541	271.544	1764.203			18500
19000	30.595	533.233	300.356	272.291	1779.479			19000
19500	30.654	548.547	301.152	273.021	1794.793			19500
20000	30.685	563.883	301.928	273.734	1810.129			20000

*Assigned reference element phase change at 1135 K and 2125 K

TABLE A139.—THERMODYNAMIC PROPERTIES FOR Zr^-

T	C_p°	$H^\circ-H^\circ(298.15)$	S°	$-[G^\circ-H^\circ(298.15)]/T$	H°	$\Delta_f H^\circ$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
0	---------	–7.749	----------	----------	545.203	556.897	----------	0
298.15	28.693	0.000	185.765	185.765	552.952	552.952	–90.2954	298.15
300	28.681	0.053	185.943	185.766	553.005	552.920	–89.6980	300
400	27.628	2.874	194.064	186.880	555.826	551.103	–65.6659	400
500	26.339	5.572	200.090	188.947	558.524	549.097	–51.2967	500
600	25.216	8.147	204.789	191.210	561.100	546.903	–41.7540	600
700	24.332	10.623	208.607	193.431	563.575	544.533	–34.9662	700
800	23.656	13.021	211.810	195.534	565.973	542.004	–29.8984	800
900	23.140	15.359	214.565	197.499	568.312	539.316	–25.9755	900
1000	22.743	17.653	216.982	199.329	570.605	536.474	–22.8534	1000
1100	22.433	19.911	219.134	201.033	572.863	533.483	–20.3128	1100
*1200	22.189	22.141	221.075	202.624	575.094	526.633	–18.2174	1200
1300	21.993	24.350	222.843	204.112	577.303	523.894	–16.4585	1300
1400	21.835	26.541	224.467	205.509	579.494	521.096	–14.9589	1400
1500	21.705	28.718	225.969	206.823	581.670	518.230	–13.6662	1500
1600	21.597	30.883	227.366	208.064	583.835	515.290	–12.5414	1600
1700	21.507	33.038	228.673	209.238	585.990	512.265	–11.5547	1700
1800	21.431	35.185	229.900	210.353	588.137	509.148	–10.6829	1800
1900	21.366	37.324	231.057	211.412	590.277	505.928	–9.9077	1900
2000	21.310	39.458	232.151	212.422	592.411	502.596	–9.2145	2000
2100	21.262	41.587	233.190	213.386	594.539	499.143	–8.5916	2100
*2200	21.220	43.711	234.178	214.309	596.663	474.236	–8.0469	2200
2300	21.183	45.831	235.120	215.194	598.783	470.093	–7.5595	2300
2400	21.151	47.948	236.021	216.043	600.900	465.947	–7.1166	2400
2500	21.123	50.061	236.884	216.859	603.014	461.798	–6.7127	2500
2600	21.097	52.172	237.712	217.646	605.125	457.647	–6.3433	2600
2700	21.075	54.281	238.508	218.404	607.233	453.493	–6.0043	2700
2800	21.055	56.387	239.274	219.135	609.340	449.337	–5.6924	2800
2900	21.036	58.492	240.012	219.843	611.444	445.179	–5.4047	2900
3000	21.020	60.595	240.725	220.527	613.547	441.019	–5.1386	3000
3100	21.005	62.696	241.414	221.190	615.648	436.857	–4.8921	3100
3200	20.992	64.796	242.081	221.832	617.748	432.695	–4.6631	3200
3300	20.979	66.894	242.726	222.455	619.847	428.530	–4.4501	3300
3400	20.968	68.992	243.353	223.061	621.944	424.365	–4.2516	3400
3500	20.958	71.088	243.960	223.649	624.040	420.199	–4.0662	3500
3600	20.949	73.183	244.551	224.222	626.136	416.032	–3.8929	3600
3700	20.940	75.278	245.124	224.779	628.230	411.863	–3.7306	3700
3800	20.932	77.371	245.683	225.322	630.324	407.694	–3.5783	3800
3900	20.924	79.464	246.226	225.851	632.417	403.524	–3.4353	3900
4000	20.918	81.556	246.756	226.367	634.509	399.354	–3.3009	4000
4100	20.911	83.648	247.272	226.871	636.600	395.183	–3.1744	4100
4200	20.905	85.739	247.776	227.362	638.691	391.011	–3.0552	4200
4300	20.900	87.829	248.268	227.843	640.781	386.839	–2.9427	4300
4400	20.895	89.918	248.749	228.313	642.871	382.666	–2.8364	4400
4500	20.890	92.008	249.218	228.772	644.960	378.492	–2.7360	4500
4600	20.885	94.096	249.677	229.221	647.049	374.318	–2.6411	4600
4700	20.881	96.185	250.126	229.661	649.137	370.144	–2.5511	4700
4800	20.877	98.273	250.566	230.092	651.225	365.969	–2.4659	4800
4900	20.874	100.360	250.996	230.515	653.313	361.794	–2.3851	4900
5000	20.870	102.447	251.418	230.928	655.400	357.619	–2.3084	5000

TABLE A139.—THERMODYNAMIC PROPERTIES FOR Zr^- (Concluded)

T	$C_p°$	$H°–H°(298.15)$	$S°$	$–[G°–H°(298.15)]/T$	$H°$	$\Delta_f H°$	$\log_{10}K$	T
K	J/K·mol	kJ/mol	J/K·mol	J/K·mol	kJ/mol	kJ/mol		K
5100	20.867	104.534	251.831	231.334	657.487	353.443	–2.2356	5100
5200	20.864	106.621	252.236	231.732	659.573	349.267	–2.1664	5200
5300	20.861	108.707	252.634	232.123	661.659	345.091	–2.1006	5300
5400	20.858	110.793	253.024	232.506	663.745	340.914	–2.0380	5400
5500	20.856	112.879	253.406	232.883	665.831	336.737	–1.9784	5500
5600	20.853	114.964	253.782	233.253	667.917	332.560	–1.9216	5600
5700	20.851	117.049	254.151	233.616	670.002	328.382	–1.8675	5700
5800	20.849	119.134	254.514	233.973	672.087	324.205	–1.8160	5800
5900	20.846	121.219	254.870	234.325	674.171	320.027	–1.7668	5900
6000	20.844	123.304	255.221	234.670	676.256	315.849	–1.7199	6000
6200	20.841	127.472	255.904	235.344	680.424			6200
6400	20.837	131.640	256.566	235.997	684.592			6400
6600	20.834	135.807	257.207	236.630	688.759			6600
6800	20.831	139.974	257.829	237.244	692.926			6800
7000	20.829	144.140	258.432	237.841	697.092			7000
7200	20.827	148.305	259.019	238.421	701.258			7200
7400	20.824	152.470	259.590	238.986	705.423			7400
7600	20.822	156.635	260.145	239.535	709.587			7600
7800	20.821	160.799	260.686	240.071	713.752			7800
8000	20.819	164.963	261.213	240.593	717.916			8000
8500	20.815	175.372	262.475	241.843	728.324			8500
9000	20.812	185.778	263.665	243.023	738.731			9000
9500	20.809	196.184	264.790	244.139	749.136			9500
10000	20.807	206.588	265.857	245.198	759.540			10000
10500	20.805	216.991	266.872	246.207	769.943			10500
11000	20.803	227.393	267.840	247.168	780.346			11000
11500	20.802	237.794	268.765	248.087	790.747			11500
12000	20.801	248.195	269.650	248.967	801.148			12000
12500	20.800	258.595	270.499	249.812	811.548			12500
13000	20.799	268.995	271.315	250.623	821.947			13000
13500	20.798	279.394	272.100	251.404	832.346			13500
14000	20.797	289.792	272.856	252.157	842.745			14000
14500	20.796	300.191	273.586	252.883	853.143			14500
15000	20.796	310.589	274.291	253.585	863.541			15000
15500	20.795	320.986	274.973	254.264	873.939			15500
16000	20.794	331.384	275.633	254.922	884.336			16000
16500	20.794	341.781	276.273	255.559	894.733			16500
17000	20.793	352.177	276.894	256.178	905.130			17000
17500	20.793	362.574	277.497	256.778	915.526			17500
18000	20.793	372.971	278.082	257.362	925.923			18000
18500	20.792	383.367	278.652	257.930	936.319			18500
19000	20.792	393.763	279.207	258.482	946.715			19000
19500	20.792	404.159	279.747	259.021	957.111			19500
20000	20.791	414.555	280.273	259.545	967.507			20000

*Assigned reference element phase change at 1135 K and 2125 K

Appendix B
Format and Least-Squares Coefficients for Data in Appendix A

Least-squares coefficients for the data in appendix A were obtained by means of the procedure described in the main-text section Least-Squares Coefficients. The general format for these coefficients is given in table B1 and the coefficients are given in table B2. Until approximately 1993 the functional form for NASA Lewis least-squares coefficients for heat capacity was a fourth-order polynomial (see McBride et al., 1993b, for example). This gave a total of seven coefficients for each temperature interval (five for heat capacity plus two integration constants). However, since that time a seven-constant representation of heat capacity has been used (see McBride et al., 1993a) giving a total of nine coefficients for each temperature interval. A set of coefficients for each species consists of five different kinds of record. These records are described in table B1 and in information for the first three records which follows:

Record 1

a) The species names are the chemical symbols with "+" and "–" indicating the positive and negative ions respectively. For two of the species and their ions, namely Cl and Al, an upper-case letter "L" is used to avoid confusion with the number 1. Thus, for example, chlorine is designated as CL rather than the conventional Cl.
b) The comments are usually references described in the following ways:
   1) Authors are not given for journal articles.
   2) The data taken from Chase (1985) are referred to as "JANAF" with the month and year the data were last updated.
   3) The data taken from Cox et al. (1989) are referred to as "CODATA 1989."
   4) The data taken from Gurvich are referred to as "TPIS" (thermodynamic properties of individual species).

Record 2

a) The number of temperature intervals is three.
b) The identification code is a lower-case "el" which refers to NASA Lewis followed by the date on which the data were calculated.
c) The atomic symbols are all upper case. Ions are indicated with the symbol "E" followed by the number of missing or additional electrons. These numbers are negative for positive ions and positive for negative ions.
d) The phase is always indicated by a "0" for gases.
e) The molecular weight for all species in this report is the atomic weight.
f) Electron gas and the inert gases (Ar, He, Kr, Ne, Rn, and Xe) are reference elements, and therefore their enthalpies of formation are zero.

Record 3

a) The temperature range is indicated by the first and last values of the interval in degrees kelvin. For the first interval the first value is 200 K for neutral atoms and 298.15 K for ions and the second value is 1000 K.
b) The number of coefficients for heat capacity is seven except when heat capacity is constant over the entire interval, in which case the number is one.
c) The T exponents correspond to those in the empirical equations shown in table B1, which were taken from Gordon and McBride (1994). If the number discussed in b) is 7, then the exponents are –2, –1, 0, 1, 2, 3, and 4. If the number discussed in b) is 1, only the exponent 0 is given.

TABLE B1.—GENERAL FORMAT

Record	Constants	Format	Columns
1	Species name or formula	A24	1–24
	Comments (data source)	A56	25–80
2	Number of T intervals	12	2
	Optional identification code	A6	4–9
	Chemical formulas, symbols, and numbers	5(A2,F6.2)	11–50
	Zero for gas and nonzero for condensed phases	11	52
	Molecular weight	F13.5	53–65
	Heat of formation at 298.15 K, J/mol	F13.5	66–80
3	Temperature range	2F10.3	2–21
	Number of coefficients for $\frac{C_p^\circ(T)}{R}$	11	23
	T exponents in empirical equation for $\frac{C_p^\circ(T)}{R}$	8F5.1	24–63
	$\{H^\circ(298.15)–H^\circ(0)\}$, J/mol	F15.3	66–80
4	First five coefficients for $\frac{C_p^\circ(T)}{R}$	5D16.8	1–80
5	Last three coefficients for $\frac{C_p^\circ(T)}{R}$	3D16.8	1–48
	Integration constants, b_1 and b_2	2D16.8	49–80
--	Repeat 3, 4, and 5 for each interval	----------	--------

EMPIRICAL EQUATIONS

Heat capacity: $$\frac{C_p^\circ(T)}{R} = a_1T^{-2} + a_2T^{-1} + a_3 + a_4T + a_5T^2 + a_6T^3 + a_7T^4$$

Enthalpy: $$\frac{H^\circ(T)}{RT} = -a_1T^{-2} + a_2T^{-1}\ln T + a_3 + a_4\frac{T}{2} + a_5\frac{T^2}{3} + a_6\frac{T^3}{4} + a_7\frac{T^4}{5} + \frac{b_1}{T}$$

Entropy: $$\frac{S^\circ(T)}{R} = -a_1\frac{T^{-2}}{2} - a_2T^{-1} + a_3\ln T + a_4T + a_5\frac{T^2}{2} + a_6\frac{T^3}{3} + a_7\frac{T^4}{4} + b_2$$

TABLE B2. - LEAST-SQUARES COEFFICIENTS

```
Ag                Hf:CODATA1989. Spec:NSRDS-NBS 35 v3 1971.
 3 l10/97 AG  1.00    0.00    0.00    0.00    0.00 0    107.86820     284900.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 3.352002370D+04 6.562819350D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-3.309926370D+05 9.820086420D+02 1.381179917D+00 6.170899990D-04-1.688114600D-07
 2.008826848D-11-5.627285655D-16 0.000000000D+00 2.726719171D+04 1.456862733D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-3.717441500D+08 2.758069172D+05-7.385982610D+01 9.606158720D-03-5.393935740D-07
 1.358856730D-11-1.272610104D-16 0.000000000D+00-2.107724971D+06 6.628374570D+02

Ag+               Spec: NSRDS-NBS 35 v3 1971.
 3 l10/97 AG  1.00E  -1.00    0.00    0.00    0.00 0    107.86765    1022093.730
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.530
 3.691132750D+06-4.316983000D+04 2.028445385D+02-4.658413740D-01 5.586200510D-04
-3.154880975D-07 6.578702060D-11 0.000000000D+00 3.371574470D+05-1.142924427D+03
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.530
-5.327432350D+07 1.310710631D+05-1.098820208D+02 4.826002760D-02-1.093661557D-05
 1.263835910D-09-5.852542535D-14 0.000000000D+00-7.439122510D+05 8.446266190D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.530
-2.119469170D+08 1.159621936D+05-2.220792532D+01 2.938747589D-03-1.822389545D-07
 5.823925360D-12-7.455184012D-17 0.000000000D+00-8.068014150D+05 2.271702823D+02

Ag-               JPCRD v14 n3 1985 p731.
 3 l10/97 AG  1.00E   1.00    0.00    0.00    0.00 0    107.86875     153078.728
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.766565919D+04 5.869679800D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.766565919D+04 5.869679800D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.766565919D+04 5.869679800D+00

AL                Spec:JPCRD v20 n5 p775 1991. Hf:CODATA 1989 p24.
 3 l12/97 AL  1.00    0.00    0.00    0.00    0.00 0     26.98154     330000.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6918.671
 5.006608890D+03 1.861304407D+01 2.412531111D+00 1.987604647D-04-2.432362152D-07
 1.538281506D-10-3.944375734D-14 0.000000000D+00 3.887412680D+04 6.086585820D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6918.671
-2.920820938D+04 1.167751876D+02 2.356906505D+00 7.737231520D-05-1.529455262D-08
-9.971670260D-13 5.053278264D-16 0.000000000D+00 3.823288650D+04 6.600920210D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6918.671
-5.040682320D+08 3.802322650D+05-1.082347159D+02 1.549444292D-02-1.070103856D-06
 3.592110900D-11-4.696039394D-16 0.000000000D+00-2.901050501D+06 9.491883160D+02
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AL+                 Spec:JPCRD v20 n5 1991 p775; NSRDS-NBS 35 v1 1971.
 3 1 1/98 AL  1.00E  -1.00    0.00    0.00    0.00 0     26.98099     913015.128
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.090644788D+05 3.791005840D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-4.181183250D+03-9.948557270D+00 2.548615878D+00-5.878760040D-05 3.132291294D-08
-7.748894630D-12 7.274447690D-16 0.000000000D+00 1.091011485D+05 3.488667350D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-9.080958540D+08 5.509673040D+05-1.279244177D+02 1.510503026D-02-8.932051950D-07
 2.719381070D-11-3.367986284D-16 0.000000000D+00-4.268693020D+06 1.141245444D+03

AL-                 Spec:JANAF 1985 6/83. EA:JPCRD v14 n3 1985 p731.
 3 1 3/97 AL  1.00E   1.00    0.00    0.00    0.00 0     26.98209     281090.113
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6756.213
 2.910800014D+04-3.836981670D+02 4.655141860D+00-6.045819640D-03 8.577256840D-06
-5.476258170D-09 1.322713578D-12 0.000000000D+00 3.490616880D+04-5.957092220D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6756.213
 6.339829490D+05-2.383442269D+03 5.469974720D+00-1.299842045D-03 2.888309666D-07
-3.253245760D-11 1.472438690D-15 0.000000000D+00 4.780309030D+04-1.536909445D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6756.213
 5.900938300D+06-2.295848307D+03 3.072740558D+00-6.894315690D-05 4.413059860D-09
-1.445270534D-13 1.905642152D-18 0.000000000D+00 5.241748900D+04 1.452081350D+00

Ar                  Ref-Elm. Spec: NSRDS-NBS 35 1971.
 3 1 3/98 AR  1.00    0.00    0.00    0.00    0.00 0     39.94800          0.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02 4.379674910D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 2.010538475D+01-5.992661070D-02 2.500069401D+00-3.992141160D-08 1.205272140D-11
-1.819015576D-15 1.078576636D-19 0.000000000D+00-7.449939610D+02 4.379180110D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-9.951265080D+08 6.458887260D+05-1.675894697D+02 2.319933363D-02-1.721080911D-06
 6.531938460D-11-9.740147729D-16 0.000000000D+00-5.078300340D+06 1.465298484D+03

Ar+                 Spec: NSRDS-NBS 35 1971; IP:NSRDS-NBS 34 1970.
 3 1 1/99 AR  1.00E  -1.00    0.00    0.00    0.00 0     39.94745    1526778.407
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6205.988
-5.731209170D+04 7.930791470D+02-1.717121217D+00 1.044184018D-02-1.180207501D-05
 6.528134780D-09-1.447558130D-12 0.000000000D+00 1.790572230D+05 2.949150950D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6205.988
-3.835965400D+05 8.162019700D+02 2.301342628D+00-4.952983770D-06 1.205108477D-08
-2.185050286D-12 1.265493898D-16 0.000000000D+00 1.771811455D+05 7.947507480D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6205.988
 1.006884827D+07-6.624361280D+03 4.446908200D+00-3.017567664D-04 2.612882069D-08
-1.201637769D-12 2.299206903D-17 0.000000000D+00 2.349504137D+05-1.032262257D+01

B                   JPCA v102 n18 1998 p2995. Spec:JPCRD v8 n1 1979 p63.
 3 1 9/98 B   1.00    0.00    0.00    0.00    0.00 0     10.81100     575598.760
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6316.060
 1.182394638D+02-7.009916910D-02 2.500236159D+00-4.584213700D-07 5.123185830D-10
-3.057217674D-13 7.533815325D-17 0.000000000D+00 6.848359080D+04 4.209501920D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6316.060
-1.072659610D+05 3.225307160D+02 2.126407232D+00 2.106579339D-04-5.937129160D-08
 7.377427990D-12-2.282443381D-16 0.000000000D+00 6.643413100D+04 6.877069670D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6316.060
-4.150001310D+08 2.329576796D+05-4.720913710D+01 4.877655960D-03-2.069413791D-07
 3.233519090D-12-1.824076527D-18 0.000000000D+00-1.802904743D+06 4.439617640D+02
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B+                  Spec: NSRDS-NBS 35 1971. IP:NSRDS-NBS 34 1970.
 3 1 9/98 B   1.00E  -1.00    0.00    0.00    0.00 0     10.81045    1382315.528
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 7.849791190D-02-8.947480950D-04 2.500004085D+00-9.577271230D-09 1.218136411D-11
-7.986752520D-15 2.113769829D-18 0.000000000D+00 1.655080260D+05 2.419053631D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-8.911548030D+03 4.587790090D+00 2.531500086D+00-4.903949100D-05 2.853326582D-08
-7.382175910D-12 7.120721560D-16 0.000000000D+00 1.654526303D+05 2.238669780D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-7.977322890D+08 4.734044940D+05-1.055286044D+02 1.170310076D-02-6.075531110D-07
 1.484174716D-11-1.328323987D-16 0.000000000D+00-3.609116960D+06 9.497399750D+02

B-                  Spec:JPCRD v14 n3 1985 p731.
 3 1 9/98 B   1.00E   1.00    0.00    0.00    0.00 0     10.81155     542631.498
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6272.598
 2.201568105D+01-4.740468880D-03 2.500014238D+00-2.497056599D-08 2.556360708D-11
-1.415274780D-14 3.271770710D-18 0.000000000D+00 6.451791880D+04 4.616367290D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6272.598
 2.118018248D+01 2.070697496D-04 2.499999729D+00 1.456693631D-10-3.888571760D-14
 5.090598630D-18-2.601566168D-22 0.000000000D+00 6.451789140D+04 4.616455830D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6272.598
-1.311386485D+02 9.028908800D-02 2.499978572D+00 2.606391052D-09-1.716068068D-13
 5.810865540D-18-7.925029090D-23 0.000000000D+00 6.451717400D+04 4.616640300D+00

Ba                  TPIS 1996;NSRDS-NBS 35 1971;NSRDS-NBS 34 1970
 3 110/97 BA  1.00    0.00    0.00    0.00    0.00 0    137.32700     185000.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 2.222563526D+03-3.407977850D+01 2.706751118D+00-6.382894490D-04 1.063003846D-06
-9.102624270D-10 3.148062219D-13 0.000000000D+00 2.166549702D+04 5.102545880D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-1.926579228D+07 6.006501040D+04-6.633964130D+01 3.507565930D-02-7.807601830D-06
 8.085126800D-10-3.199486918D-14 0.000000000D+00-3.589663720D+05 5.007583400D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 3.483452070D+08-2.925558261D+05 9.774888490D+01-1.345477126D-02 9.567239790D-07
-3.380662310D-11 4.727390540D-16 0.000000000D+00 2.250335260D+06-7.968444410D+02

Ba+                 NSRDS NBS 35 vIII 1971.
 3 110/97 BA  1.00E  -1.00    0.00    0.00    0.00 0    137.32645     694049.528
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-5.423167550D+04 6.744680780D+02-8.940272500D-01 8.796642950D-03-1.222812901D-05
 8.387953870D-09-2.037964358D-12 0.000000000D+00 7.941774640D+04 2.607063698D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 8.794971850D+06-1.951817883D+04 1.485542861D+01-9.404233500D-04-7.031257790D-07
 1.667412753D-10-1.070117310D-14 0.000000000D+00 2.146800732D+05-9.228264190D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-1.055569557D+08 4.530799570D+04-5.410673220D-01-7.531497600D-04 1.295568595D-07
-6.013388590D-12 8.846178515D-17 0.000000000D+00-3.000874708D+05 4.370610780D+01

Be                  Hf:CODATA1989. JPCRD v26 n5 1997 p1185.
 3 111/97 BE  1.00    0.00    0.00    0.00    0.00 0      9.01218     324000.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-4.112901520D-04 5.364967360D-06 2.499999972D+00 7.569203690D-11-1.097852652D-13
 8.002110240D-17-2.303022777D-20 0.000000000D+00 3.822264590D+04 2.146172983D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-6.926285840D+05 2.466773005D+03-9.776613340D-01 2.458939515D-03-9.047950420D-07
 1.587880407D-10-9.415600603D-15 0.000000000D+00 2.300212917D+04 2.623234754D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 4.145833520D+08-2.254147519D+05 4.411437910D+01-3.022853591D-03 1.178346131D-07
-2.273387650D-12 1.196838345D-17 0.000000000D+00 1.866686325D+06-3.752337400D+02
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Be+                 Spec: NSRDS-NBS 35 1971; NSRDS-NBS 34 1970.
 3 l 1/98 BE  1.00E  -1.00    0.00    0.00    0.00 0      9.01163    1229701.328
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.471528569D+05 2.839228698D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-9.478135980D+04 2.768325398D+02 2.191388413D+00 1.648824289D-04-4.280166820D-08
 4.542350470D-12-6.270417825D-17 0.000000000D+00 1.453850986D+05 5.055503840D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-2.321269508D+08 1.525464518D+05-3.651092580D+01 4.812692090D-03-2.928878120D-07
 8.899649840D-12-1.055676610D-16 0.000000000D+00-1.052744318D+06 3.402173130D+02

Br                  Hf:CODATA1989. NSRDS-NBS 35 vII 1971;NSRDS-NBS 34 1970.
 3 l 3/97 BR  1.00    0.00    0.00    0.00    0.00 0     79.90400     111870.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-3.700293910D+03 6.145215420D+01 2.092120721D+00 1.376818870D-03-2.445566658D-06
 2.050975161D-09-5.144249091D-13 0.000000000D+00 1.242508647D+04 8.996166200D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-4.789717400D+06 1.692051999D+04-2.024085357D+01 1.395620355D-02-3.656230560D-06
 4.489781000D-10-2.122507526D-14 0.000000000D+00-9.207054960D+04 1.661695929D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-1.240248003D+08 7.034034730D+04-1.023087313D+01 1.373755814D-03-7.476473480D-08
 2.160883187D-12-2.659054603D-17 0.000000000D+00-5.563101070D+05 1.226657143D+02

Br+                 Spec: NSRDS-NBS 35 1971;NSRDS-NBS 34 1970.
 3 l10/97 BR  1.00E  -1.00    0.00    0.00    0.00 0     79.90345    1257927.034
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.434
 3.981187420D+04-4.751581470D+02 4.734578980D+00-5.169324790D-03 5.905857520D-06
-2.885129283D-09 5.054894290D-13 0.000000000D+00 1.529052046D+05-5.769283220D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.434
 1.741149829D+06-5.455465670D+03 8.470663350D+00-2.683465574D-03 6.590454560D-07
-7.953770300D-11 3.735898818D-15 0.000000000D+00 1.851781643D+05-3.637909030D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.434
-6.174903280D+07 3.641704160D+04-5.739744680D+00 1.067497350D-03-7.127689890D-08
 2.155618820D-12-1.769476126D-17 0.000000000D+00-1.399767498D+05 7.931577700D+01

Br-                 JPCRD v14 n3 1985 p731.
 3 l10/97 BR  1.00E   1.00    0.00    0.00    0.00 0     79.90455    -219000.472
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-2.708492743D+04 5.419556170D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-2.708492743D+04 5.419556170D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-2.708492743D+04 5.419556170D+00

C                   Hf:CJP v33 1955 p125. NSRDS-NBS 3 sec3 1970.
 3 l 7/97 C   1.00    0.00    0.00    0.00    0.00 0     12.01100     716680.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6535.895
 6.495031470D+02-9.649010860D-01 2.504675479D+00-1.281448025D-05 1.980133654D-08
-1.606144025D-11 5.314483411D-15 0.000000000D+00 8.545763110D+04 4.747999220D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6535.895
-1.289136472D+05 1.719528572D+02 2.646044387D+00-3.353068950D-04 1.742092740D-07
-2.902817829D-11 1.642182385D-15 0.000000000D+00 8.410597850D+04 4.130122350D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6535.895
 4.432528010D+08-2.886018412D+05 7.737108320D+01-9.715281890D-03 6.649595330D-07
-2.230078776D-11 2.899388702D-16 0.000000000D+00 2.355273444D+06-6.405122410D+02
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C+                  Spec: NSRDS-NBS 3 sec3 1970.
 3 l 6/98 C   1.00E  -1.00    0.00    0.00    0.00 0     12.01045    1809444.482
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6649.282
 2.258535929D+03-1.574575687D+00 2.503637730D+00-5.202878370D-06 4.516908390D-09
-2.181431053D-12 4.495047033D-16 0.000000000D+00 2.168951913D+05 4.345774440D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6649.282
 1.255112551D+04-3.411874670D+01 2.543383218D+00-2.805120849D-05 9.751641970D-09
-1.736855394D-12 1.246191931D-16 0.000000000D+00 2.171001786D+05 4.063988450D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6649.282
 5.618135320D+05-6.047058900D+03 5.884541470D+00-7.211894530D-04 6.823484110D-08
-2.599878590D-12 3.633868358D-17 0.000000000D+00 2.581370458D+05-2.280012265D+01

C-                  JPCRD v14 n3 1985 p731.
 3 l 3/98 C   1.00E   1.00    0.00    0.00    0.00 0     12.01155     588314.236
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6218.836
 4.671291530D+00-1.986169369D-03 2.500008638D+00-1.976750928D-08 2.478947477D-11
-1.610664044D-14 4.236506810D-18 0.000000000D+00 7.001218550D+04 4.879645070D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6218.836
 4.253175720D+00 5.778186480D-04 2.499999424D+00 2.836136231D-10-7.327253420D-14
 9.478507810D-18-4.830487320D-22 0.000000000D+00 7.001217170D+04 4.879699140D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6218.836
 1.223289007D+01-5.196185830D-03 2.500001344D+00-1.743497251D-10 1.206609009D-14
-4.252419790D-19 5.992333270D-24 0.000000000D+00 7.001221630D+04 4.879683350D+00

Ca                  Hf:CODATA 1989. JPCRD v14 sup.2 1985.
 3 l 8/97 CA  1.00    0.00    0.00    0.00    0.00 0     40.07800     177800.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.063892786D+04 4.384548330D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 7.547341240D+06-2.148642662D+04 2.530849567D+01-1.103773705D-02 2.293249636D-06
-1.209075383D-10-4.015333268D-15 0.000000000D+00 1.585862323D+05-1.609512955D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 2.291781634D+09-1.608862960D+06 4.312466360D+02-5.396508990D-02 3.531856210D-06
-1.164403850D-10 1.527134223D-15 0.000000000D+00 1.258651434D+07-3.692101610D+03

Ca+                 Spec:JPCRD v14 sup.2 1985.
 3 l 1/98 CA  1.00E  -1.00    0.00    0.00    0.00 0     40.07745     773827.728
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 9.232417790D+04 5.077674980D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 3.747070820D+06-1.174707738D+04 1.672546969D+01-8.334797710D-03 2.394593294D-06
-2.988243468D-10 1.356563002D-14 0.000000000D+00 1.664329088D+05-9.582821260D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 9.117128410D+08-6.220428460D+05 1.683741136D+02-2.140862670D-02 1.452947686D-06
-4.920790880D-11 6.575369235D-16 0.000000000D+00 4.959472060D+06-1.422600719D+03

Cd                  Hf:CODATA 1989 p25. NSRDS-NBS 35 vIII 1971 p55
 3 l 7/97 CD  1.00    0.00    0.00    0.00    0.00 0    112.41100     111800.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-1.081751543D-04 1.816433041D-06 2.499999989D+00 3.129989231D-11-4.600710160D-14
 3.407048740D-17-9.989497436D-21 0.000000000D+00 1.270099766D+04 5.931549760D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-2.699757467D+05 7.866001140D+02 1.628169079D+00 4.594123290D-04-1.150420443D-07
 1.074836707D-11 8.790199555D-17 0.000000000D+00 7.675148260D+03 1.220006052D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-1.336284287D+09 9.320949110D+05-2.490956222D+02 3.302878610D-02-2.200384347D-06
 7.425712550D-11-1.026730246D-15 0.000000000D+00-7.267528990D+06 2.167946107D+03
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Cd+                 NSRDS,NBS 35 vIII 1971 p59
 3 1 7/97 CD  1.00E  -1.00    0.00    0.00    0.00 0    112.41045     985754.328
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.098344940D-04-4.343581620D-06 2.500000019D+00-4.389036810D-11 5.563969200D-14
-3.638228260D-17 9.607881995D-21 0.000000000D+00 1.178129439D+05 6.624689450D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 1.484880812D+04-4.669153680D+01 2.557883006D+00-3.624701700D-05 1.213747570D-08
-2.072802814D-12 1.420665367D-16 0.000000000D+00 1.181070109D+05 6.216414480D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-6.428364400D+07 4.740395160D+04-1.165755517D+01 2.220273739D-03-1.964219980D-07
 9.262295070D-12-1.560026961D-16 0.000000000D+00-2.489244513D+05 1.263946278D+02

CL                  Hf:CODATA1989.Spec:NSRDS-NBS 35 1971;NSRDS-NBS 34 1970.
 3 1 7/97 CL  1.00    0.00    0.00    0.00    0.00 0     35.45270     121301.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6271.588
 2.276215854D+04-2.168413293D+02 2.745185115D+00 2.451101694D-03-5.458011990D-06
 4.417986880D-09-1.288134004D-12 0.000000000D+00 1.501357068D+04 3.102950764D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6271.588
-1.697932930D+05 6.081726460D+02 2.128664090D+00 1.307367034D-04-2.644883596D-08
 2.842504775D-12-1.252911731D-16 0.000000000D+00 9.934387400D+03 8.844759410D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6271.588
-7.139687070D+07 4.499936330D+04-9.264315350D+00 1.657437964D-03-1.326219399D-07
 5.533998870D-12-8.390301878D-17 0.000000000D+00-3.405333030D+05 1.069111299D+02

CL+                 Spec: NSRDS-NBS 35 1971;NSRDS-NBS 34 1970.
 3 1 1/98 CL  1.00E  -1.00    0.00    0.00    0.00 0     35.45215    1378799.635
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6386.335
 1.034697859D+05-1.293758873D+03 8.186702690D+00-9.916014600D-03 9.208472370D-06
-4.507426240D-09 9.182127880D-13 0.000000000D+00 1.714758780D+05-2.766419200D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6386.335
 4.056409480D+04-4.960165720D+01 3.101653630D+00-5.868738290D-04 2.252039316D-07
-3.299703020D-11 1.708780842D-15 0.000000000D+00 1.652982337D+05 2.574929905D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6386.335
-3.078099946D+06-6.858418280D+02 3.092289282D+00-1.922260015D-05 3.805551560D-10
-1.571848967D-13 8.442513880D-18 0.000000000D+00 1.683434405D+05 1.334394541D+00

CL-                 JPCRD v14 n3 1985 p731.
 3 1 4/97 CL  1.00E   1.00    0.00    0.00    0.00 0     35.45325    -233957.972
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-2.888389093D+04 4.200629330D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-2.888389093D+04 4.200629330D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-2.888389093D+04 4.200629330D+00

Co                  Hf:Hultgren 1973 p128. Spec:JPCRD v14 sup2 1985 p513.
 3 1 7/97 CO  1.00    0.00    0.00    0.00    0.00 0     58.93320     428441.600
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6359.768
-2.598939184D+03 2.461989844D+02-6.106058370D-01 1.393005772D-02-2.210012979D-05
 1.623755261D-08-4.534904351D-12 0.000000000D+00 4.984613760D+04 2.257584199D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6359.768
 1.381841305D+06-3.756036680D+03 6.657130650D+00-1.269246675D-03 1.464092329D-07
 6.574946570D-12-1.102384178D-15 0.000000000D+00 7.494442910D+04-2.258500836D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6359.768
-5.468015750D+08 4.037704950D+05-1.142413163D+02 1.663014422D-02-1.156228007D-06
 3.862515150D-11-5.002032746D-16 0.000000000D+00-3.076031798D+06 1.003028648D+03
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Co+                 JPCRD v14 sup2 1985.
 3 l 7/97 CO  1.00E  -1.00    0.00    0.00    0.00 0     58.93265    1193003.307
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6291.507
 1.028494160D+05-8.744731260D+02 4.279500280D+00 2.225857835D-03-7.457274570D-06
 7.279221950D-09-2.347541963D-12 0.000000000D+00 1.474895959D+05-5.679019220D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6291.507
 2.907386174D+06-8.619705750D+03 1.188134934D+01-3.510647420D-03 5.748004680D-07
-2.534065135D-11 2.976607469D-16 0.000000000D+00 1.977419221D+05-6.096533440D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6291.507
 2.701785479D+09-1.604232092D+06 3.687314770D+02-4.041150820D-02 2.371848586D-06
-7.119952160D-11 8.635423717D-16 0.000000000D+00 1.293631390D+07-3.201662470D+03

Co-                 JPCRD v14 n3 1985 p731.
 3 l 9/97 CO  1.00E   1.00    0.00    0.00    0.00 0     58.93375     358414.372
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6306.772
 3.459493760D+04-1.355041712D+02 1.116330898D+00 9.042761830D-03-1.454296726D-05
 9.994940630D-09-2.595633259D-12 0.000000000D+00 4.337037820D+04 1.270494975D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6306.772
-5.741394170D+05 1.763109207D+03 1.415561988D+00 3.776869690D-04-7.534179980D-08
 7.995701540D-12-3.490440000D-16 0.000000000D+00 3.083493114D+04 1.634360353D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6306.772
-7.121795840D+05 7.962447120D+02 2.328870839D+00 1.919463732D-05-1.179708474D-09
 3.764228600D-14-4.875340940D-19 0.000000000D+00 3.689285080D+04 9.511282720D+00

Cr                  Hf298:JANAF 6/79. Spec:JPCRD v14 sup2 1985 p264.
 3 l 7/97 CR  1.00    0.00    0.00    0.00    0.00 0     51.99610     397480.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.335658217D+03-2.102424026D+01 2.631908173D+00-4.246263250D-04 7.439194160D-07
-6.763931630D-10 2.507855625D-13 0.000000000D+00 4.715866640D+04 6.005425450D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-1.120220789D+07 3.401163690D+04-3.657062170D+01 2.110296902D-02-5.518180140D-06
 7.173601710D-10-3.505127367D-14 0.000000000D+00-1.688993440D+05 2.864481267D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 3.900886930D+09-2.462918543D+06 5.915632640D+02-6.697121640D-02 3.946957790D-06
-1.166504597D-10 1.367279456D-15 0.000000000D+00 1.955381984D+07-5.133510550D+03

Cr+                 Spec:JPCRD v14 sup2 1985.
 3 l 7/97 CR  1.00E  -1.00    0.00    0.00    0.00 0     51.99555    1056546.728
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.819187467D+02-2.188843517D+00 2.510676511D+00-2.706791825D-05 3.768492630D-08
-2.736784742D-11 8.115389932D-15 0.000000000D+00 1.263380825D+05 6.506276170D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 3.342330790D+06-1.064261051D+04 1.557884307D+01-7.708971480D-03 2.158300274D-06
-2.368108110D-10 8.952805604D-15 0.000000000D+00 1.932997670D+05-8.604356670D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 4.853867040D+08-4.114535830D+05 1.242898882D+02-1.610102894D-02 1.147677369D-06
-4.099673600D-11 5.728606039D-16 0.000000000D+00 3.281645810D+06-1.034723629D+03

Cr-                 JPCRD v14 n3 1985 p731.
 3 l10/97 CR  1.00E   1.00    0.00    0.00    0.00 0     51.99665     327023.428
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 3.858627870D+04 6.566835370D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 3.858627870D+04 6.566835370D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 3.858627870D+04 6.566835370D+00
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Cs                  Hf:CODATA1989.Spec:NSRDS-NBS 35 1971;NSRDS-NBS 34 1970.
 3 l 7/97 CS  1.00    0.00    0.00    0.00    0.00 0    132.90543      76500.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 5.466584070D+01-8.279346040D-01 2.504942210D+00-1.494620690D-05 2.425976774D-08
-2.013172322D-11 6.704271991D-15 0.000000000D+00 8.459321390D+03 6.848825320D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 6.166040900D+06-1.896175522D+04 2.483229903D+01-1.251977234D-02 3.309017390D-06
-3.354012020D-10 9.626500908D-15 0.000000000D+00 1.285111231D+05-1.522942192D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-9.566231720D+08 4.321690420D+05-6.371801020D+01 5.246260580D-03-2.366560159D-07
 5.848488480D-12-6.169370441D-17 0.000000000D+00-3.585268840D+06 6.156618170D+02

Cs+                 Spec:NSRDS-NBS 35 v3 1971 p128.
 3 l 1/98 CS  1.00E  -1.00    0.00    0.00    0.00 0    132.90488     458401.828
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 5.438737820D+04 6.182757540D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 5.438737820D+04 6.182757540D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-2.479469300D+08 1.405115456D+05-2.805027359D+01 3.087928133D-03-1.273598265D-07
-3.748818380D-13 1.214944533D-16 0.000000000D+00-1.072498017D+06 2.756827321D+02

Cs-                 JPCRD v14 n3 1985 p731.
 3 l10/97 CS  1.00E   1.00    0.00    0.00    0.00 0    132.90598      24797.228
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.237029001D+03 6.182769930D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.237029001D+03 6.182769930D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.237029001D+03 6.182769930D+00

Cu                  Hf:CODATA,1989. Spec:JPCRD v19 n3 1990.
 3 l12/97 CU  1.00    0.00    0.00    0.00    0.00 0     63.54600     337400.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 7.713133150D+01-1.169236206D+00 2.506987803D+00-2.116434879D-05 3.441714710D-08
-2.862608999D-11 9.559250991D-15 0.000000000D+00 3.983981210D+04 5.730813220D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 2.308090411D+06-8.503261000D+03 1.467859102D+01-8.467136520D-03 2.887821016D-06
-4.270659180D-10 2.304265084D-14 0.000000000D+00 9.207535620D+04-7.854701560D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-6.490595890D+08 4.240323360D+05-1.028965806D+02 1.297259934D-02-7.766697680D-07
 2.220446727D-11-2.441532031D-16 0.000000000D+00-3.305304580D+06 9.198622920D+02

Cu+                 Spec:JPCRD v19 n3 1990 p527.
 3 l 3/98 CU  1.00E  -1.00    0.00    0.00    0.00 0     63.54545    1089079.728
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-2.452340093D-03 2.606893531D-05 2.499999890D+00 2.351922485D-10-2.669362382D-13
 1.510315123D-16-3.278224814D-20 0.000000000D+00 1.302400621D+05 5.075940770D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-2.181443016D+06 7.217858190D+03-6.941154750D+00 6.208248920D-03-2.139340497D-06
 3.566431440D-10-2.081198501D-14 0.000000000D+00 8.516456660D+04 7.116800670D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 2.994686480D+09-1.831416099D+06 4.294926960D+02-4.801927720D-02 2.836504248D-06
-8.452189040D-11 1.013018211D-15 0.000000000D+00 1.468809255D+07-3.729918010D+03
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Cu-                 JPCRD v14 n3 1985 p731.
 3 110/97 CU  1.00E   1.00    0.00    0.00    0.00 0     63.54655     212718.628
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.483864954D+04 5.075966030D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.483864954D+04 5.075966030D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.483864954D+04 5.075966030D+00

D                   D0(D2):JMolSpc,v33 1970 p147. NSRDS-NBS 3 SEC 6 1972.
 3 1 6/97 D   1.00    0.00    0.00    0.00    0.00 0      2.01410     221720.228
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.592128700D+04 5.917143380D-01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 6.050019210D+01-1.810766064D-01 2.500210817D+00-1.220711706D-07 3.715172170D-11
-5.660680210D-15 3.393920393D-19 0.000000000D+00 2.592243752D+04 5.902125370D-01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 2.169259778D+08-1.309309862D+05 3.392595050D+01-3.805973810D-03 2.427699393D-07
-7.677967800D-12 9.624191177D-17 0.000000000D+00 1.065922040D+06-2.726201602D+02

D+                  IP for D: Moore, NSRDS-NBS 3, SEC 6, 1972.
 3 1 9/96 D   1.00E  -1.00    0.00    0.00    0.00 0      2.01355    1540324.328
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.845120037D+05-1.018414521D-01
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.845120037D+05-1.018414521D-01
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.845120037D+05-1.018414521D-01

D-                  JPCRD v14 n3 1985 p731.
 3 1/8/96 D   1.00E   1.00    0.00    0.00    0.00 0      2.01465     142752.728
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.642373393D+04-1.010243437D-01
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.642373393D+04-1.010243437D-01
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.642373393D+04-1.010243437D-01

e-                  Ref-Species. JANAF 1985 3/82
 3 112/98 E   1.00    0.00    0.00    0.00    0.00 0      0.00055          0.000
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02-1.172081224D+01
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02-1.172081224D+01
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02-1.172081224D+01
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F                   Hf:CODATA1989. NSRDS-NBS 35 1971 & 34 1970.
 3 l 5/97 F   1.00    0.00    0.00    0.00    0.00 0     18.99840      79380.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6518.460
 1.137409088D+03-1.453392797D+02 4.077403610D+00-4.303360140D-03 5.728897740D-06
-3.819312900D-09 1.018322509D-12 0.000000000D+00 9.311110120D+03-3.558982650D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6518.460
 1.473506226D+04 8.149927360D+01 2.444371819D+00 2.120210026D-05-4.546918620D-09
 5.109528730D-13-2.333894647D-17 0.000000000D+00 8.388374650D+03 5.478710640D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6518.460
-2.926724756D+07 1.775674924D+04-1.814463258D+00 5.351200280D-04-3.513620800D-08
 1.101519690D-12-1.061293837D-17 0.000000000D+00-1.319642721D+05 4.248814560D+01

F+                  Moore: NSRDS-NBS 35 1971 p62; NSRDS-NBS 34 1970 p6a.
 3 l 3/97 F   1.00E  -1.00     .00     .00     .00 0     18.99785    1766816.332
    298.150  1000.000 7 -2.0 -1.0   .0  1.0  2.0  3.0  4.0   .0          6710.732
-3.871680190D+04 3.218815660D+02 2.200920452D+00-2.455492688D-04 7.858355060D-07
-6.435987920D-10 1.839793564D-13 0.000000000D+00 2.098830937D+05 7.816999240D+00
   1000.000  6000.000 7 -2.0 -1.0   .0  1.0  2.0  3.0  4.0   .0          6710.732
 1.649635664D+04 1.337351478D+02 2.332522942D+00 1.215277877D-04-4.801037700D-08
 9.027225150D-12-5.470664940D-16 0.000000000D+00 2.110745327D+05 6.625817090D+00
   6000.000 20000.000 7 -2.0 -1.0   .0  1.0  2.0  3.0  4.0   .0          6710.732
 7.599619330D+06-1.391106563D+03 1.714871534D+00 2.428311844D-04-1.894860146D-08
 6.420828070D-13-8.257979730D-18 0.000000000D+00 2.269126001D+05 1.102848944D+01

F-                  JPCRD v14 n3 1985 p731.
 3 l 1/98 F   1.00E   1.00    0.00    0.00    0.00 0     18.99895    -255092.072
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-3.142572443D+04 3.264882710D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-3.142572443D+04 3.264882710D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-3.142572443D+04 3.264882710D+00

Fe                  Hf:Hultgren 1973. Spec:JPCRD v14 sup2 1985.
 3 l 5/97 FE  1.00    0.00    0.00    0.00    0.00 0     55.84500     415471.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6850.327
 6.790822660D+04-1.197218407D+03 9.843393310D+00-1.652324828D-02 1.917939959D-05
-1.149825371D-08 2.832773807D-12 0.000000000D+00 5.466995940D+04-3.383946260D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6850.327
-1.954923682D+06 6.737161100D+03-5.486410970D+00 4.378803450D-03-1.116286672D-06
 1.544348856D-10-8.023578182D-15 0.000000000D+00 7.137370060D+03 6.504979860D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6850.327
 1.216352511D+09-5.828563930D+05 9.789634510D+01-5.370704430D-03 3.192037920D-08
 6.267671430D-12-1.480574914D-16 0.000000000D+00 4.847648290D+06-8.697289770D+02

Fe+                 Spec:JPCRD v14 sup2 1985.
 3 l 3/98 FE  1.00E  -1.00    0.00    0.00    0.00 0     55.84445    1184217.849
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6935.749
-5.691231620D+04 1.847134390D+02 4.196972120D+00-5.978275970D-03 1.054267912D-05
-8.059804320D-09 2.256925874D-12 0.000000000D+00 1.401206571D+05-3.602542580D-01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6935.749
-8.176450090D+05 1.925359408D+03 1.717387154D+00 3.385338980D-04-9.813533120D-08
 2.228179208D-11-1.483964439D-15 0.000000000D+00 1.286352466D+05 1.500256262D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6935.749
 1.065217491D+08-2.883923997D+04-2.821752459D+00 2.712846797D-03-3.107069182D-07
 1.543726493D-11-2.725133516D-16 0.000000000D+00 4.142981690D+05 4.053497330D+01
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Fe-                 JPCRD v14 n3 1985 p731.
 3 1 9/97 FE  1.00E   1.00    0.00    0.00    0.00 0     55.84555     393338.036
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6641.836
 1.341276767D+05-1.775438064D+03 1.084366935D+01-1.499440282D-02 1.412129744D-05
-6.942189050D-09 1.410953082D-12 0.000000000D+00 5.519472530D+04-4.140886490D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6641.836
-1.237808631D+05 8.249279070D+02 1.912936452D+00 2.280194065D-04-4.942014160D-08
 5.591493490D-12-2.566386941D-16 0.000000000D+00 4.156251610D+04 1.265367627D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6641.836
-1.008467687D+06 7.642402360D+02 2.332880311D+00 1.892649914D-05-1.170322571D-09
 3.749758920D-14-4.871021520D-19 0.000000000D+00 4.111417150D+04 9.680921840D+00

Ge                  Hf:TPIS 1991 v2 pt1 p311. Spec:JPCRD v22 n5 1993 p1213.
 3 1 3/99 GE  1.00    0.00    0.00    0.00    0.00 0     72.61000     367800.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7398.584
-2.059215242D+04-1.432022103D+02 4.506002330D+00 1.547187840D-03-8.518296550D-06
 8.243824460D-09-2.566167305D-12 0.000000000D+00 4.363070860D+04-6.225268510D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7398.584
-8.565413840D+05 3.917958660D+03-1.809888212D+00 2.276482224D-03-5.365627550D-07
 5.984958090D-11-2.541700646D-15 0.000000000D+00 1.956518798D+04 3.841346790D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7398.584
 2.423965136D+07-2.543605174D+04 1.456087539D+01-2.592562254D-03 2.658628502D-07
-1.122785077D-11 1.620997559D-16 0.000000000D+00 2.295812461D+05-8.953585860D+01

Ge+                 JPCRD v22 n5 1993 p1213.
 3 1 3/99 GE  1.00E  -1.00    0.00    0.00    0.00 0     72.60945    1134984.385
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6205.785
-3.453666430D+05 4.008449710D+03-1.522395737D+01 3.626030020D-02-3.351367260D-05
 1.431059219D-08-2.236976459D-12 0.000000000D+00 1.157058042D+05 1.090151986D+02
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6205.785
-2.244860570D+06 5.165531140D+03-3.867516510D-01 8.528730940D-04-1.386040003D-07
 1.155945775D-11-3.784413134D-16 0.000000000D+00 1.006823985D+05 2.965783448D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6205.785
 5.768056240D+07-3.078606210D+04 8.706291820D+00-4.942233500D-04-2.690467703D-11
 1.853441677D-12-5.082067525D-17 0.000000000D+00 3.857785420D+05-4.842599100D+01

Ge-                 Spec:JPCRD v14 n3 1985 p731.
 3 1 3/99 GE  1.00E   1.00    0.00    0.00    0.00 0     72.61055     245402.540
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6980.940
 2.989142308D+03 8.657417230D+01 2.191868507D+00 5.900795270D-04-6.375800580D-07
 3.661132150D-10-8.689778450D-14 0.000000000D+00 2.835695190D+04 9.417004020D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6980.940
 1.352040246D+04-5.048518780D-01 2.500140247D+00-3.652944160D-09-6.716722200D-12
 1.378119925D-15-8.475212940D-20 0.000000000D+00 2.881739757D+04 7.577334250D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6980.940
 1.079877187D+04 1.149969180D+00 2.499738027D+00 3.051383052D-08-1.930296476D-12
 6.305166240D-17-8.327676240D-22 0.000000000D+00 2.880429709D+04 7.580847710D+00

H                   D0(H2):JMolSpc,v33 1970 p147. NSRDS-NBS 3 SEC 6 1972.
 3 1 6/97 H   1.00    0.00    0.00    0.00    0.00 0      1.00794     217998.828
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.547370801D+04-4.466828530D-01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 6.078774250D+01-1.819354417D-01 2.500211817D+00-1.226512864D-07 3.732876330D-11
-5.687744560D-15 3.410210197D-19 0.000000000D+00 2.547486398D+04-4.481917770D-01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 2.173757694D+08-1.312035403D+05 3.399174200D+01-3.813999680D-03 2.432854837D-07
-7.694275540D-12 9.644105630D-17 0.000000000D+00 1.067638086D+06-2.742301051D+02
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H+                IP: Moore,NSRDS-NBS 3,SEC 6,1972.
 3 1 8/96 H   1.00E  -1.00     .00     .00     .00 0      1.00739    1536245.928
    200.000  1000.000 1   .0   .0   .0   .0   .0   .0   .0   .0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.840214877D+05-1.140646644D+00
   1000.000  6000.000 1   .0   .0   .0   .0   .0   .0   .0   .0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.840214877D+05-1.140646644D+00
   6000.000 20000.000 1   .0   .0   .0   .0   .0   .0   .0   .0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.840214877D+05-1.140646644D+00

H-                JPCRD v14 n3 1985 p731.
 3 1 9/96 H   1.00E   1.00    0.00    0.00    0.00 0      1.00849     139031.328
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.597615494D+04-1.139013868D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.597615494D+04-1.139013868D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.597615494D+04-1.139013868D+00

He                Ref-Elm. Moore NSRDS-NBS 35 1971; NSRDS-NBS 34 1970.
 3 1 5/97 HE  1.00    0.00    0.00    0.00    0.00 0      4.00260          0.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02 9.287239740D-01
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02 9.287239740D-01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 3.396845420D+06-2.194037652D+03 3.080231878D+00-8.068957550D-05 6.252784910D-09
-2.574990067D-13 4.429960218D-18 0.000000000D+00 1.650518960D+04-4.048814390D+00

He+               Spec: NSRDS-NBS 35 1971; NSRDS-NBS 34 1970.
 3 1 3/97 HE  1.00E  -1.00    0.00    0.00    0.00 0      4.00205    2378521.473
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.853233739D+05 1.621665557D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.853233739D+05 1.621665557D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.853233739D+05 1.621665557D+00

Hg                Hf:CODATA1989. Spec:NSRDS-NBS 35 vIII 1971 p191.
 3 1 1/98 HG  1.00    0.00    0.00    0.00    0.00 0    200.59000      61380.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 6.636900080D+03 6.800201540D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 5.146573510D+04-1.681269855D+02 2.718343098D+00-1.445026192D-04 5.158977660D-08
-9.472485010D-12 7.034797406D-16 0.000000000D+00 7.688684930D+03 5.271236090D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 5.358443930D+08-4.433853810D+05 1.463223992D+02-2.318441669D-02 1.916335174D-06
-7.419662000D-11 1.067224054D-15 0.000000000D+00 3.391999920D+06-1.201225990D+03
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Hg+                 NSRDS,NBS 35 vIII 1971 p196
 3 l 7/97 HG  1.00E  -1.00    0.00    0.00    0.00 0    200.58945    1074643.128
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.098344940D-04-4.343581620D-06 2.500000019D+00-4.389036810D-11 5.563969200D-14
-3.638228260D-17 9.607881995D-21 0.000000000D+00 1.285037483D+05 7.493344500D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-1.229984728D+04 2.732269908D+01 2.484182160D+00-4.426797610D-06 7.489685860D-09
-2.549887287D-12 2.819873366D-16 0.000000000D+00 1.283188257D+05 7.625244570D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-5.498617710D+07 3.775543500D+04-7.155545550D+00 1.170310234D-03-7.931471440D-08
 4.029174000D-12-7.741071633D-17 0.000000000D+00-1.676894201D+05 9.116750020D+01

I                   Hf:CODATA1989. NSRDS-NBS 35 1971;NSRDS-NBS 34 1970.
 3 l 3/97 I   1.00    0.00    0.00    0.00    0.00 0    126.90447     106760.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 1.698199675D+02-2.716437233D+00 2.517385557D+00-5.730692070D-05 1.031716184D-07
-9.670641930D-11 3.706471651D-14 0.000000000D+00 1.210750090D+04 7.405823130D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-7.785860570D+05 2.303279568D+03 2.886686091D-03 1.180878463D-03-2.264074866D-07
 1.963511339D-11-6.243525941D-16 0.000000000D+00-2.616792742D+03 2.558922997D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.747630780D+07-8.681111190D+04 3.950617020D+01-6.514063250D-03 5.380695340D-07
-1.969145066D-11 2.643177163D-16 0.000000000D+00 6.384843030D+05-2.972997119D+02

I+                  Spec: NSRDS-NBS 35 1971;NSRDS-NBS 34 1970.
 3 l10/97 I   1.00E  -1.00    0.00    0.00    0.00 0    126.90392    1121351.028
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-8.014969010D+02 8.139052610D+00 2.470174760D+00 4.161393820D-05 7.133397860D-09
-7.105950140D-11 4.873766102D-14 0.000000000D+00 1.340794213D+05 7.903420090D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-7.788385330D+05 2.404962651D+03-1.791751142D-01 1.227311979D-03-1.801494030D-07
 9.923983960D-12-9.775286439D-17 0.000000000D+00 1.188531631D+05 2.710544347D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-6.314420010D+08 3.971131910D+05-9.860191990D+01 1.358236563D-02-9.920747650D-07
 3.684927700D-11-5.301687095D-16 0.000000000D+00-3.001474591D+06 8.790468740D+02

I-                  JPCRD v14 n3 1985 p731.
 3 l10/97 I   1.00E   1.00    0.00    0.00    0.00 0    126.90502    -194595.572
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-2.414970936D+04 6.113465380D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-2.414970936D+04 6.113465380D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-2.414970936D+04 6.113465380D+00

K                   Hf: CODATA 89. Spec: JPCRD v14 sup2 1985 p11.
 3 l 7/97 K   1.00    0.00    0.00    0.00    0.00 0     39.09830      89000.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 9.665143930D+00-1.458059455D-01 2.500865861D+00-2.601219276D-06 4.187306580D-09
-3.439722110D-12 1.131569009D-15 0.000000000D+00 9.959493490D+03 5.035822260D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-3.566422360D+06 1.085289825D+04-1.054134898D+01 8.009801350D-03-2.696681041D-06
 4.715294150D-10-2.976897350D-14 0.000000000D+00-5.875337010D+04 9.738551240D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 9.205786590D+08-6.935300280D+05 1.911270788D+02-2.305931672D-02 1.430294866D-06
-4.409335020D-11 5.366769166D-16 0.000000000D+00 5.395082190D+06-1.622158805D+03
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K+                JPCRD v14 sup2 1985 p26.
 3 1 6/97 K   1.00E  -1.00    0.00    0.00    0.00 0     39.09775     514007.528
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 6.107516860D+04 4.347404440D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 6.107516860D+04 4.347404440D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 2.177901245D+07-1.415076630D+04 6.248954270D+00-5.187436800D-04 3.959640680D-08
-1.584335542D-12 2.603558905D-17 0.000000000D+00 1.722753576D+05-2.781728990D+01

K-                JPCRD v14 n3 1985 p731.
 3 1 9/97 K   1.00E   1.00    0.00    0.00    0.00 0     39.09885      34418.128
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 3.394150710D+03 4.347446530D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 3.394150710D+03 4.347446530D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 3.394150710D+03 4.347446530D+00

Kr                Ref-Elm. Spec:JPCRD v20 n5 1991 p859.
 3 1 8/97 KR  1.00    0.00    0.00    0.00    0.00 0     83.80000          0.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02 5.490956510D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 2.643639057D+02-7.910050820D-01 2.500920585D+00-5.328164110D-07 1.620730161D-10
-2.467898017D-14 1.478585040D-18 0.000000000D+00-7.403488940D+02 5.484398150D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-1.375531087D+09 9.064030530D+05-2.403481435D+02 3.378312030D-02-2.563103877D-06
 9.969787790D-11-1.521249677D-15 0.000000000D+00-7.111667370D+06 2.086866326D+03

Kr+               Spec:JPCRD v20 n5 1991 p859.
 3 1 7/97 KR  1.00E  -1.00    0.00    0.00    0.00 0     83.79945    1356953.918
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-5.650402860D+03 6.930740810D+01 2.157028132D+00 8.711228930D-04-1.181609730D-06
 7.862198630D-10-1.832589387D-13 0.000000000D+00 1.621164118D+05 8.818242260D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-2.216567015D+05 1.166167840D+03 4.869655320D-01 1.429223599D-03-3.949628610D-07
 4.982853510D-11-2.406719258D-15 0.000000000D+00 1.556002861D+05 2.059230986D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-3.319875960D+07 1.797953100D+04-7.155015940D-01 2.671088984D-04-6.196251880D-09
-4.107025960D-13 2.000619351D-17 0.000000000D+00 1.648114259D+04 3.620325750D+01

Li                Hf:CODATA1989. NSRDS-NBS 35 1971;NSRDS-NBS 34 1970.
 3 1 7/97 LI  1.00    0.00    0.00    0.00    0.00 0      6.94100     159300.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.841390197D+04 2.447622965D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.125610652D+06-3.463536730D+03 6.566611920D+00-2.260983356D-03 5.922289160D-07
-6.281635100D-11 2.884948238D-15 0.000000000D+00 4.034637400D+04-2.655918195D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 2.604352623D+09-1.521952201D+06 3.454400500D+02-3.779674850D-02 2.222420069D-06
-6.691570800D-11 8.088023606D-16 0.000000000D+00 1.217791847D+07-3.006680193D+03
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Li+                 Moore, NSRDS-NBS 35 v1 1971
 3 1 3/97 LI  1.00E  -1.00     .00     .00     .00 0      6.94045     685719.428
    298.150  1000.000 1   .0   .0   .0   .0   .0   .0   .0   .0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 8.172724550D+04 1.754357228D+00
   1000.000  6000.000 1   .0   .0   .0   .0   .0   .0   .0   .0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 8.172724550D+04 1.754357228D+00
   6000.000 20000.000 1   .0   .0   .0   .0   .0   .0   .0   .0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 8.172724550D+04 1.754357228D+00

Li-                 JPCRD v14 n3 1985 p731.
 3 1 1/98 LI  1.00E   1.00    0.00    0.00    0.00 0      6.94155      93474.728
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.049698659D+04 1.754594332D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.049698659D+04 1.754594332D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.049698659D+04 1.754594332D+00

Mg                  Hf:CODATA 1989. Spec:JPCRD v20 n1 1991 p83-152.
 3 1 6/97 MG  1.00    0.00    0.00    0.00    0.00 0     24.30500     147100.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.694658761D+04 3.634330140D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-5.364831550D+05 1.973709576D+03-3.633776900D-01 2.071795561D-03-7.738051720D-07
 1.359277788D-10-7.766898397D-15 0.000000000D+00 4.829188110D+03 2.339104998D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 2.166012586D+09-1.008355665D+06 1.619680021D+02-8.790130350D-03-1.925690961D-08
 1.725045214D-11-4.234946112D-16 0.000000000D+00 8.349525900D+06-1.469355261D+03

Mg+                 Spec:JPCRD v20 n1 1991 p97.
 3 1 6/97 MG  1.00E  -1.00    0.00    0.00    0.00 0     24.30445     891047.000
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.064223354D+05 4.327443460D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-1.914758821D+04 4.877347920D+01 2.457662661D+00 1.218104674D-05 1.897261686D-09
-1.580433756D-12 2.135732238D-16 0.000000000D+00 1.061022394D+05 4.646442860D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.015949550D+08-2.281591735D+05 5.421745710D+01-5.983017190D-03 3.657189130D-07
-1.020737688D-11 1.024202854D-16 0.000000000D+00 1.932463961D+06-4.480157830D+02

Mn                  Hf:JPCRD v16 n1 1987 p97. Spec:JPCRD v14 sup2 1985.
 3 1 7/97 MN  1.00    0.00    0.00    0.00    0.00 0     54.93805     282400.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 1.034061359D-01-1.551537349D-03 2.500009148D+00-2.723162066D-08 4.333897430D-11
-3.511093890D-14 1.136032201D-17 0.000000000D+00 3.321935190D+04 6.649325490D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 5.855155820D+03 8.838588440D+02-3.648662580D-02 2.703720687D-03-1.324971998D-06
 2.872603290D-10-1.923633570D-14 0.000000000D+00 2.867803487D+04 2.292541201D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 3.936189040D+09-2.353549748D+06 5.377244800D+02-5.824812570D-02 3.330475100D-06
-9.689631050D-11 1.133286034D-15 0.000000000D+00 1.879530161D+07-4.690097890D+03
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Mn+                JPCRD v14 sup2 1985.
 3 1 6/97 MN  1.00E  -1.00    0.00    0.00    0.00 0     54.93750    1005871.328
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 3.458017700D+02-4.251151330D+00 2.521281028D+00-5.565087280D-05 8.037162210D-08
-6.093550970D-11 1.900014268D-14 0.000000000D+00 1.202533602D+05 6.683468190D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 6.471314100D+05-2.403796253D+03 5.937715750D+00-2.341014594D-03 7.464165640D-07
-9.075969730D-11 4.467879847D-15 0.000000000D+00 1.349902108D+05-1.702666338D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.717119921D+09-9.029185830D+05 1.784788847D+02-1.566770206D-02 7.346534410D-07
-1.750673350D-11 1.667889239D-16 0.000000000D+00 7.443546080D+06-1.568005804D+03

Mo                 Hf:JPCRD v16 n1 1987 p107.Spec:JPCRD v17 n1 1988 p155.
 3 1 7/97 MO  1.00    0.00    0.00    0.00    0.00 0     95.94000     658500.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 7.646367910D+01-1.159269043D+00 2.506929462D+00-2.099249725D-05 3.414779430D-08
-2.841269591D-11 9.492443321D-15 0.000000000D+00 7.845899800D+04 7.601835660D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 5.573271000D+06-1.662365811D+04 2.135147077D+01-1.003069377D-02 2.409784357D-06
-1.811267352D-10 1.034189087D-15 0.000000000D+00 1.842646473D+05-1.275326434D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 6.205038910D+09-3.855961600D+06 9.371595060D+02-1.108164544D-01 6.929123900D-06
-2.199865715D-10 2.798315513D-15 0.000000000D+00 3.062163602D+07-8.122811340D+03

Mo+                JPCRD v17 n1 1988 p155.
 3 1 7/97 MO  1.00E  -1.00    0.00    0.00    0.00 0     95.93945    1349012.928
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.298236623D+02-1.560279908D+00 2.507600281D+00-1.923789063D-05 2.673316651D-08
-1.937174292D-11 5.729735412D-15 0.000000000D+00 1.615103759D+05 7.442543460D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.298891120D+07-3.948276230D+04 4.866599780D+01-2.605352326D-02 7.215431920D-06
-8.719164960D-10 3.788423040D-14 0.000000000D+00 4.118948570D+05-3.216791030D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-1.731253943D+09 8.776685240D+05-1.669716753D+02 1.732439603D-02-9.372726850D-07
 2.593422324D-11-2.913787941D-16 0.000000000D+00-6.989098130D+06 1.517101780D+03

Mo-                JPCRD v14 n3 1985 p731.
 3 110/97 MO  1.00E   1.00    0.00    0.00    0.00 0     95.94055     580324.628
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 6.905123690D+04 7.485659540D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 6.905123690D+04 7.485659540D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 6.905123690D+04 7.485659540D+00

N                  Hf:CODATA1989. Spec:NSRDS-NBS 3 sec5 1975.
 3 1 5/97 N   1.00    0.00    0.00    0.00    0.00 0     14.00674     472680.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 5.610463780D+04 4.193909320D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 8.876501380D+04-1.071231500D+02 2.362188287D+00 2.916720081D-04-1.729515100D-07
 4.012657880D-11-2.677227571D-15 0.000000000D+00 5.697351330D+04 4.865235790D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 5.475181050D+08-3.107574980D+05 6.916782740D+01-6.847988130D-03 3.827572400D-07
-1.098367709D-11 1.277986024D-16 0.000000000D+00 2.550585618D+06-5.848769710D+02
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N+                  Spec:NSRDS-NBS 3 sec5 1975.
 3 l 6/97 N   1.00E  -1.00    0.00    0.00    0.00 0     14.00619    1882127.624
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7116.524
 5.237079210D+03 2.299958315D+00 2.487488821D+00 2.737490756D-05-3.134447576D-08
 1.850111332D-11-4.447350984D-15 0.000000000D+00 2.256284738D+05 5.076835070D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7116.524
 2.904970374D+05-8.557908610D+02 3.477389290D+00-5.288267190D-04 1.352350307D-07
-1.389834122D-11 5.046166279D-16 0.000000000D+00 2.310809984D+05-1.994142261D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7116.524
 1.646092148D+07-1.113165218D+04 4.976986640D+00-2.005393583D-04 1.022481356D-08
-2.691430863D-13 3.539931593D-18 0.000000000D+00 3.136284696D+05-1.706645952D+01

N-                  EA:JPCRD v14 n3 1985 p731. Spec:JANAF 1985 12/82.
 3 j12/82 N   1.00E   1.00    0.00    0.00    0.00 0     14.00729     473537.545
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6498.345
 1.445682471D+03 7.335205110D+00 2.476680939D+00 4.227869180D-05-4.426293320D-08
 2.490985431D-11-5.831608090D-15 0.000000000D+00 5.617625000D+04 5.145758260D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6498.345
 2.404189576D+03 2.954965336D-01 2.499789368D+00 8.307564970D-08-1.829942770D-11
 2.100136461D-15-9.754986710D-20 0.000000000D+00 5.621413890D+04 5.006488440D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6498.345
 1.884379470D+03 3.905516910D-01 2.499914043D+00 9.818512540D-09-6.126037340D-13
 1.980010689D-17-2.593295116D-22 0.000000000D+00 5.621304520D+04 5.005651890D+00

Na                  Hf:CODATA 1989 p27. Spec:JPCRD v10 n1 p153 1981
 3 l 8/97 NA  1.00    0.00    0.00    0.00    0.00 0     22.98977     107500.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.218382949D+04 4.244028050D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 9.525723380D+05-2.623807254D+03 5.162596620D+00-1.210218586D-03 2.306301844D-07
-1.249597843D-11 7.226771190D-16 0.000000000D+00 2.912963564D+04-1.519717074D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 1.592533392D+09-9.717836660D+05 2.238443963D+02-2.380930558D-02 1.352018117D-06
-3.936971110D-11 4.630689121D-16 0.000000000D+00 7.748677260D+06-1.939615505D+03

Na+                 Spec:JPCRD v10 n1 1981 p153.
 3 l 1/98 NA  1.00E  -1.00    0.00    0.00    0.00 0     22.98922     609542.928
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 7.256537070D+04 3.550845080D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 7.256537070D+04 3.550845080D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 3.401202990D+04-2.137774622D+01 2.505443851D+00-7.186631690D-07 5.188796390D-11
-1.944511626D-15 2.959355125D-20 0.000000000D+00 7.273413620D+04 3.503904060D+00

Na-                 JPCRD v14 n3 1985 p731.
 3 l 4/97 NA  1.00E   1.00    0.00    0.00    0.00 0     22.99032      48453.428
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000001D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 5.082199670D+03 3.550916660D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000001D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 5.082199670D+03 3.550916660D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000001D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 5.082199670D+03 3.550916660D+00
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Nb                Hf0:TPIS1982. Spec:NSRDS-NBS 35 1971;NSRDS-NBS 34 1970.
 3 1 3/98 NB  1.00    0.00    0.00    0.00    0.00 0     92.90638     723113.099
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          8354.099
 7.889660670D+04-1.212813914D+03 1.034579819D+01-1.676630056D-02 1.979119979D-05
-1.218224409D-08 3.058098336D-12 0.000000000D+00 9.165315140D+04-3.594742850D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          8354.099
-1.096553196D+06 2.546650713D+03 2.236054882D+00-1.280029198D-03 8.464237990D-07
-1.486269508D-10 8.714309406D-15 0.000000000D+00 6.879124550D+04 1.398169030D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          8354.099
 1.818626365D+09-1.032414940D+06 2.308238005D+02-2.445004311D-02 1.395626888D-06
-4.087233010D-11 4.826490497D-16 0.000000000D+00 8.359622560D+06-1.997797290D+03

Nb+               Spec:NSRDS-NBS 35 v2 1971. IP:NSRDS-NBS 34 1970.
 3 1 7/97 NB  1.00E  -1.00    0.00    0.00    0.00 0     92.90583    1393604.675
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          8589.075
 1.314447859D+05-2.000135035D+03 1.505024212D+01-2.996583942D-02 3.729868630D-05
-2.269869569D-08 5.449089902D-12 0.000000000D+00 1.760054029D+05-6.224595520D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          8589.075
-1.077639646D+06 2.159046421D+03 2.310604767D+00-5.363991760D-04 5.057915090D-07
-1.032401533D-10 6.629241280D-15 0.000000000D+00 1.517945546D+05 1.210678502D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          8589.075
 1.876113970D+07-2.202847919D+04 1.427004521D+01-2.295936786D-03 2.430819459D-07
-1.116131589D-11 1.836221996D-16 0.000000000D+00 3.245415600D+05-8.494555710D+01

Nb-               JPCRD v14 n3 1985 p731.
 3 1 9/97 NB  1.00E   1.00    0.00    0.00    0.00 0     92.90693     631054.008
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          8653.808
-7.220924850D+04 5.259501250D+02 3.470468390D+00-4.950505530D-03 7.401859030D-06
-5.016302070D-09 1.314100719D-12 0.000000000D+00 7.178828870D+04 5.155510070D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          8653.808
 1.117458019D+05 1.340072834D+02 2.391474129D+00 4.524813430D-05-1.025345000D-08
 1.195577988D-12-5.606330450D-17 0.000000000D+00 7.473996750D+04 9.675315610D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          8653.808
-1.279446680D+05 1.664265071D+02 2.463334336D+00 4.161717840D-06-2.573750764D-10
 8.239892930D-15-1.069096936D-19 0.000000000D+00 7.430433860D+04 9.186188470D+00

Ne                Moore: NSRDS-NBS 35 1971; NSRDS-NBS 34 1970.
 3 1 5/97 NE  1.00    0.00    0.00    0.00    0.00 0     20.17970        0.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02 3.355322720D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02 3.355322720D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-1.238252746D+07 6.958579580D+03 1.016709287D+00 1.424664555D-04-4.803933930D-09
-1.170213183D-13 8.415153652D-18 0.000000000D+00-5.663933630D+04 1.648438697D+01

Ne+               Spec: NSRDS-NBS 35 1971; NSRDS-NBS 34 1970.
 3 1 3/97 NE  1.00E  -1.00    0.00    0.00    0.00 0     20.17915    2086965.946
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6304.214
 7.281551480D+04-8.695697990D+02 6.108646970D+00-5.841356930D-03 5.041044170D-06
-2.293759207D-09 4.339065680D-13 0.000000000D+00 2.545996890D+05-1.673449355D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6304.214
-1.112742658D+05 4.765697970D+02 2.196650531D+00 1.102593151D-04-2.287564425D-08
 2.510218183D-12-1.126646096D-16 0.000000000D+00 2.472536944D+05 7.466140540D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6304.214
-5.615474110D+04 1.418980160D+02 2.475716842D+00 1.944430992D-06-6.323099200D-11
-1.313313446D-16 3.534699010D-20 0.000000000D+00 2.494452217D+05 5.366882220D+00
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Ni                  Hf0:Hultgren 1973. Spec:Physica Scripta v47 1993 p628.
 3 l 8/97 NI  1.00    0.00    0.00    0.00    0.00 0     58.69340     430116.605
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6825.013
-3.235810550D+04 6.015264620D+02-1.079270657D+00 1.089505519D-02-1.369578748D-05
 8.317725790D-09-2.019206968D-12 0.000000000D+00 4.813810810D+04 2.718829200D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6825.013
-4.938262210D+05 1.092909991D+03 2.410485014D+00-1.599071827D-05-1.047414069D-08
 4.624795210D-12-4.448865218D-17 0.000000000D+00 4.336072170D+04 9.677195600D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6825.013
 3.492669880D+08-1.654227575D+05 3.349869360D+01-3.527085900D-03 3.240060240D-07
-1.604177606D-11 2.935430214D-16 0.000000000D+00 1.409017848D+06-2.672455567D+02

Ni+                 Spec:JPCRD v14 sup2 1985.
 3 l 8/97 NI  1.00E  -1.00    0.00    0.00    0.00 0     58.69285    1172594.573
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6205.773
-8.969386030D+04 1.173601500D+03-3.410620410D+00 1.390739137D-02-1.501714923D-05
 7.896337900D-09-1.648686761D-12 0.000000000D+00 1.345589500D+05 4.031495160D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6205.773
-3.961999320D+06 1.017084853D+04-6.029331290D+00 2.770858029D-03-8.902077700D-08
-5.541000580D-11 5.235342833D-15 0.000000000D+00 7.340395120D+04 7.137503100D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6205.773
 5.286662360D+07-3.719827100D+04 1.470794435D+01-1.489309517D-03 8.648712770D-08
-1.705443550D-12 5.049635419D-18 0.000000000D+00 4.253204090D+05-9.590502160D+01

Ni-                 JPCRD v14 n3 1985 p731.
 3 l 9/97 NI  1.00E   1.00    0.00    0.00    0.00 0     58.69395     311764.357
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6207.157
-8.437624750D+04 1.135476552D+03-3.380615830D+00 1.423003786D-02-1.582586302D-05
 8.608840410D-09-1.875316029D-12 0.000000000D+00 3.124307590D+04 3.998061300D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6207.157
-5.433424800D+05 1.182645330D+03 2.126441240D+00 3.730455940D-05 6.953608430D-09
-1.945719381D-12 1.271571579D-16 0.000000000D+00 2.854759122D+04 1.043462235D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6207.157
 2.235741343D+06-7.539321100D+02 2.675777011D+00-2.056834268D-05 1.297167360D-09
-4.210909080D-14 5.520885950D-19 0.000000000D+00 4.359114370D+04 5.724516640D+00

O                   D0(O2):CJP v32 1954 p110. Spec:NSRDS-NBS 3 sec 1976.
 3 l 5/97 O   1.00    0.00    0.00    0.00    0.00 0     15.99940     249175.003
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6725.403
-7.953611300D+03 1.607177787D+02 1.966226438D+00 1.013670310D-03-1.110415423D-06
 6.517507500D-10-1.584779251D-13 0.000000000D+00 2.840362437D+04 8.404241820D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6725.403
 2.619020262D+05-7.298722030D+02 3.317177270D+00-4.281334360D-04 1.036104594D-07
-9.438304330D-12 2.725038297D-16 0.000000000D+00 3.392428060D+04-6.679585350D-01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6725.403
 1.779004264D+08-1.082328257D+05 2.810778365D+01-2.975232262D-03 1.854997534D-07
-5.796231540D-12 7.191720164D-17 0.000000000D+00 8.890942630D+05-2.181728151D+02

O+                  Spec:JPCRD v22 n5 1993.
 3 l 8/97 O   1.00E  -1.00    0.00    0.00    0.00 0     15.99885    1568787.228
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.879352842D+05 4.393376760D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-2.166513208D+05 6.665456150D+02 1.702064364D+00 4.714992810D-04-1.427131823D-07
 2.016595903D-11-9.107157762D-16 0.000000000D+00 1.837191966D+05 1.005690382D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-2.143835383D+08 1.469518523D+05-3.680864540D+01 5.036164540D-03-3.087873854D-07
 9.186834870D-12-1.074163268D-16 0.000000000D+00-9.614208960D+05 3.426193080D+02
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O-                  Spec:TPIS 1989 v1 pt1 p93. EA:JPCRD v14 n3 1985 p731.
 3 1 1/97 O   1.00E   1.00    0.00    0.00    0.00 0     15.99995     101846.192
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6570.792
-5.695857110D+03 1.099287334D+02 2.184719661D+00 5.326359800D-04-5.298878440D-07
 2.870216236D-10-6.524692740D-14 0.000000000D+00 1.093287498D+04 6.729863860D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6570.792
 9.769363180D+03 7.159604780D+00 2.494961726D+00 1.968240938D-06-4.304174850D-10
 4.912083080D-14-2.271600083D-18 0.000000000D+00 1.149554438D+04 4.837036440D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6570.792
 5.662391000D+02 7.572340320D+00 2.498352500D+00 1.862632395D-07-1.151227211D-11
 3.688814210D-16-4.793297600D-21 0.000000000D+00 1.148426000D+04 4.813406590D+00

P                   Hf:CODATA 1989. Spec:JPCRD v14 n3 1985 p751.
 3 1 5/97 P   1.00    0.00    0.00    0.00    0.00 0     30.97376     316500.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 5.040866570D+01-7.639418650D-01 2.504563992D+00-1.381689958D-05 2.245585515D-08
-1.866399889D-11 6.227063395D-15 0.000000000D+00 3.732421910D+04 5.359303530D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.261794642D+06-4.559838190D+03 8.918079310D+00-4.381401460D-03 1.454286224D-06
-2.030782763D-10 1.021022887D-14 0.000000000D+00 6.541723960D+04-3.915974790D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-2.215392545D+07-4.566911180D+04 2.837245428D+01-4.483244040D-03 3.579413080D-07
-1.255311557D-11 1.590290483D-16 0.000000000D+00 3.370905760D+05-2.056960927D+02

P+                  Spec:JPCRD v14 n3 1985 p751.
 3 1 4/97 P   1.00E  -1.00    0.00    0.00    0.00 0     30.97321    1336453.460
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         8141.860
-7.316908110D+04 9.627979140D+02-3.693938050D-01 4.766778340D-03-4.574768580D-06
 2.371262331D-09-5.131314900D-13 0.000000000D+00 1.549406849D+05 2.376640767D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         8141.860
-5.594249360D+05 1.722576545D+03 8.430381090D-01 6.287368940D-04-6.317195460D-08
-1.810842484D-12 4.318112570D-16 0.000000000D+00 1.490493431D+05 1.845275212D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         8141.860
 1.362531054D+07-8.717502380D+03 4.747426280D+00-1.620871933D-04-3.935548100D-10
 4.845613020D-13-7.448402970D-18 0.000000000D+00 2.284649718D+05-1.346454889D+01

P-                  JPCRD v14 n3 1985 p731.
 3 1 4/97 P   1.00E   1.00    0.00    0.00    0.00 0     30.97431     238826.765
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6747.865
-1.008949093D+04 1.826468403D+02 1.962456304D+00 9.197377540D-04-9.214998630D-07
 5.012872360D-10-1.142677121D-13 0.000000000D+00 2.703082432D+04 9.478137870D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6747.865
 1.543488016D+04 9.495009340D+00 2.493170861D+00 2.700167711D-06-5.949210390D-10
 6.823766290D-14-3.166959910D-18 0.000000000D+00 2.797572693D+04 6.246793920D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6747.865
 1.724147889D+03 1.074832503D+01 2.497654940D+00 2.655333078D-07-1.642839012D-11
 5.268015350D-16-6.849362660D-21 0.000000000D+00 2.795482976D+04 6.215849310D+00

Pb                  Hf:TPIS 1991. Spec:NSRDS-NBS 35 1971;NSRDS-NBS 34 1970.
 3 1 8/97 PB  1.00    0.00    0.00    0.00    0.00 0    207.20000     195200.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.213382285D+03-1.906116019D+01 2.619299546D+00-3.829519610D-04 6.688180450D-07
-6.061231080D-10 2.240022429D-13 0.000000000D+00 2.282096238D+04 6.201369200D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-9.084313070D+06 2.672673180D+04-2.626244039D+01 1.358282305D-02-2.685523566D-06
 2.352432800D-10-7.324114532D-15 0.000000000D+00-1.481650666D+05 2.154011624D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 5.325474970D+08-2.751419152D+05 6.303031930D+01-6.813672740D-03 4.447489610D-07
-1.519361678D-11 2.043475665D-16 0.000000000D+00 2.243651683D+06-5.225649900D+02
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Pb+                 Spec: NSRDS-NBS 35 v3 1971; NSRDS-NBS 34 1970.
 3 l10/97 PB  1.00E  -1.00    0.00    0.00    0.00 0    207.19945     916996.528
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 9.486689040D+00-1.134955793D-01 2.500549799D+00-1.382464681D-06 1.906022991D-09
-1.368396828D-12 4.003528117D-16 0.000000000D+00 1.095438901D+05 7.538855900D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 1.320690183D+06-4.096048010D+03 7.389101510D+00-2.807751909D-03 7.830991650D-07
-9.310600910D-11 4.016371727D-15 0.000000000D+00 1.354347306D+05-2.722020908D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.101539500D+08-2.538072503D+05 6.239804790D+01-6.542962120D-03 3.507316530D-07
-8.114133770D-12 5.908352630D-17 0.000000000D+00 2.122867468D+06-5.163550210D+02

Pb-                 JPCRD v14 n3 1985 p731.
 3 l 9/97 PB  1.00E   1.00    0.00    0.00    0.00 0    207.20055     153881.928
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.776226140D+04 8.235132100D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.776226140D+04 8.235132100D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.776226140D+04 8.235132100D+00

Rb                  Hf:CODATA1989. NSRDS-NBS-35 v2 1971;NSRDS-NBS 34 1970.
 3 l 1/98 RB  1.00    0.00    0.00    0.00    0.00 0     85.46780      80900.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 1.352856616D+01-2.042232679D-01 2.501213823D+00-3.650619900D-06 5.884722670D-09
-4.842274720D-12 1.596211946D-15 0.000000000D+00 8.985569210D+03 6.207005480D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-1.138274064D+06 3.804041940D+03-2.750899258D+00 3.891460700D-03-1.632296823D-06
 3.511893140D-10-2.521064422D-14 0.000000000D+00-1.466454849D+04 4.253442370D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 3.245192200D+08-3.493850870D+05 1.159097652D+02-1.492843123D-02 9.582385060D-07
-2.996233671D-11 3.657332046D-16 0.000000000D+00 2.636178014D+06-9.586517230D+02

Rb+                 Spec:NSRDS-NBS-35 v2 1971. IP:NSRDS-NBS 34 1970
 3 l 1/98 RB  1.00E  -1.00    0.00    0.00    0.00 0     85.46725     490129.128
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 5.820327360D+04 5.520506920D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 5.820327360D+04 5.520506920D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.120352830D+07-2.920376515D+04 1.102096776D+01-1.311457972D-03 1.124752629D-07
-5.107819770D-12 9.622794537D-17 0.000000000D+00 2.850166118D+05-6.672202250D+01

Rb-                 JPCRD v14 n3 1985 p731.
 3 l 9/97 RB  1.00E   1.00    0.00    0.00    0.00 0     85.46835      27818.528
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.600405796D+03 5.520526170D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.600405796D+03 5.520526170D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 2.600405796D+03 5.520526170D+00
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Rn                  Ref-Elm. Spec:NSRDS-NBS 35 v3 1971 p228.
 3 1 5/97 RN  1.00    0.00    0.00    0.00    0.00 0    222.01760          0.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 3.389432090D-06-1.311675533D-07 2.500000001D+00-2.978593139D-12 4.337050730D-15
-3.182040220D-18 9.247787030D-22 0.000000000D+00-7.453749990D+02 6.952441980D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 2.730190029D+04-8.284672620D+01 2.598178483D+00-5.813729850D-05 1.819136527D-08
-2.866656182D-12 1.789322176D-16 0.000000000D+00-2.202809340D+02 6.255005710D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 9.180866680D+08-6.245854600D+05 1.724946531D+02-2.325758595D-02 1.636222413D-06
-5.369173150D-11 6.507189926D-16 0.000000000D+00 4.883105900D+06-1.449516146D+03

Rn+                 NSRDS-NBS 35,v3,1971,p230.
 3 1 1/97 RN  1.00E  -1.00    0.00    0.00    0.00 0    222.01705    1043270.264
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-9.697148970D-02 1.106742047D-03 2.499994937D+00 1.189388239D-08-1.515895754D-11
 9.958934810D-15-2.640751817D-18 0.000000000D+00 1.247304760D+05 8.338761700D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-1.998285319D+04 5.930675660D+01 2.432476003D+00 3.716025920D-05-1.012057848D-08
 1.192256661D-12-3.184521980D-17 0.000000000D+00 1.243528478D+05 8.821997790D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
-2.408821471D+07 1.571151698D+04-1.411683762D+00 4.495267600D-04-2.324033616D-08
 5.830243350D-13-5.821682810D-18 0.000000000D+00 9.187457500D+02 4.233613280D+01

S                   Hf: CODATA 1989 p22. Spec:JPCRD v19 n4 1990 p821.
 3 1 5/97 S   1.00    0.00    0.00    0.00    0.00 0     32.06600     277170.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6657.425
-3.174841820D+02-1.924704923D+02 4.686825930D+00-5.841365600D-03 7.538533520D-06
-4.863586040D-09 1.256976992D-12 0.000000000D+00 3.323592180D+04-5.718477190D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6657.425
-4.854244790D+05 1.438830408D+03 1.258504116D+00 3.797990430D-04 1.630685864D-09
-9.547095850D-12 8.041466646D-16 0.000000000D+00 2.334995270D+04 1.559559533D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6657.425
-1.302005414D+08 6.909362020D+04-1.176228025D+01 1.601540850D-03-1.050533340D-07
 4.341829020D-12-7.675621927D-17 0.000000000D+00-5.261485030D+05 1.322195719D+02

S+                  Spec:JPCRD v19 n4 1990 p821.
 3 1 1/98 S   1.00E  -1.00    0.00    0.00    0.00 0     32.06545    1282496.428
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0         6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.535026117D+05 5.436270120D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.346218684D+06-4.056871510D+03 7.153436550D+00-2.523562352D-03 6.429539610D-07
-6.431672160D-11 2.141387919D-15 0.000000000D+00 1.792823835D+05-2.786930401D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.542254583D+08-1.023073546D+05 2.591796942D+01-2.111469141D-03 9.215571560D-08
-1.964168821D-12 2.096218597D-17 0.000000000D+00 9.622418410D+05-2.017239489D+02

S-                  JPCRD v14 n3 1985 p731.
 3 1 4/97 S   1.00E   1.00    0.00    0.00    0.00 0     32.06655      70368.505
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6464.905
-2.596051473D+03-1.422398653D+02 4.007825670D+00-3.608855910D-03 4.236230000D-06
-2.520987604D-09 6.079479760D-13 0.000000000D+00 8.197793070D+03-2.582330567D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6464.905
 2.730311692D+03 1.414072078D+02 2.403340775D+00 3.693577530D-05-7.944080440D-09
 8.952208380D-13-4.099662820D-17 0.000000000D+00 6.931195700D+03 6.575033680D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6464.905
-1.223682088D+05 1.203125842D+02 2.473942293D+00 2.935459895D-06-1.808577869D-10
 5.778854260D-15-7.490337240D-20 0.000000000D+00 6.947841220D+03 6.070626550D+00
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Sc                Hf0:TPIS v4 1982. Spec:JPCRD v14 sup2 1985.
 3 1 1/99 SC  1.00    0.00    0.00    0.00    0.00 0     44.95591     377700.259
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7002.259
-3.700805940D+03 1.692506026D+02 1.842242597D+00 1.364835821D-03-1.580085847D-06
 9.613111150D-10-2.392381918D-13 0.000000000D+00 4.385215240D+04 1.072781921D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7002.259
 8.810382650D+06-2.711232975D+04 3.476588660D+01-1.861104581D-02 5.290283900D-06
-6.585408060D-10 2.997850429D-14 0.000000000D+00 2.162460097D+05-2.225618519D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7002.259
 2.283130511D+09-1.367701232D+06 3.213593060D+02-3.563171100D-02 2.093254715D-06
-6.238650020D-11 7.425605615D-16 0.000000000D+00 1.092708359D+07-2.781409383D+03

Sc+               Spec:JPCRD v14 sup2 1985.
 3 1 7/97 SC  1.00E  -1.00    0.00    0.00    0.00 0     44.95536    1017145.222
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7161.922
-5.884930160D+03 1.479044408D+02 2.009576456D+00 7.389566970D-04-6.617964820D-07
 6.841073760D-10-2.164125532D-13 0.000000000D+00 1.208439139D+05 1.026570620D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7161.922
 1.973658531D+06-4.954384100D+03 6.360627350D+00-7.168785920D-04 2.464991123D-08
 9.632373790D-12-8.544709642D-16 0.000000000D+00 1.543423764D+05-2.261925782D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7161.922
 2.219151811D+08-1.287881370D+05 3.265593870D+01-3.379963200D-03 1.981741972D-07
-5.190207160D-12 4.635586113D-17 0.000000000D+00 1.149364313D+06-2.553294937D+02

Sc-               JPCRD v14 n3 1985 p731. Used J from isoelectronic Ti.
 3 1 9/97 SC  1.00E   1.00    0.00    0.00    0.00 0     44.95646     352558.828
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 4.165746390D+04 8.270420720D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 4.165746390D+04 8.270420720D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 4.165746390D+04 8.270420720D+00

Si                Hf:CODATA1989. Spec:NIST data version1.1 [Online]1997.
 3 1 8/97 SI  1.00    0.00    0.00    0.00    0.00 0     28.08550     450000.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7550.258
 9.836140810D+01 1.546544523D+02 1.876436670D+00 1.320637995D-03-1.529720059D-06
 8.950562770D-10-1.952873490D-13 0.000000000D+00 5.263510310D+04 9.698288880D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7550.258
-6.169298850D+05 2.240683927D+03-4.448619320D-01 1.710056321D-03-4.107714160D-07
 4.558884780D-11-1.889515353D-15 0.000000000D+00 3.953558760D+04 2.679668061D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7550.258
-9.286548940D+08 5.443989890D+05-1.206739736D+02 1.359662698D-02-7.606498660D-07
 2.149746065D-11-2.474116774D-16 0.000000000D+00-4.293792120D+06 1.086382839D+03

Si+               Spec:JPCRD v12 n2 1983 p323.
 3 1 4/97 SI  1.00E  -1.00    0.00    0.00    0.00 0     28.08495    1242508.045
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7342.945
-4.329791880D+04 6.795894490D+02 2.257046144D-01 4.118600490D-03-4.234881600D-06
 2.327995626D-09-5.318388059D-13 0.000000000D+00 1.452039813D+05 1.934650510D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7342.945
 5.919390230D+04-4.856730950D+01 2.556312024D+00-3.503397160D-05 1.190298787D-08
-2.082923821D-12 1.471452049D-16 0.000000000D+00 1.491431392D+05 5.244267140D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7342.945
-4.364077210D+07 2.434350601D+04-2.763336522D+00 5.924483200D-04-4.454048310D-08
 2.509351585D-12-5.090212919D-17 0.000000000D+00-4.683214410D+04 5.196564190D+01
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Si-                 Spec: JANAF 3/83. EA:JPCRD v14 n3 1985 p731.
 3 1 4/97 SI  1.00E   1.00    0.00    0.00    0.00 0     28.08605     308817.528
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-7.940146670D+02 5.567418420D+00 2.499837183D+00-9.481394460D-05 3.171246930D-07
-4.191323180D-10 2.035924380D-13 0.000000000D+00 3.636443380D+04 5.270119840D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-6.162070100D+06 1.883310402D+04-1.899302450D+01 1.111021657D-02-2.535790208D-06
 2.699962923D-10-1.105062911D-14 0.000000000D+00-8.314089310D+04 1.595298253D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-5.429517960D+07 3.297105700D+04-2.470579690D+00 3.966577600D-04-1.764141255D-08
 4.115769760D-13-3.904369380D-18 0.000000000D+00-2.315881505D+05 5.226601830D+01

Sn                  Hf:CODATA 1989 p24. NSRDS-NBS 35 vIII 1971 p74
 3 1 7/97 SN  1.00    0.00    0.00    0.00    0.00 0    118.71000     301200.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6214.713
-1.248692263D+05 1.618841190D+03-4.602397350D+00 1.045433308D-02 2.998265550D-06
-1.068699386D-08 4.323421310D-12 0.000000000D+00 2.748364008D+04 4.805067230D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6214.713
-5.145695640D+06 1.140575108D+04-4.179632060D+00 2.236390679D-03-3.603219770D-07
 2.440237836D-11-2.937628285D-16 0.000000000D+00-4.215013570D+04 5.981450930D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6214.713
-1.119787114D+09 6.427046040D+05-1.378615913D+02 1.453867222D-02-7.109586030D-07
 1.501409263D-11-8.940758657D-17 0.000000000D+00-5.111296870D+06 1.245625545D+03

Sn+                 NSRDS,NBS 35 vIII 1971 p80
 3 1 7/97 SN  1.00E  -1.00    0.00    0.00    0.00 0    118.70945    1015949.928
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-5.571297780D+03 1.222323189D+02 1.566361415D+00 3.397061410D-03-6.312922290D-06
 5.585452080D-09-1.689021340D-12 0.000000000D+00 1.209024120D+05 1.162634765D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.622916850D+06-1.185958712D+04 1.237026473D+01-2.773624217D-03 3.098513490D-07
-5.362951440D-12-8.663474691D-16 0.000000000D+00 1.994322977D+05-6.837108280D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 1.913728057D+08-1.145730242D+05 3.070294184D+01-3.387878800D-03 1.966377351D-07
-4.388396290D-12 2.057062343D-17 0.000000000D+00 1.031631149D+06-2.370157923D+02

Sn-                 JPCRD v14 n3 1985 p731.
 3 1 9/97 SN  1.00E   1.00    0.00    0.00    0.00 0    118.71055     179495.949
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6490.449
 2.722796000D+05-3.369935800D+03 1.743906405D+01-2.810527618D-02 2.790684767D-05
-1.442400675D-08 3.070159757D-12 0.000000000D+00 3.753227750D+04-8.007856970D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6490.449
-6.447713220D+04 7.430555100D+02 1.921380256D+00 2.361623997D-04-5.280668360D-08
 6.102339380D-12-2.843422486D-16 0.000000000D+00 1.645739414D+04 1.265436865D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6490.449
-1.314284778D+06 8.972354270D+02 2.302354538D+00 2.246840970D-05-1.392571963D-09
 4.468904450D-14-5.811846560D-19 0.000000000D+00 1.428800599D+04 1.004933765D+01

Sr                  Hf:TPIS 1996. NSRDS-NBS 35 1971 p189. NSRDS-NBS 34 1970.
 3 1 1/98 SR  1.00    0.00    0.00    0.00    0.00 0     87.62000     160500.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.190649840D+00-6.304437580D-02 2.500373027D+00-1.115455943D-06 1.785248643D-09
-1.456209589D-12 4.750132981D-16 0.000000000D+00 1.855852648D+04 5.555772840D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 1.489414410D+07-4.375335050D+04 5.137266280D+01-2.592566025D-02 6.582990000D-06
-6.949611800D-10 2.417779662D-14 0.000000000D+00 2.977545522D+05-3.454890770D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 5.562233720D+08-6.093193220D+05 2.109096848D+02-3.010063957D-02 2.178021676D-06
-7.824003460D-11 1.109909620D-15 0.000000000D+00 4.579268340D+06-1.752716908D+03
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Sr+                 Spec:NSRDS-NBS 35 vII 1971 p191
 3 l 1/98 SR  1.00E  -1.00    0.00    0.00    0.00 0     87.61945     716166.328
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 1.127287678D+01-1.346951870D-01 2.500651495D+00-1.635163061D-06 2.249493149D-09
-1.610827539D-12 4.698612333D-16 0.000000000D+00 8.538981180D+04 6.247259240D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 3.145095058D+06-9.514756890D+03 1.350086948D+01-6.059717120D-03 1.594068746D-06
-1.718800946D-10 6.322256169D-15 0.000000000D+00 1.457991907D+05-7.236416930D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6197.428
 9.016769220D+08-6.244641660D+05 1.695763594D+02-2.154835606D-02 1.462482744D-06
-4.930465390D-11 6.505705019D-16 0.000000000D+00 4.966238870D+06-1.431844579D+03

Ta                  Hf0:TPIS vIV 1982. NSRDS-NBS 35 vIII 1971 pp149-54.
 3 l 7/97 TA  1.00    0.00    0.00    0.00    0.00 0    180.94790     782518.638
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6199.638
-1.150907339D+04 4.780730430D+01 3.185588390D+00-5.366528160D-03 1.288379705D-05
-1.045798666D-08 3.050617695D-12 0.000000000D+00 9.299797630D+04 5.336056610D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6199.638
 1.689726898D+06-5.986854660D+03 9.565039670D+00-2.511649459D-03 6.443031170D-07
-7.189237250D-11 3.113352070D-15 0.000000000D+00 1.306710983D+05-4.335096270D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6199.638
-8.413419560D+08 6.381509040D+05-1.856031850D+02 2.797353600D-02-2.073321805D-06
 7.397299170D-11-1.017863944D-15 0.000000000D+00-4.836410620D+06 1.607007750D+03

Ta+                 NSRDS NBS 35 vIII 1971 pp149-55.
 3 l 7/97 TA  1.00E  -1.00    0.00    0.00    0.00 0    180.94735    1549679.335
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6337.835
 2.869712865D+05-3.084920994D+03 1.430679704D+01-1.984772164D-02 1.951445133D-05
-8.970946030D-09 1.501974665D-12 0.000000000D+00 2.013828712D+05-6.306427830D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6337.835
 3.656142130D+06-1.254073524D+04 1.865022579D+01-7.943274660D-03 2.151786937D-06
-2.816764844D-10 1.413722944D-14 0.000000000D+00 2.636876455D+05-1.065864286D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6337.835
 3.724273560D+07-3.405709310D+04 1.630056321D+01-2.064987830D-03 1.616826024D-07
-5.752060330D-12 7.636581870D-17 0.000000000D+00 4.405115500D+05-1.040237652D+02

Ta-                 JPCRD v14 n3 1985 p731.
 3 l 9/97 TA  1.00E   1.00    0.00    0.00    0.00 0    180.94845     745469.429
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6416.129
 1.873982301D+05-1.681268679D+03 6.480040150D+00-2.254355782D-04 2.028434876D-06
-4.679801430D-09 1.997027996D-12 0.000000000D+00 9.793496020D+04-2.049618155D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6416.129
-4.235467480D+06 1.101056361D+04-4.736911070D+00 2.503562129D-03-4.821851690D-07
 4.886408030D-11-2.030547835D-15 0.000000000D+00 1.574699408D+04 6.491802700D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         6416.129
 4.149884030D+05 1.227972146D+03 2.209211582D+00 3.401090760D-05-2.136872502D-09
 6.906775410D-14-9.017779200D-19 0.000000000D+00 8.249065600D+04 1.195636187D+01

Ti                  Hf:CODATA 1989. JPCRD v14 sup2 1985.
 3 l 7/97 TI  1.00    0.00    0.00    0.00    0.00 0     47.86700     473000.000
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         7539.141
-4.570179400D+04 6.608092020D+02 4.295257490D-01 3.615029910D-03-3.549792810D-06
 1.759952494D-09-3.052720871D-13 0.000000000D+00 5.270947930D+04 2.026149738D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         7539.141
-1.704786714D+05 1.073852803D+03 1.181955014D+00 2.245246352D-04 3.091697848D-07
-5.740027280D-11 2.927371014D-15 0.000000000D+00 4.978069910D+04 1.740431368D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0         7539.141
 1.152797766D+09-7.222408380D+05 1.777167465D+02-2.008059096D-02 1.221052354D-06
-3.811452080D-11 4.798092423D-16 0.000000000D+00 5.772614540D+06-1.518080466D+03
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Ti+                JPCRD v14 sup2 1985.
 3 l 7/97 TI  1.00E  -1.00    0.00    0.00    0.00 0     47.86645    1137624.029
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7899.829
 1.707457044D+05-1.727524602D+03 9.615885330D+00-1.089655060D-02 8.201809650D-06
-2.871464413D-09 3.420382976D-13 0.000000000D+00 1.447897558D+05-3.463143660D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7899.829
-7.685463080D+05 2.545868100D+03 3.423862780D-01 7.099901360D-04 2.706231875D-08
-2.371660100D-11 1.895443077D-15 0.000000000D+00 1.198821489D+05 2.484799150D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7899.829
 3.918035620D+07-2.534581605D+04 9.586759720D+00-7.584155410D-04 4.432999350D-08
-8.442571760D-13-4.517128089D-19 0.000000000D+00 3.344440620D+05-5.220026270D+01

Ti-                JPCRD v14 n3 1985 p731.
 3 l 9/97 TI  1.00E   1.00    0.00    0.00    0.00 0     47.86755     459203.814
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7562.614
-3.006484990D+03 2.040911689D+02 1.822638976D+00 1.245254812D-03-1.309239865D-06
 7.372143220D-10-1.724319779D-13 0.000000000D+00 5.346772050D+04 1.205926588D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7562.614
 2.341117640D+04 2.580413872D+00 2.497754577D+00 9.769072040D-07-2.280024955D-10
 2.717202291D-14-1.295670294D-18 0.000000000D+00 5.454662180D+04 7.999823950D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7562.614
 1.417514172D+04 5.638799640D+00 2.498751709D+00 1.426579908D-07-8.889194940D-12
 2.867172222D-16-3.746329300D-21 0.000000000D+00 5.451843520D+04 7.994109450D+00

V                  Hf0:TPIS v4 1982 p60.  Spec:JPCRD v14 sup2 1985.
 3 l 7/97 V   1.00    0.00    0.00    0.00    0.00 0     50.94150     517267.064
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7907.064
-5.535376020D+04 5.593338510D+02 2.675543482D+00-6.243049630D-03 1.565902337D-05
-1.372845314D-08 4.168388810D-12 0.000000000D+00 5.820664360D+04 9.524567490D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7907.064
 1.200390300D+06-5.027005300D+03 1.058830594D+01-5.044326100D-03 1.488547375D-06
-1.785922508D-10 8.113013866D-15 0.000000000D+00 9.170740910D+04-4.768336320D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7907.064
 2.456040166D+09-1.339992028D+06 2.781039851D+02-2.638937359D-02 1.303527149D-06
-3.214680330D-11 3.099999094D-16 0.000000000D+00 1.087152043D+07-2.439954380D+03

V+                 Spec:JPCRD v14 sup2 1985.
 3 l 7/97 V   1.00E  -1.00    0.00    0.00    0.00 0     50.94095    1173745.411
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7897.811
 7.568834460D+04-8.415273820D+02 7.559232710D+00-1.441722656D-02 2.038356397D-05
-1.289073883D-08 3.065656561D-12 0.000000000D+00 1.444478191D+05-1.991067645D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7897.811
 2.347072054D+06-9.021197190D+03 1.477349798D+01-6.891896880D-03 1.968884877D-06
-2.539798544D-10 1.226783122D-14 0.000000000D+00 1.958351444D+05-7.855592930D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7897.811
 2.516527258D+08-1.866476656D+05 5.633587110D+01-7.198536950D-03 5.074401490D-07
-1.699749225D-11 2.157800037D-16 0.000000000D+00 1.585980536D+06-4.512822600D+02

V-                 JPCRD v14 n3 1985 p731.
 3 l 9/97 V   1.00E   1.00    0.00    0.00    0.00 0     50.94205     460386.063
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7878.263
-3.799273560D+03 2.313840448D+02 1.725608190D+00 1.429275357D-03-1.506038188D-06
 8.491815170D-10-1.987980413D-13 0.000000000D+00 5.347402920D+04 1.261900982D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7878.263
 2.600100430D+04 2.096334097D+00 2.498006548D+00 8.991278840D-07-2.139749508D-10
 2.581021334D-14-1.240812796D-18 0.000000000D+00 5.470007080D+04 7.977900240D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7878.263
 1.601102910D+04 5.820974900D+00 2.498705489D+00 1.484212570D-07-9.272956840D-12
 2.997799727D-16-3.924862230D-21 0.000000000D+00 5.466692550D+04 7.974557420D+00
```

```
W                   Hf0:TPIS v4 1982. NSRDS-NBS 35 v3 1971;NSRDS-NBS 34 1970
 3 l 4/98 W   1.00    0.00    0.00    0.00    0.00 0    183.84000     851243.526
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6216.526
 1.595223922D+05-2.673843928D+03 2.060469727D+01-6.252315230D-02 1.105654838D-04
-8.453511610D-08 2.336187771D-11 0.000000000D+00 1.139648616D+05-9.011836900D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6216.526
-8.048745960D+06 1.465700424D+04-2.508531501D-01-2.596486992D-03 1.409225475D-06
-2.233011706D-10 1.262640862D-14 0.000000000D+00-3.091130919D+03 3.955822190D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6216.526
 1.421636486D+09-4.325365550D+05-8.841615070D+00 1.645538940D-02-1.908373835D-06
 8.530482890D-11-1.360501851D-15 0.000000000D+00 3.994798750D+06-1.266418236D+01

W+                  NSRDS,NBS 35 vIII 1971 p162
 3 l 7/97 W   1.00E  -1.00    0.00    0.00    0.00 0    183.83945    1627840.965
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6221.265
-1.969284929D+05 2.670137332D+03-1.131686913D+01 3.308183730D-02-3.629035500D-05
 2.066142971D-08-4.808285562D-12 0.000000000D+00 1.820950862D+05 8.552104480D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6221.265
 6.387743400D+06-2.061811463D+04 2.759291576D+01-1.244535845D-02 3.271200490D-06
-4.065463720D-10 1.912595872D-14 0.000000000D+00 3.245174430D+05-1.716919194D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6221.265
 6.839559150D+07-8.981711810D+04 3.845720800D+01-5.465752290D-03 4.024981150D-07
-1.342970538D-11 1.667637540D-16 0.000000000D+00 8.546932820D+05-2.892805521D+02

W-                  JPCRD v14 n3 1985 p731.
 3 l 1/99 W   1.00E   1.00    0.00    0.00    0.00 0    183.84055     766391.528
    298.150  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 9.142981370D+04 8.461169670D+00
   1000.000  6000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 9.142981370D+04 8.461169670D+00
   6000.000 20000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 9.142981370D+04 8.461169670D+00

Xe                  Ref-Elm. Spec: NSRDS-NBS 35 1971; NSRDS-NBS 34 1970.
 3 l 1/99 XE  1.00    0.00    0.00    0.00    0.00 0    131.29000          0.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00-7.453750000D+02 6.164419930D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.025226680D+03-1.209507521D+01 2.514153347D+00-8.248102080D-06 2.530232618D-09
-3.892333230D-13 2.360439138D-17 0.000000000D+00-6.685800730D+02 6.063676440D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 2.540397456D+08-1.105373774D+05 1.382644099D+01 1.500614606D-03-3.935359030D-07
 2.765790584D-11-5.943990574D-16 0.000000000D+00 9.285443830D+05-1.109834899D+02

Xe+                 Moore: NSRDS-NBS 35 1971; NSRDS-NBS 34 1970.
 3 l 3/97 XE  1.00E  -1.00    0.00    0.00    0.00 0    131.28945    1176552.232
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 1.002923620D+02-1.218753648D+00 2.506016493D+00-1.547411334D-05 2.191372741D-08
-1.623684074D-11 4.929132670D-15 0.000000000D+00 1.407665368D+05 7.516678190D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-1.241683887D+04-1.500654643D+02 2.964678293D+00-4.693396660D-04 1.959138719D-07
-3.037761925D-11 1.637361082D-15 0.000000000D+00 1.414966808D+05 4.565651460D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-2.562275878D+08 1.570476914D+05-3.635537230D+01 5.019392580D-03-3.438107240D-07
 1.140544651D-11-1.295661530D-16 0.000000000D+00-1.103556546D+06 3.436188470D+02
```

```
Zn                  Hf:CODATA 1989. JPCRD v24 n6 1995 p1803.
 3 l 6/97 ZN  1.00    0.00    0.00    0.00    0.00 0     65.39000     130400.000
    200.000  1000.000 1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0          6197.428
 2.500000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00 0.000000000D+00
 0.000000000D+00 0.000000000D+00 0.000000000D+00 1.493805072D+04 5.118861010D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-1.755591489D+05 4.984139240D+02 1.969386292D+00 2.608808787D-04-5.627195080D-08
 2.723336049D-12 4.266685808D-16 0.000000000D+00 1.173773458D+04 8.961085650D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-2.087287962D+08 1.578178131D+05-3.622033110D+01 3.345230020D-03-8.567422720D-09
-7.122544740D-12 1.691187274D-16 0.000000000D+00-1.217847671D+06 3.459439960D+02

Zn+                 JPCRD v24 n6 1995 pp1803-72.
 3 l 6/97 ZN  1.00E  -1.00    0.00    0.00    0.00 0     65.38945    1043000.128
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
 4.098344940D-04-4.343581620D-06 2.500000019D+00-4.389036810D-11 5.563969200D-14
-3.638228260D-17 9.607881995D-21 0.000000000D+00 1.246979918D+05 5.811995500D+00
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-3.436179460D+05 9.567355240D+02 1.511478952D+00 4.613467960D-04-8.786800980D-08
 7.558567780D-13 1.168827311D-15 0.000000000D+00 1.185321933D+05 1.300742670D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6197.428
-3.011747676D+09 2.074729347D+06-5.589526960D+02 7.501396440D-02-5.136763100D-06
 1.741662147D-10-2.323920111D-15 0.000000000D+00-1.609057856D+07 4.824788010D+03

Zr                  Hf:TPIS 1982. Spec:NSRDS-NBS 35 v2 1971;JCP v85 n6 1986.
 3 l 1/98 ZR  1.00    0.00    0.00    0.00    0.00 0     91.22400     599318.611
    200.000  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6815.611
 6.715899960D+04-9.435981740D+02 6.359756180D+00-9.790119730D-04-7.608224150D-06
 9.308717430D-09-3.124675586D-12 0.000000000D+00 7.588019470D+04-1.665770522D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6815.611
 6.006771840D+06-1.566960605D+04 1.796982350D+01-6.763409650D-03 1.733678968D-06
-2.064699786D-10 9.334092610D-15 0.000000000D+00 1.734636249D+05-1.051117377D+02
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          6815.611
 5.207701380D+08-2.825652444D+05 6.077054350D+01-5.081211410D-03 2.345845819D-07
-6.237212120D-12 8.010718759D-17 0.000000000D+00 2.351487351D+06-5.093183060D+02

Zr+                 Spec:NSRDS-NBS 35 vII 1971. IP:NSRDS-NBS v34 1970.
 3 l 1/98 ZR  1.00E  -1.00    0.00    0.00    0.00 0     91.22345    1246246.292
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7471.892
 1.739842193D+05-2.224598466D+03 1.400787829D+01-2.378785396D-02 2.641058912D-05
-1.442565487D-08 3.135982142D-12 0.000000000D+00 1.598210714D+05-5.816728810D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7471.892
 7.298137160D+05-2.017117556D+03 5.037498300D+00-5.503371950D-04 1.023753499D-07
-1.261537793D-11 7.092401042D-16 0.000000000D+00 1.620884945D+05-9.820640860D+00
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7471.892
-2.294818875D+07 1.860972745D+04-1.661509984D+00 6.020341290D-04-3.930742580D-08
 1.543806931D-12-2.618341088D-17 0.000000000D+00 4.907298890D+03 4.642130480D+01

Zr-                 JPCRD v14 n3 1985 p731.
 3 l 2/98 ZR  1.00E   1.00    0.00    0.00    0.00 0     91.22455     552952.398
    298.150  1000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7749.498
 3.046662367D+04-8.074277210D+02 9.213006110D+00-1.614342054D-02 1.908653551D-05
-1.138888914D-08 2.745019116D-12 0.000000000D+00 6.903034030D+04-2.862644371D+01
   1000.000  6000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7749.498
 8.471861160D+04 3.175439340D+02 2.251491246D+00 1.018645389D-04-2.285208242D-08
 2.647293502D-12-1.235813604D-16 0.000000000D+00 6.422337600D+04 1.081261057D+01
   6000.000 20000.000 7 -2.0 -1.0  0.0  1.0  2.0  3.0  4.0  0.0          7749.498
-4.386641560D+05 3.768748730D+02 2.417088403D+00 9.411538660D-06-5.824251210D-10
 1.866281342D-14-2.423724320D-19 0.000000000D+00 6.334701050D+04 9.677778690D+00
```

Appendix C
Figures for Data in Appendixes A and B
(Figures C1 Through C139)

Figures of $C_p^\circ(T)/R$ versus T are presented for most of the species in this report. Twenty-five species for which figures are not given are those for which $C_p^\circ(T)/R$ has a constant value of 2.5 over the entire temperature range. These species are Ag^-, Br^-, C^-, Cl^-, Cr^-, Cs^-, Cu^-, D^+, D^-, e^-, F^-, H^+, H^-, He^+, I^-, K^-, Li^+, Li^-, Mo^-, Na^+, Na^-, Pb^-, Rb^-, Sc^-, and W^-. Four figures are given per page. The figures are numbered to correspond to the same species as in the appendixes A and B tables. Two curves are given in each figure. One curve, consisting of circles, is a plot of the NASA Lewis data in appendix A. The second curve is solid and is the least-squares fit through the NASA Lewis data obtained from the coefficients in appendix B.

FIGURE C1. NASA Lewis Data for Ag

FIGURE C2. NASA Lewis Data for Ag^+

FIGURE C4. NASA Lewis Data for AL

FIGURE C5. NASA Lewis Data for AL^+

FIGURE C6. NASA Lewis Data for AL^-

FIGURE C7. NASA Lewis Data for Ar

FIGURE C8. NASA Lewis Data for Ar^+

FIGURE C9. NASA Lewis Data for B

FIGURE C10. NASA Lewis Data for B^+

FIGURE C11. NASA Lewis Data for B^-

FIGURE C12. NASA Lewis Data for Ba

FIGURE C13. NASA Lewis Data for Ba^+

FIGURE C14. NASA Lewis Data for Be

FIGURE C15. NASA Lewis Data for Be^+

FIGURE C16. NASA Lewis Data for Br

FIGURE C17. NASA Lewis Data for Br^+

FIGURE C19. NASA Lewis Data for C

FIGURE C20. NASA Lewis Data for C^+

FIGURE C22. NASA Lewis Data for Ca

FIGURE C23. NASA Lewis Data for Ca^+

FIGURE C24. NASA Lewis Data for Cd

FIGURE C25. NASA Lewis Data for Cd^+

FIGURE C26. NASA Lewis Data for CL

FIGURE C27. NASA Lewis Data for CL^+

FIGURE C29. NASA Lewis Data for Co

FIGURE C30. NASA Lewis Data for Co^+

FIGURE C31. NASA Lewis Data for Co^-

FIGURE C32. NASA Lewis Data for Cr

FIGURE C33. NASA Lewis Data for Cr^+

FIGURE C35. NASA Lewis Data for Cs

FIGURE C36. NASA Lewis Data for Cs^+

FIGURE C38. NASA Lewis Data for Cu

FIGURE C39. NASA Lewis Data for Cu^+

FIGURE C41. NASA Lewis Data for D

FIGURE C45. NASA Lewis Data for F

FIGURE C46. NASA Lewis Data for F^+

FIGURE C48. NASA Lewis Data for Fe

FIGURE C49. NASA Lewis Data for Fe^+

FIGURE C50. NASA Lewis Data for Fe^-

FIGURE C51. NASA Lewis Data for Ge

FIGURE C52. NASA Lewis Data for Ge^+

FIGURE C53. NASA Lewis Data for Ge^-

FIGURE C54. NASA Lewis Data for H

FIGURE C57. NASA Lewis Data for He

FIGURE C59. NASA Lewis Data for Hg

FIGURE C60. NASA Lewis Data for Hg^+

FIGURE C61. NASA Lewis Data for I

FIGURE C62. NASA Lewis Data for I^+

FIGURE C64. NASA Lewis Data for K

FIGURE C65. NASA Lewis Data for K^+

FIGURE C67. NASA Lewis Data for Kr

FIGURE C68. NASA Lewis Data for Kr^+

FIGURE C69. NASA Lewis Data for Li

FIGURE C72. NASA Lewis Data for Mg

FIGURE C73. NASA Lewis Data for Mg^+

FIGURE C74. NASA Lewis Data for Mn

FIGURE C75. NASA Lewis Data for Mn^+

FIGURE C76. NASA Lewis Data for Mo

FIGURE C77. NASA Lewis Data for Mo^+

FIGURE C79. NASA Lewis Data for N

FIGURE C80. NASA Lewis Data for N^+

FIGURE C81. NASA Lewis Data for N^-

FIGURE C82. NASA Lewis Data for Na

FIGURE C85. NASA Lewis Data for Nb

FIGURE C86. NASA Lewis Data for Nb^+

FIGURE C87. NASA Lewis Data for Nb^-

FIGURE C88. NASA Lewis Data for Ne

FIGURE C89. NASA Lewis Data for Ne^+

FIGURE C90. NASA Lewis Data for Ni

FIGURE C91. NASA Lewis Data for Ni^+

FIGURE C92. NASA Lewis Data for Ni^-

FIGURE C93. NASA Lewis Data for O

FIGURE C94. NASA Lewis Data for O^+

FIGURE C95. NASA Lewis Data for O^-

FIGURE C96. NASA Lewis Data for P

FIGURE C97. NASA Lewis Data for P^+

FIGURE C98. NASA Lewis Data for P^-

FIGURE C99. NASA Lewis Data for Pb

FIGURE C100. NASA Lewis Data for Pb^+

FIGURE C102. NASA Lewis Data for Rb

FIGURE C103. NASA Lewis Data for Rb^+

FIGURE C105. NASA Lewis Data for Rn

FIGURE C106. NASA Lewis Data for Rn^+

FIGURE C107. NASA Lewis Data for S

FIGURE C108. NASA Lewis Data for S^+

FIGURE C109. NASA Lewis Data for S^-

FIGURE C110. NASA Lewis Data for Sc

FIGURE C111. NASA Lewis Data for Sc^+

FIGURE C113. NASA Lewis Data for Si

FIGURE C114. NASA Lewis Data for Si^+

FIGURE C115. NASA Lewis Data for Si^-

FIGURE C116. NASA Lewis Data for Sn

FIGURE C117. NASA Lewis Data for Sn^+

FIGURE C118. NASA Lewis Data for Sn^-

FIGURE C119. NASA Lewis Data for Sr

FIGURE C120. NASA Lewis Data for Sr^+

FIGURE C121. NASA Lewis Data for Ta

FIGURE C122. NASA Lewis Data for Ta^+

FIGURE C123. NASA Lewis Data for Ta^-

FIGURE C124. NASA Lewis Data for Ti

FIGURE C125. NASA Lewis Data for Ti^+

FIGURE C126. NASA Lewis Data for Ti^-

FIGURE C127. NASA Lewis Data for V

FIGURE C128. NASA Lewis Data for V^+

FIGURE C129. NASA Lewis Data for V^-

FIGURE C130. NASA Lewis Data for W

FIGURE C131. NASA Lewis Data for W^+

FIGURE C133. NASA Lewis Data for Xe

FIGURE C135. NASA Lewis Data for Zn

FIGURE C134. NASA Lewis Data for Xe^+

FIGURE C137. NASA Lewis Data for Zr

FIGURE C136. NASA Lewis Data for Zn^+

FIGURE C138. NASA Lewis Data for Zr^+

FIGURE C139. NASA Lewis Data for Zr^-

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13. ABSTRACT ***(Maximum 200 words)***

This report contains standard-state thermodynamic functions for 50 gaseous atomic elements plus deuterium and electron gas, 51 singly ionized positive ions, and 36 singly ionized negative ions. The data were generated by the NASA Lewis computer program PAC97, a modified version of PAC91 reported in McBride and Gordon (1992). This report is being published primarily to document part of the data currently being used in several NASA Lewis computer programs. The data are presented in tabular and graphical form and are also represented in the form of least-squares coefficients. The tables give the following data as functions of temperature: heat capacity, enthalpy, entropy, Gibbs energy, enthalpy of formation, and equilibrium constant. A brief discussion and a comparison of calculated results are given for several models for calculating ideal thermodynamic data for monatomic gases.

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