TECHNICAL NOTE

270-4

Selected Values of Chemical Thermodynamic Properties

Tables for Elements 35 Through 53 in the Standard Order of Arrangement

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

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Maurice H. Stans, Secretary
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Standard Order of Arrangement

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PREFACE

Technical Note 270-4 is the fourth part of a series of Notes containing the tables of material prepared as a revision of Series I of National Bureau of Standards Circular 500, Selected Values of Chemical Thermodynamic Properties, by F. D. Rossini, D. D. Wagman, W. H. Evans, S. Levine and I. Jaffe. This Note contains data for compounds of nineteen elements, numbered 35 through 53 in the Standard Order of Arrangement. In addition the Appendix contains a list of corrections for errors and misprints which have been detected in the previous summary Note TN 270-3. Data for compounds of elements numbered 1 through 34 are contained in TN 270-3.

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SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES

by

Donald D. Wagman, William H. Evans, Vivian B. Parker,
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INTRODUCTION

Substances and Properties Included in the Tables

The tables contain values where known of the enthalpy and Gibbs energy of formation, enthalpy, entropy and heat capacity at 298.15°K (25°C), and the enthalpy of formation at 0°K, for all inorganic substances and organic molecules containing not more than two carbon atoms. In some instances such as metal-organic compounds, data are given for substances in which each organic radical contains one or two carbon atoms.

No values are given in these tables for metal alloys or other solid solutions, fused salts, or for substances of undefined chemical composition.

Physical States

The physical state of each substance is indicated in the column headed "State" as crystalline solid (c), liquid (liq), glassy or amorphous (amorp), or gaseous (g). Solutions in water are listed as aqueous (aq). For non-aqueous systems the physical state is that normal for the indicated solvent at 298.15°K.

Definition of Symbols

The symbols used in these tables are defined as follows: P = pressure; V = volume; T = absolute temperature; E = intrinsic or internal energy; S = entropy; $H = E + PV$ = enthalpy (heat content); $G = H - TS$ = Gibbs energy (formerly the free energy); $C_p = (dH/dT)_P$ = heat capacity at constant pressure.

Conventions Regarding Pure Substances

The values of the thermodynamic properties of the pure substances given in these tables are for the substances in their standard states (indicated by the superscript ° on the thermodynamic symbol). These standard states are defined as follows:

For a pure solid or liquid, the standard state is the substance in the condensed phase under a pressure of one atmosphere.

For a gas the standard state is the hypothetical ideal gas at unit fugacity, in which state the enthalpy is that of the real gas at the same temperature and at zero pressure.

The values of Δ Hf° and Δ Gf° given in the tables represent the change in the appropriate thermodynamic quantity when one gram-formula weight of the substance in its standard state is formed, isothermally at the indicated temperature, from the elements, each in its appropriate standard reference state. The standard reference state at 25°C for each element except phosphorus has been chosen to be the standard state that is thermodynamically stable at 25°C and at one atmosphere pressure. For phosphorus the standard reference state is the crystalline white form; the more stable forms have not been well characterized thermochemically. The same reference states have been maintained for the elements at 0°K except for the liquid elements bromine and mercury, for which the reference states have been chosen as the stable crystalline forms. The standard reference states are indicated in the tables by the fact that the values of Δ Hf° and Δ Gf° are exactly zero.

The values of $H^\circ_{298.} - H^\circ_0$ represent the enthalpy difference for the given substance between 298.15°K and 0°K. If the indicated standard state at 25°C is the gas, the corresponding state at 0°K is the hypothetical ideal gas; if the state at 25°C is solid or liquid, the corresponding state at 0°K is the thermodynamically stable crystalline solid, unless otherwise specifically indicated.

The values of S° represent the virtual or "thermal" entropy of the substance in the standard state at 298.15°K, omitting contributions from nuclear spins. Isotope mixing effects, etc., are also excluded except in the case of the hydrogen-deuterium (^1H-^2H) system. Where data have been available only for a particular isotope, they have been corrected when possible to the normal isotopic composition.

The values of the enthalpies of formation of gaseous ionic species are computed on the convention that the value of ΔHf° for the electron is zero. Conversions between 0 and 298.15°K are calculated using the value of $H^\circ_{298} - H^\circ_0$ = 1.481 kcal per mole of electrons, and assuming that the values of $H^\circ_{298} - H^\circ_0$ for the ionized and un-ionized molecules are the same.

Conventions Regarding Solutions

Solutions in water are designated as aqueous (aq); other solvents are designated by name or chemical formula. The concentration of the solution is expressed in terms of the number of moles of solvent associated with one mole of the solute. If no concentration is indicated, the solution is assumed to be "dilute".

The standard state for a solute in aqueous solution is taken as the hypothetical ideal solution of unit molality (indicated as "std. state, m = 1"). In this state the partial molal enthalpy and heat capacity of the solute are the same as in the infinitely dilute real solution. For non-aqueous solutions the standard state of the solute is the hypothetical ideal solution of unit mole fraction of solute ("std. state, $x_2 = 1$").

The value of Δ Hf° given in the tables for a solute in its standard state is the apparent molal enthalpy of formation of the substance in the infinitely dilute real solution. At this dilution the partial molal enthalpy is equal to the apparent molal quantity. At concentrations other than the standard state, the value of Δ Hf° represents the apparent enthalpy of the reaction of formation of the solution from the elements comprising the solute, each in its standard reference state, and the appropriate total number of moles of solvent. In this representation the value of Δ Hf° for the solvent is not required. The experimental value for a heat of dilution is obtained directly as the difference between the two values of Δ Hf° at the corresponding concentrations.

The values of the thermodynamic properties tabulated for the individual ions in aqueous solution are based on the usual convention that the values of ΔHf°, ΔGf°, S° and C_p° for H^+ (aq, std. state, m = 1) are zero. The properties of a neutral electrolyte in aqueous solution in the standard state are equal to the algebraic sum of these values for the appropriate kinds and number of individual ions assumed to constitute the molecule of the given electrolyte. When the undissociated species, rather than the sum of the ions, is meant, the notation "undissociated" or "un-ionized" is used. For an ionic species the properties tabulated refer to that undissociated ion. By adopting the above convention with respect to aqueous H^+, it follows that the thermodynamic relation Δ Gf° = Δ Hf° - T Δ Sf° will not hold for an individual ionic species. However no problem arises when neutral chemical systems are considered.

Unit of Energy and Fundamental Constants

All of the energy values given in these tables are expressed in terms of the thermochemical calorie. This unit, defined as equal to 4.1840 joules, is generally accepted for the presentation of chemical thermodynamic data. Values reported in other units have been converted to calories by means of the conversion factors for molecular energy given in Table A.

The following values of the fundamental physical constants have been used in these calculations:

R = gas constant = 8.3143 ± 0.0012 J/deg mol = 1.98717 ± 0.00029 cal/deg mol

F = Faraday constant = 96487.0 ± 1.6 coulombs/mol = 23060.9 ± 0.4 cal/volt equivalent

$Z = Nhc' = 11.96258 \pm 0.00107$ J/cm^{-1} mol = 2.85912 ± 0.00026 cal/cm^{-1} mol

c_2 = second radiation constant = hc/k = 1.43879 ± 0.00015 cm deg

0°C = 273.15°K

These constants are consistent with those given in the Table of General Physical Constants, recommended by the National Academy of Sciences - National Research Council[1]. The formula weights in the tables have been calculated for the molecular formula given in the Formula and Description column using the 1961 Table of Relative Atomic Weights based on the atomic mass of $^{12}C = 12$ exactly[2].

Internal Consistency of the Tables

All of the values given in these tables have been calculated from the original articles, using consistent values for all subsidiary and auxiliary quantities. The original data were corrected where possible for differences in energy units, molecular weights, temperature scales, etc. Thus we have sought to maintain a uniform scale of energies for all the substances in the tables. In addition the tabulated values of the properties of a substance satisfy all the known physical and thermodynamic relationships among these properties. The quantities Δ Hf°, Δ Gf°, and S° at 298.15°K satisfy the relation:

$$\Delta Gf^\circ = \Delta Hf^\circ - T \Delta Sf^\circ.$$

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[1] NBS Technical News Bulletin, October 1963.

[2] A. E. Cameron and E. Wichers, J. Am. Chem. Soc. 84, 4192 (1962).

Furthermore the calculated value of any thermodynamic quantity for a reaction is independent of the path chosen for the evaluation.

In some cases newer data may have become available on certain substances after the values were selected for these tables. Because of the need to maintain the internal consistency of the tables, it is not always possible to incorporate these newer data into the tables without a detailed analysis of the effect of such a change. Unless great care is used, relatively significant errors in calculated values of $\Delta H°$ or $\Delta G°$ for specific reactions may result from the introduction of such data.

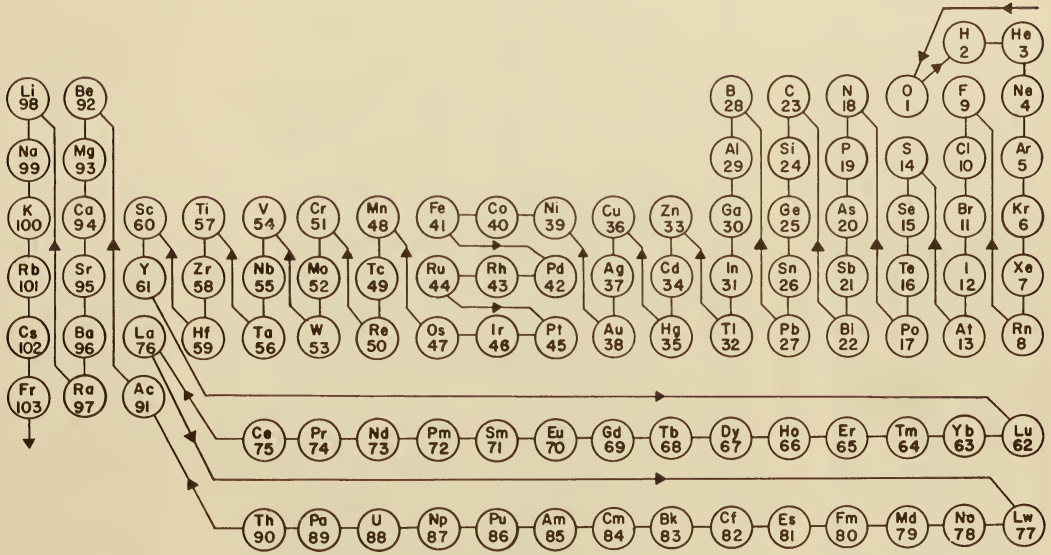
Uncertainties

The uncertainty in any value in the tables depends on the uncertainties of all the determinations in the total chain of reactions used to establish the value.

A discussion of the uncertainties will be included in the final publication of these tables in the National Standard Reference Data System. However we have followed certain rules with respect to significant figures to indicate these uncertainties. Values are tabulated in general such that the overall uncertainty lies between 2 and 20 units of the last figure. On the other hand, values are given so that the experimental data from which they are derived may be recovered with an accuracy equal to that of the original quantities. Thus the number of significant figures for any one value in the tables need not represent the absolute accuracy of that value. For solutions of varying composition values are frequently tabulated to more figures to make possible the recovery of enthalpies of solution and dilution. Similarly values of ΔHf°_{0} and $\Delta Hf^{\circ}_{298.15}$ may be given to different numbers of significant figures. In this instance the quantity with the lesser number of figures is used to represent the uncertainty estimate. The larger number of figures is used for the other quantity to retain the significance of the temperature correction term.

Arrangement of the Tables

The compounds in the tables are entered according to the Standard Order of Arrangement, (see Figure 1), by the principle of latest position. In this scheme, a compound is listed under the element occurring latest in the list; water of hydration is neglected. Within a given element-table will be found all of the compounds of that element with elements occurring earlier in the order; the arrangement within a table follows the same ordering. An exception occurs in the carbon tables (Table 23), which is divided into subgroups consisting of all compounds with one carbon atom, then all with two carbon atoms, etc.



Standard Order of Arrangement of the Elements

Compounds are located in the Table for the element (in the compound) having the highest number in the above Figure.

Figure 1.

TABLE A

CONVERSION FACTORS FOR UNITS OF MOLECULAR ENERGY

	J/mol	cal/mol	cm^3 atm/mol	kWh/mol	Btu/lb-mol	cm^{-1}/molecule	eV/molecule
1 J/mol =	1	2.390057×10^{-1}	9.86923	2.77778×10^{-7}	0.429923	8.35940×10^{-2}	1.036409×10^{-5}
1 cal/mol =	4.18400	1	41.2929	1.162222×10^{-6}	1.798796	3.49757×10^{-1}	4.33634×10^{-5}
1 cm^3 atm/mol =	0.1013250	2.42173×10^{-2}	1	2.81458×10^{-8}	4.35619×10^{-2}	8.47016×10^{-3}	1.050141×10^{-6}
1 kWh/mol =	3,600,000	860,421	3.55292×10^{7}	1	1,547,721	300,938	37.3107
1 Btu/lb-mol =	2.32600	5.55927×10^{-1}	22.9558	6.46111×10^{-7}	1	1.944396×10^{-1}	2.41069×10^{-5}
1 cm^{-1}/molecule =	11.96258	2.85912	118.0614	3.32294×10^{-6}	5.14299	1	1.239812×10^{-4}
1 eV/molecule =	96487.0	23060.9	952,252	2.68019×10^{-2}	41482.0	8065.73	1

The underlined numbers represent the fundamental values used in deriving this table. The remaining factors were obtained by applying the relationships:

$$n_{ij} = n_{ik} \cdot n_{kj} \qquad n_{ii} = n_{ik} \cdot n_{ki} = 1$$

TABLES OF SELECTED VALUES OF PROPERTIES

SERIES I

Enthalpy of Formation at 0°K

Enthalpy of Formation at 298.15°K

Gibbs Energy of Formation at 298.15°K

Enthalpy at 298.15°K

Entropy at 298.15°K

Heat Capacity at 298.15°K

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 35(1) MERCURY

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Hg	c	200.59	0					
	liq			0.	0	2.233	18.17	6.688
	g		15.407	14.655	7.613	1.481	41.79	4.968
std. state, m=1	aq			9.0	9.4		17.	
Hg^+	g		256.10	256.82				
Hg^{2+}	g		688.63	690.83				
std. state, m=1	aq			40.9	39.30		-7.7	
Hg^{3+}	g		1478.	1480.				
Hg_2	g	401.18	27.8	26.0	16.3	2.62	68.82	8.94
Hg_2^{2+} std. state, m=1	aq			41.2	36.70		20.2	
HgO red, orthorhombic	c	216.589		-21.71	-13.995		16.80	10.53
yellow	c			-21.62	-13.964		17.0	
hexagonal	c			-21.4	-13.92		17.6	
	g					2.22	57.8	8.15
HgH	g	201.598	58.36	57.20	51.63	2.078	52.46	7.16
$Hg(OH)^+$ std. state, m=1	aq	217.597		-20.2	-12.5		17.	
$HHgO_2^-$ std. state, m=1	aq	233.597			-45.5			
$Hg(OH)_2$ undissoc.; std. state, m=1	aq	234.605		-84.9	-65.7		34.	

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 35(2) MERCURY

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
HgF	g	219.588	2.	1.0	-2.4	2.22	53.98	8.26
HgF^+ std. state, m=1	aq			-37.8	-29.5		-1.	
Hg_2F_2	c	439.177			-104.1			
$HgCl$	g	236.043	21.	20.1	15.0	2.35	62.09	8.68
$HgCl^+$ std. state, m=1	aq			-4.5	-1.3		18.	
$HgCl_2$	c	271.496		-53.6	-42.7		34.9	
undissoc.; std. state, m=1	aq			-51.7	-41.4		37.	
in CH_3OH				-54.31				
in C_2H_5OH				-53.64				
in 200 C_5H_5N				-67.0				
$HgCl_3^-$ std. state, m=1	aq	306.949		-92.9	-73.9		50.	
$HgCl_4^{2-}$ std. state, m=1	aq	342.402		-132.4	-106.8		70.	
Hg_2Cl_2	c	472.086		-63.39	-50.377		46.0	
$HgBr^+$ std. state, m=1	aq	280.499		1.5	2.1		19.	
$HgBr_2$	c	360.408		-40.8	-36.6		41.	
undissoc.; std. state, m=1	aq			-38.4	-34.2		41.	
in CH_3OH				-41.21				
in C_2H_5OH				-41.15				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 35(3) MERCURY

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$HgBr_3^-$	std. state, m=1	aq	440.317		-70.1	-62.0		62.	
$HgBr_4^{2-}$	std. state, m=1	aq	520.226		-103.0	-88.7		74.	
Hg_2Br_2		c	560.998		-49.45	-43.278		52.	
$HgBr_2 \cdot HgO$		c	576.997		-65.8				
$HgBr_2 \cdot 2HgO$		c	793.587		-88.6				
$HgBr_2 \cdot 3HgO$		c	1010.176		-112.2				
$HgBr_2 \cdot 4HgO$		c	1226.766		-135.3				
HgBrCl		g	315.952				3.456	71.55	14.16
	std. state, m=1	aq			-45.5	-38.7		40.	
HgI		g	327.494	49.2	47.94	37.44	2.546	67.26	8.99
HgI^+	std. state, m=1	aq			10.3	9.5		19.	
HgI_2	red	c	454.399		-25.2	-24.3		43.	
	yellow	c			-24.6				
		g		-2.60	-4.1	-14.3	3.88	80.31	14.60
	undissoc.; std. state, m=1	aq			-19.0	-18.0		42.	
	in CH_3OH				-23.35				
	in 200 C_5H_5N				-35.2				

National Bureau of Standards — Washington, D. C.

Table 35(4) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — MERCURY

Substance: Formula and Description		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
HgI_3^-	std. state, m=1	aq	581.303		-36.5	-35.5		72.	
HgI_4^{2-}	std. state, m=1	aq	708.208		-56.2	-50.6		86.	
Hg_2I_2		c	654.989		-29.00	-26.53		55.8	
HgICl	undissoc.; std. state, m=1	aq	362.947		-35.2	-30.8		42.	
HgBrI		g	407.403				3.717	76.59	14.54
	undissoc.; std. state, m=1	aq			-28.1	-26.7		46.	
$HgIBr_3^{2-}$	std. state, m=1	aq	567.221			-80.54			
$HgI_2Br_2^{2-}$	std. state, m=1	aq	614.217			-71.15			
HgI_3Br^{2-}	std. state, m=1	aq	661.212			-61.2			
HgS	red	c	232.654		-13.9	-12.1		19.7	11.57
	black	c			-12.8	-11.4		21.1	
		g					2.37	60.86	
HgS_2^{2-}	std. state, m=1	aq	264.718			10.0			
$HgSO_4$		c	296.652		-169.1				
	undissoc.; std. state, m=1	aq				-140.6			
Hg_2SO_4		c	497.242		-177.61	-149.589		47.96	31.54
$HgSO_4 \cdot 2HgO$		c	729.830		-223.0				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 35(5) MERCURY

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Hg(HS)_2$ undissoc.; std. state, m=1	aq	266.734			-6.4			
HgSe	c	279.55		-11.				
	g		17.	18.1	7.5	2.46	63.82	8.8
$HgSeO_3$	c	327.548			-68.0			
Hg_2SeO_3	c	528.138			-71.1			
HgTe	c	328.19		-10.				
	g					2.51	65.73	
$Hg_2(N_3)_2$	c	485.220		142.0	178.4		49.	
$Hg(NO_3)_2$ in 400 H_2O	aq	324.600		-58.4				
$Hg(NO_3)_2 \cdot \frac{1}{2}H_2O$	c	333.603		-93.8				
$Hg_2(NO_3)_2$ in 400 H_2O	aq	525.190		-58.8				
$Hg_2(NO_3)_2 \cdot 2H_2O$	c	561.221		-207.5				
$Hg(NO_3)_2 \cdot 2HgO \cdot H_2O$	c	775.784		-179.4				
$(Hg_2N)_2O$ Millon's oxide	c	846.373		76.2				
$(Hg_2N)_2O \cdot H_2O$	c	864.388		4.9				
$(Hg_2N)_2O \cdot 4H_2O$	c	918.434		-207.9				

$(Hg_2N)_2O \cdot 4H_2O$

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 35(6) MERCURY

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Hg(NH_3)_2^{2+}$ std. state, m=1	aq	234.651		-22.4	2.5		43.	
$Hg(NH_3)_3^{2+}$ std. state, m=1	aq	251.682		-44.8	-5.2		63.	
$Hg(NH_3)_4^{2+}$ std. state, m=1	aq	268.713		-67.6	-12.4		80.	
$(NHg_2Cl)_2 \cdot H_2O$	c	919.285		-55.9				
$(NHg_2Cl)_2 \cdot 2H_2O$	c	937.300		-126.9				
$(NHg_2Cl)_2 \cdot HgCl_2$	c	1172.775		-49.5				
$HgCl_2 \cdot \frac{2}{3}NH_3$	c	282.850		-74.1				
$HgCl_2 \cdot 2NH_3$	c	305.557		-110.2				
$HgCl_2 \cdot 8NH_3$	c	407.742		-227.3				
$HgCl_2 \cdot 9\frac{1}{2}NH_3$	c	433.288		-254.7				
$HgCl_2 \cdot NOCl$	c	336.955			-26.			
$NHg_2Cl \cdot NH_4Cl$	c	504.131		-73.5				
$Hg_2Cl_2 \cdot 2NH_3$	c	506.147		*114.0				
$NHg_2Cl \cdot 3NH_4Cl$	c	611.148		-223.4				
$(NHg_2Cl)_2 \cdot NH_3$	c	918.310		-10.8				
$(NHg_2Cl)_2 \cdot 2NH_3$	c	935.341		-26.9				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 35(7) MERCURY

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
NHg_2Br	c	495.096		15.0				
$(NHg_2Br)_2 \cdot HgBr_2$	c	1350.599		-21.7				
$(NHg_2Br)_4 \cdot HgBr_2$	c	2340.791		4.0				
$HgBr_2 \cdot 2NH_3$	c	394.469		-95.2				
$HgBr_2 \cdot 8NH_3$	c	496.654		-208.1				
$NHg_2Br \cdot NH_4Br$	c	593.043		-56.0				
$NHg_2Br \cdot 3NH_4Br$	c	788.939		-185.6				
$HgINO_3$	c	389.499		-43.				
$HgI_2 \cdot 4/3\ NH_3$	c	477.106		-57.6	≈34.3		61.	
$HgI_2 \cdot 2NH_3$	c	488.460		-71.8	-37.1		69.	
$HgI_2 \cdot 6NH_3$	c	556.583		-146.0	-44.9		125.	
$Hg_2P_2O_7^{2-}$ std. state, m=1	aq	575.123			-435.			
$Hg_2(OH)P_2O_7^{3-}$ std. state, m=1	aq	592.131			-481.			
HgC_2O_4	c	288.610		-162.1				
$Hg(C_2O_4)_2^{2-}$ std. state, m=1	aq	376.630			-295.0			
Hg_2CO_3	c	461.189		-132.3	-111.9		43.	
$Hg_2C_2O_4$	c	489.200			-141.8			

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 35(8) MERCURY

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$HgCH_3$	g	215.625		40.				
$Hg(CH_3)_2$	liq	230.660		14.3	33.5		50.	
	g			22.56	34.9	4.29	73.	19.9
$Hg(CH_3)(C_2H_5)$	liq	244.688		11.1				
$Hg(C_2H_5)_2$	liq	258.715		7.2				
	g			18.0				
in CH_3OH				8.57				
$Hg(C_2H_3O_2)^+$ std. state, m=1	aq	259.635			-53.2			
$Hg(C_2H_3O_2)_2$	c	318.680		-195.2				
in 200 H_2O	aq			-191.6				
$Hg_2(OH)(C_2O_4)^-$ std. state, m=1	aq	506.207			-179.8			
$Hg_2(C_2H_3O_2)_2$	c	519.270		-199.6	-153.3		78.	
$HgCH_3Cl$	c	251.078		-27.8				
	g			-12.5				
in C_2H_5OH				-23.6				
HgC_2H_5Cl	c	265.105		-33.3				
	g			-15.0				
in CH_3OH				-28.1				

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Table 35(9) MERCURY

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$HgClCHCHCl$	cis-chlorovinylmercuric chloride	c	297.534		-13.0				
	trans-chlorovinylmercuric chloride	c			-8.6				
$HgCl_2 \cdot CH_3OH$		c	303.539		-113.1	-82.7		58.	
$HgCH_3Br$		c	295.534		-20.5				
		g			-4.4				
	in C_2H_5OH				-16.5				
HgC_2H_5Br		c	309.561		-25.5				
		g			-7.2				
	in CH_3OH				-20.9				
$HgCH_3I$		c	342.530		-10.2				
		g			5.2				
HgC_2H_5I		c	356.557		-15.7				
		g			3.3				
	in CH_3OH				-10.9				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 35(10) MERCURY

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$HgCN^+$	std. state, m=1	aq	226.608		53.9	56.9		20.2	
$Hg(CN)_2$		c	252.626		63.0				
		g			91.				
	undissoc.; std. state, m=1	aq			66.5	74.6		37.3	
$Hg(CN)_3^-$	std. state, m=1	aq	278.644		94.9	110.7		51.4	
$Hg(CN)_4^{2-}$	std. state, m=1	aq	304.662		125.8	147.8		71.	
$Hg(ONC)_2$	mercuric fulminate	c	284.624		64.				
$Hg(CN)_2 \cdot HgO$		c	469.215		39.1				
$3Hg(CN)_2 \cdot HgO$		c	974.466		158.6				
$Hg(CH_3NH_2)^{2+}$	std. state, m=1	aq	231.648			32.5			
$Hg(CH_3NH_2)_2^{2+}$	std. state, m=1	aq	262.706		-13.1	24.9		70.	
$Hg(C_2H_4(NH_2)_2)_2^{2+}$		aq	320.790		-16.1				
$Hg(NH_2CH_2COO)^+$	std. state, m=1	aq	274.650			-50.0			
$Hg(NH_2CH_2COO)_2$	undissoc.; std. state, m=1	aq	348.710		-205.4	-137.5		64.	
$Hg(CN)_2Cl^-$	std. state, m=1	aq	288.079			43.6			
$Hg(CN)_3Cl^{2-}$	std. state, m=1	aq	314.097			80.			

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Table 35(11) MERCURY

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$HgCl(CH_3NH_2)^+$ std. state, m=1	aq	267.101		-35.3	-8.4		41.	
$Hg(CN)_2 \cdot NH_4Cl \cdot \frac{3}{4}H_2O$	c	319.629		-64.1				
$HgClC_2H_4(NH_2)_2^+$	aq	296.143		-33.7				
$HgCl_2 \cdot C_2H_4(NH_2)_2$	c	331.596		-86.5				
$HgCl(NH_2CH_2COO)$ undissoc.; std. state, m=1	aq	310.103		-130.1	-90.0		47.	
$Hg(CN)_3Br^{2-}$ std. state, m=1	aq	358.553			85.			
$Hg(CN)_2 \cdot NH_4Br \cdot H_2O$	c	368.589		-73.6				
$HgBr_2 \cdot C_2H_4(NH_2)_2$	c	420.508		-68.8				
$Hg(CN)_2 \cdot NH_4I \cdot \frac{1}{2}H_2O$	c	402.073		-9.7				
$HgI_2 \cdot C_2H_4(NH_2)_2$	c	514.499		-47.2				
$Hg(CNS)(CN)_3^{2-}$ std. state, m=1	aq	336.726			132.2			
$Hg(CNS)_2$ undissoc.; std. state, m=1	aq	316.754		46.9	60.1		37.6	
$Hg(CNS)_3^-$ std. state, m=1	aq	374.836			78.5			
$Hg(CNS)_4^{2-}$ std. state, m=1	aq	432.918		78.0	98.3		109.	
$Hg_2(CNS)_2$	c	517.344			54.4			

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Table 35(12) MERCURY

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Hg((NH_2)_2CS)_4^{2+}$ std. state, m=1	aq	505.072		-65.6				
Hg(CNS)Cl undissoc.; std. state, m=1	aq	294.125			8.4			
Hg(CNS)Br undissoc.; std. state, m=1	aq	338.581			12.2			
Hg_5Tl_2	c	1411.69		-2.5				
$2Hg(CN)_2 \cdot ZnCl_2 \cdot 7H_2O$	c	767.635		-475.9				
$2Hg(CN)_2 \cdot ZnBr_2 \cdot 8H_2O$	c	874.563		-530.8				
$Hg(CN)_2 \cdot CdCl_2 \cdot 2H_2O$	c	471.963		-176.8				
$Hg(CN)_2 \cdot CdBr_2 \cdot 3H_2O$	c	578.890		-228.4				
$2Hg(CN)_2 \cdot CdI_2 \cdot 8H_2O$	c	1015.584		-487.1				

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Table 36(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
COPPER

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Cu	c	63.54	0	0	0	1.196	7.923	5.840
	g		80.58	80.86	71.37	1.481	39.74	4.968
in Hg-2 phase amalgam				-1.25	-0.236		4.52	
Cu^+	g		258.752	260.513				
std. state, m = 1	aq			17.13	11.95		9.7	
Cu^{2+}	g		726.69	729.93				
std. state, m = 1	aq			15.48	15.66		-23.8	
Cu^{3+}	g		1576.1	1580.8				
Cu_2	g	127.08	115.7	115.72	103.24	2.370	57.71	8.75
CuO	c	79.539		-37.6	-31.0		10.19	10.11
CuO_2^{2-} std. state, m = 1	aq	95.539			-43.9			
Cu_2O	c	143.079		-40.3	-34.9		22.26	15.21
CuH	c	64.548		5.1				
	g			70.				
$HCuO_2^-$ std. state, m = 1	aq	96.547			-61.8			
$Cu(OH)_2$	c	97.555		-107.5				
std. state, m = 1	aq			-94.46	-59.53		-28.9	
CuF^+ std. state, m = 1	aq	82.538		-62.4	-52.7		-16.	
CuF_2	c	101.537		-129.7				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 36(2) COPPER

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$CuF_2 \cdot 2H_2O$	c	137.567			-234.6			
CuCl	c	98.993		-32.8	-28.65		20.6	11.6
in $HCl \cdot 65H_2O$	aq			-23.6				
$CuCl^+$ std. state, m = 1	aq				-16.3			
$CuCl_2$	c	134.446	-52.79	-52.6	-42.0	3.581	25.83	13.82
undissoc.; std. state, m = 1	aq				-47.3			
in 10 H_2O	aq			-58.70				
15 H_2O	aq			-59.87				
20 H_2O	aq			-60.64				
25 H_2O	aq			-61.12				
30 H_2O	aq			-61.50				
50 H_2O	aq			-62.40				
100 H_2O	aq			-63.23				
200 H_2O	aq			-63.79				
400 H_2O	aq			-64.3				
500 H_2O	aq			-64.42				
800 H_2O	aq			-64.63				
1,000 H_2O	aq			-64.70				
2,000 H_2O	aq			-64.72				
in $HCl \cdot 8.8H_2O$	aq			-56.0				

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Table 36(3) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — COPPER

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$CuCl_2$ in $HCl \cdot 25\ H_2O$	aq			-60.7				
5 C_2H_5OH	aq			-55.78				
7 C_2H_5OH	aq			-56.03				
10 C_2H_5OH	aq			-56.41				
15 C_2H_5OH	aq			-56.68				
20 C_2H_5OH	aq			-56.87				
25 C_2H_5OH	aq			-57.01				
30 C_2H_5OH	aq			-57.11				
50 C_2H_5OH	aq			-57.28				
100 C_2H_5OH	aq			-57.48				
200 C_2H_5OH	aq			-57.60				
$CuCl_2 \cdot 2\ H_2O$	c	170.477		-196.3	-156.8		40.	
$CuCl_2^=$ std. state, m = 1	aq	134.446			-57.4			
$CuCl_3^{2-}$ std. state, m = 1	aq	169.899			-90.			
$Cu(ClO_3)_2$ in 1,000 H_2O	aq	230.442		-32.2				
$Cu(ClO_4)_2$ std. state, m = 1	aq	262.441		-46.34	11.54		63.2	
$Cu(ClO_4)_2 \cdot 6H_2O$	c	370.533		-460.9				
Cu_2OCl_2	c	213.985		-90.				
$CuCl_2 \cdot 3CuO$	c	373.064		-164.0				
$CuCl_2 \cdot 3CuO \cdot 4H_2O$	c	445.126		-459.0				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 36(4) COPPER

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$Cu_2(OH)_3Cl$		c	213.555			-320.2			
CuBr		c	143.449	-23.76	-25.0	-24.1	2.893	22.97	13.08
$CuBr^+$	std. state, m = 1	aq				-11.9			
$CuBr_2$		c	223.358		-33.9				
	in 400 H_2O	aq			-42.5				
$CuBr_2 \cdot 4H_2O$		c	295.419		-317.0				
$CuBr_2 \cdot 3Cu(OH)_2$		c	516.022		-378.1	-306.2		68.	
$Cu(BrO_3)_2 \cdot 3Cu(OH)_2$		c	612.019			-126.2			
CuI		c	190.444		-16.2	-16.6		23.1	12.92
$Cu(IO_3)_2$	std. state, m = 1	aq	413.345		-90.3	-45.5		32.8	
$Cu(IO_3)_2 \cdot H_2O$		c	431.361		-165.4	-112.0		59.1	
$Cu(IO_3)_2 \cdot 3Cu(OH)_2$		c	706.009			-160.0			
CuS		c	95.604		-12.7	-12.8		15.9	11.43
Cu_2S	α	c	159.144		-19.0	-20.6		28.9	18.24
$CuSO_3^-$	std. state, m = 1	aq	143.602			-115.0			
$CuSO_4$		c	159.602		-184.36	-158.2		26.	23.9
	std. state, m = 1	aq			-201.84	-162.31		-19.0	
	undissoc.; std. state, m = 1	aq				-165.45			

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Table 36(5) COPPER

Substance: Formula and Description	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CuSO_4$ in 40 H_2O	aq			-200.187				
50 H_2O	aq			-200.284				
100 H_2O	aq			-200.374				
150 H_2O	aq			-200.438				
200 H_2O	aq			-200.480				
300 H_2O	aq			-200.536				
400 H_2O	aq			-200.58				
500 H_2O	aq			-200.619				
700 H_2O	aq			-200.684				
1,000 H_2O	aq			-200.760				
1,500 H_2O	aq			-200.867				
2,000 H_2O	aq			-200.910				
3,000 H_2O	aq			-200.996				
4,000 H_2O	aq			-201.058				
5,000 H_2O	aq			-201.107				
7,000 H_2O	aq			-201.180				
10,000 H_2O	aq			-201.254				
15,000 H_2O	aq			-201.338				
20,000 H_2O	aq			-201.376				
30,000 H_2O	aq			-201.472				
50.000 H_2O	aq			-201.556				

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Table 36(6) COPPER

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$CuSO_4$ in 100,000 H_2O	aq			-201.642				
200,000 H_2O	aq			-201.700				
500,000 H_2O	aq			-201.744				
∞ H_2O	aq			-201.84				
$CuSO_4 \cdot H_2O$	c	177.617		-259.52	-219.46		34.9	32.
$CuSO_4 \cdot 3H_2O$	c	213.648		-402.56	-334.65		52.9	49.
$CuSO_4 \cdot 5H_2O$	c	249.678		-544.85	-449.344		71.8	67.
CuS_2O_6	aq	223.664		-270.9				
$CuS_2O_6 \cdot 5H_2O$	c	313.741		-617.4				
$Cu(SO_3)_2^{3-}$ std. state, m = 1	aq	223.664			-232.4			
$Cu(SO_3)_3^{5-}$ std. state, m = 1	aq	303.727			-349.7			
Cu_2SO_3 std. state, m = 1	aq	207.142		-117.6	-92.4		12.	
Cu_2SO_4	c	223.142		-179.6				
$CuO \cdot CuSO_4$	c	239.141		-223.8				
$CuSO_4 \cdot 2Cu(OH)_2$ antlerite	c	354.711			-345.8			
$CuSO_4 \cdot 3Cu(OH)_2$ brochantite	c	452.266			-434.5			
$CuSO_4 \cdot 3Cu(OH)_2 \cdot H_2O$ langite	c	470.281		-594.	-488.6		80.	

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Table 36(7) COPPER

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
CuSe	c	142.50		-9.45				
$CuSe_2$	c	221.46		-10.3				
Cu_2Se	c	206.04		-14.2				
$CuSeO_3$	c	190.498			-83.2			
std. state, m = 1	aq			-106.2	-72.7		-20.7	
$CuSeO_4$	c	206.498		-114.36				
in 700 H_2O	aq			-127.5				
$CuSeO_4 \cdot 5H_2O$	c	296.574		-466.96				
Cu_2Te	c	254.68		5.				
CuN_3	c	105.560		66.7	82.4		24.	
CuN_3^+ std. state, m = 1	aq			94.9				
$Cu(N_3)_2$	c	147.580		143.0				
Cu_3N	c	204.627		17.8				22.
$Cu(NO_3)_2$	c	187.550		-72.4				
std. state, m = 1	aq			-83.64	-37.56		46.2	
in 10 H_2O	aq			-82.76				
12 H_2O	aq			-83.28				
15 H_2O	aq			-83.58				
25 H_2O	aq			-83.83				

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Table 36(8) COPPER

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0°K	298.15°K (25°C)				
Formula and Description			kcal/mol				cal/deg mol	
$Cu(NO_3)_2$ in 50 H_2O	aq			-83.82				
100 H_2O	aq			-83.75				
200 H_2O	aq			-83.77				
400 H_2O	aq			-84.08				
800 H_2O	aq			-84.4				
∞ H_2O	aq			-83.64				
$Cu(NO_3)_2 \cdot 3H_2O$	c	241.596		-290.9				
$Cu(NO_3)_2 \cdot 6H_2O$	c	295.642		-504.5				
$Cu(NH_3)^{2+}$ std. state, m = 1	aq	80.571		-9.3	3.72		2.9	
$Cu(NH_3)_2^{2+}$ std. state, m = 1	aq	97.601		-34.0	-7.28		26.6	
$Cu(NH_3)_3^{2+}$ std. state, m = 1	aq	114.632		-58.7	-17.48		47.7	
$Cu(NH_3)_4^{2+}$ std. state, m = 1	aq	131.662		-83.3	-26.60		65.4	
$Cu(NH_3)_5^{2+}$ std. state, m = 1	aq	148.693			-32.13			
$Cu(NH_3)_4(NO_3)_2$	c	255.672		-198.0				
in 250 H_2O	aq			-181.56				
$Cu(NO_3)_2 \cdot 3Cu(OH)_2$	c	480.214		-415.8	-305.5		95.4	
$CuCl \cdot NH_3$	c	116.024		-61.8				
$CuCl \cdot 3/2NH_3$	c	124.539		-74.1				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 36(9) COPPER

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$CuCl_2 \cdot 2NH_3$	c	168.507		-117.0				
$CuCl_2 \cdot 2NH_3 \cdot 1/4H_2O$	c	173.011		-136.4				
$CuCl_2 \cdot 2NH_4Cl$	c	241.429		-203.3				
$CuCl_2 \cdot 2NH_4Cl \cdot 2H_2O$	c	277.460		-351.8				
$CuCl \cdot 3NH_3$	c	150.085		-104.2				
$CuCl_2 \cdot 10/3NH_3$	c	191.215		-150.5				
$[Cu(NH_3)_4]Cl_2 \cdot 2H_2O$	c	238.599		-309.4				
$CuCl_2 \cdot 5NH_3$	c	219.599		-189.2				
$CuCl_2 \cdot 5NH_3 \cdot 1/2H_2O$	c	228.607		-222.6				
$CuCl_2 \cdot 5NH_3 \cdot 3/2H_2O$	c	246.622		-291.0				
$[Cu(NH_3)_6]Cl_2$	c	236.630		-208.7				
$CuCl_2 \cdot 10NH_3$	c	304.752		-283.1				
$CuBr \cdot NH_3$	c	160.480		-52.5				
$CuBr \cdot 3/2NH_3$	c	168.995		-64.9				
$CuBr_2 \cdot 2NH_3$	c	257.419		-97.1				
$CuBr \cdot 3NH_3$	c	194.541		-95.0				
$CuBr_2 \cdot 10/3NH_3$	c	280.127		-132.2				
$CuBr_2 \cdot 5NH_3$	c	308.511		-172.1				
$[Cu(NH_3)_6]Br_2$	c	325.542		-192.9				
$CuBr_2 \cdot 10NH_3$	c	393.664		-267.5				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 36(10) COPPER

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$CuI \cdot 1/2NH_3$	c	198.960		-30.4				
$CuI \cdot NH_3$	c	207.475		-43.5				
$CuI \cdot 2NH_3$	c	224.506		-66.5				
$[Cu(NH_3)_3]I$	c	241.536		-88.4				
$CuSO_4 \cdot NH_3$	c	176.632		-218.0				
$CuSO_4 \cdot 2NH_3$	c	193.663		-248.2				
$CuSO_4 \cdot (NH_4)_2SO_4$	c	291.740		-491.0				
$CuSO_4 \cdot (NH_4)_2SO_4 \cdot 2H_2O$	c	327.771		-628.0				
$CuSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$	c	399.832		-901.5				
$[Cu(NH_3)_4]SO_4$	c	227.724		-302.0				
$[Cu(NH_3)_4]SO_4 \cdot 3/2\ H_2O$	c	254.747		-405.9				
$CuSO_4 \cdot 5NH_3$	c	244.755		-328.1				
CuP_2	c	125.488		-29.				
Cu_3P	c	221.594		-36.2				
$CuP_2O_7^{2-}$ std. state, m = 1	aq	237.483			-452.1			
$Cu(P_2O_7)_2^{6-}$ std. state, m = 1	aq	411.427			-913.9			
$Cu_2P_2O_7$	c	301.023			-448.0			
std. state, m = 1	aq			-511.8	-427.4		-76.	

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 36(11) COPPER

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Cu_3(PO_4)_2$	c	380.563			-490.3			
$CuCl \cdot PH_3$	c	132.991		-43.9				
$CuCl \cdot 2PH_3$	c	166.988		-51.2				
$CuBr \cdot PH_3$	c	177.447		-35.4				
$CuBr \cdot 2PH_3$	c	211.444		-44.0				
$CuI \cdot PH_3$	c	224.442		-25.5				
$CuI \cdot 2PH_3$	c	258.440		-33.7				
$Cu(NH_3)_2P_2O_7^{2-}$ std. state, m = 1	aq	271.545			-476.3			
Cu_3As	c	265.542		-2.8				
$Cu_3(AsO_4)_2$	c	468.458			-310.9			
std. state, m = 1	aq			-378.10	-263.02		-149.2	
Cu_2Sb	c	248.83		-2.8				
Cu_3Sb	c	312.37		-2.				
CuC_2O_4	c	151.560			-158.2			
std. state, m = 1	aq			-181.7	-145.5		-12.9	
undissoc.; std. state, m = 1	aq				-153.1			
$Cu(C_2O_4)_2^{2-}$ std. state, m = 1	aq	239.580		-380.5	-319.3		35.	

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Table 36(12) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

COPPER

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Cu(CHO_2)^+$ std. state, m = 1	aq	108.558			-70.9			
$Cu(CHO_2)_2$	c	153.576		-186.7				
std. state, m = 1	aq			-187.94	-152.1		20.	
in 400 H_2O	aq			-187.7				
$Cu(CHO_2)_2 \cdot 4H_2O$	c	225.637		-468.7				
$Cu(CH_3COO)^+$								
std. state, m = 1	aq	122.585			-75.67			
$Cu(CH_3COO)_2$	c	181.630		-213.5				
std. state, m = 1	aq			-216.84	-160.92		17.6	
undissoc.; std. state, m = 1	aq				-165.87			
in 400 H_2O	aq			-216.2				
$Cu(CH_3COO)_2 \cdot H_2O$	c	199.645		-284.2				
$Cu(CH_2OHCOO)_2$	c	213.629		-299.1				
in 200 H_2O	aq			-298.0				
$CuCO_3 \cdot Cu(OH)_2$								
malachite	c	221.104		-251.3	-213.6		44.5	
$2CuCO_3 \cdot Cu(OH)_2$								
azurite	c	344.653		-390.1				
$2CuCl \cdot CO \cdot 2H_2O$	c	262.027		-225.				
$2CuCl \cdot C_2H_2$	c	224.024		-23.3	-7.63		50.7	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 36(13) COPPER

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$3CuCl \cdot C_2H_2$		c	323.017		-56.4	-36.52		71.0	
$CuCl_2 \cdot 2CH_3OH$		c	198.531		-169.8	-122.3		78.5	
$CuCl_2 \cdot 2C_2H_5OH$		c	226.585		-178.1	-126.2		128.9	
$CuSO_4 \cdot 2CH_3OH$		c	223.686		-306.7				
$Cu(C_2H_5OSO_3)_2$	in 600 H_2O	aq	313.788		-402.6				
CuCN		c	89.558		23.0	26.6		20.2	
$Cu(CN)_2^-$	std. state, m = 1	aq	115.576			61.6			
$Cu(CN)_3^{2-}$	std. state, m = 1	aq	141.594			96.5			
$Cu(CN)_4^{3-}$	std. state, m = 1	aq	167.611			135.4			
CuONC	cuprous fulminate	c	105.557		26.3				
$Cu(NH_2CH_2CH_2NH_2)^{2+}$	ethylenediamine	aq	123.639		-10.6				
$Cu(NH_2CH_2CH_2NH_2)_2^{2+}$		aq	183.739		-36.3				
$Cu(NH_2CH_2COO)^+$	std. state, m = 1	aq	137.600		-102.8	-71.3		24.	

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Table 36(14) COPPER

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$Cu(HCOO)_2 \cdot 2NH_3$		c	187.637		-237.3				
$Cu(HCOO)_2 \cdot 4NH_3$		c	221.698		-284.1				
$Cu(HCOO)_2 \cdot 6NH_3$		c	255.760		-321.0				
$Cu(NH_2CH_2COO)_2$	α	c	211.659		-224.3				
	β	c			-222.9				
	undissoc.; std. state, m = 1	aq			-221.5	-156.3		63.	
$Cu(NH_2CH_2COO)_2 \cdot H_2O$	monoclinic	c	229.675		-295.9				
	rhombic	c			-295.5				
$Cu(CH_3COO)_2 \cdot 2NH_3$		c	215.691		-268.9				
$Cu(CH_2OHCOO)_2 \cdot 2NH_3$		c	247.690		-353.5				
$Cu(CH_2NH_2COO)_2 \cdot 2NH_3$		c	245.721		-266.5				
$Cu(NH_3)_4(CH_3COO)_2$		c	249.752		-314.6				
$Cu(NH_3)_4(CH_2OHCOO)_2$		c	281.751		-399.2				
$Cu(NH_3)_4(CH_2NH_2COO)_2$		c	279.782		-315.1				
$Cu(NH_3)_6(CH_3COO)_2$		c	283.814		-358.8				
$Cu(NH_3)_6(CH_2OHCOO)_2$		c	315.813		-443.8				

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Table 36(15) COPPER

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$CuCl_2 \cdot NH_2CH_2CH_2NH_2$		c	194.545		-92.2				
$CuCl_2 \cdot 2(NH_2CH_2CH_2NH_2)$		c	254.645		-117.0				
$CuBr_2 \cdot NH_2CH_2CH_2NH_2$		c	283.457		-72.0				
$CuBr_2 \cdot 2(NH_2CH_2CH_2NH_2)$		c	343.557		-102.1				
CuCNS		c	121.622			16.7			
	std. state, m = 1	aq			35.40	34.10		44.2	
$CuCNS^+$	std. state, m = 1	aq				34.63			
$Cu(CNS)_2$	std. state, m = 1	aq	179.704		52.02	59.96		45.2	
	undissoc.; std. state, m = 1	aq				54.94			
$Cu(CNS)_4^{3-}$	std. state, m = 1	aq	295.867		78.5	87.0		154.	
CuSn		g	182.23	111.4					
Cu_3Sn		c	309.31		-7.6				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 36(16) COPPER

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
CuAl	c	90.522		-9.8				
$CuAl_2$	c	117.503		-9.75				
Cu_2Al	c	154.062		-16.5				
Cu_3Al	c	217.602		-16.8				
Cu_3Al_2	c	244.583		-26.2				
$CuAl_2O_4$	c	181.501		-445.3				
$Cu_2Al_2O_4$	c	245.041		-450.2				
Cu_2Cd_3	c	464.28		-5.5				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 37(1) SILVER

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Ag	c	107.870	0	0	0	1.373	10.17	6.059
	g		67.90	68.01	58.72	1.481	41.321	4.9679
Ag^+	g		242.00	243.59				
std. state, m = 1	aq			25.234	18.433		17.37	5.2
Ag^{2+}	g		735.8	738.9				
in 4N $HClO_4$; std. state, m = 1	aq			64.2	64.3		-21.	
Ag^{3+}	g		1536.1	1540.6				
Ag_2	g	215.740	98.3	97.99	85.75	2.43	61.43	8.84
Ag_2O	c	231.7394	-7.034	-7.42	-2.68	3.397	29.0	15.74
Ag_2O_2	c	247.7388		-5.8	6.6		28.	21.
Ag_2O_3	c	263.7382		8.1	29.0		24.	
AgOH std. state, m = 1	aq	124.8774		-29.736	-19.161		14.80	-30.3
undissoc.; std. state, m = 1	aq				-22.0			
$Ag(OH)_2^-$ std. state, m = 1	aq	141.8847			-62.2			
AgF	c	126.8684		-48.9				
undissoc.; std. state, m = 1	aq			-57.1	-48.7		6.2	
std. state, m = 1	aq			-54.27	-48.21		14.1	-20.3
in 8 H_2O	aq			-53.200				
9 H_2O	aq			-53.256				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 37(2) SILVER

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
AgF	in 10 H_2O	aq			-53.288				
	15 H_2O	aq			-53.342				
	25 H_2O	aq			-53.369				
	50 H_2O	aq			-53.386				
	100 H_2O	aq			-53.394				
	200 H_2O	aq			-53.398				
	400 H_2O	aq			-53.4				
	∞ H_2O	aq			-54.27				
$AgF \cdot 2H_2O$		c	162.8991		-191.4	-160.4		41.8	31.
$AgF \cdot 4H_2O$		c	198.9298		-331.8	-274.2		64.	50.
AgF_2		c	145.8668		-87.3				
$AgHF_2$		aq	146.8748		-131.4				
AgCl		c	143.323		-30.370	-26.244		23.0	12.14
		g					2.311	58.75	8.57
	std. state, m = 1	aq			-14.718	-12.939		30.9	-27.4
	undissoc.; std. state, m = 1	aq			-17.4	-17.4		36.8	
$AgCl_2^-$	std. state, m = 1	aq	178.776		-58.6	-51.5		55.3	
$AgClO_2$		c	175.3218		2.10	18.1		32.16	20.87
	std. state, m = 1	aq			9.3	22.5		41.6	

Table 37(3) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity SILVER

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$AgClO_3$	c	191.3212		-6.1				
std. state, m = 1	aq			1.5	17.6		56.2	
$AgClO_4$	c	207.3206		-7.44				
std. state, m = 1	aq			-5.68	16.37		60.9	
in 500 H_2O	aq			-5.6				
$Ag(ClO_4)_2$ in 4N $HClO_4$	aq	306.7712		2.4				
AgBr	c	187.779		-23.99	-23.16		25.6	12.52
std. state, m = 1	aq			-3.82	-6.42		37.1	-28.7
undissoc.; std. state, m = 1	aq				-12.2			
$AgBr_2^-$ std. state, m = 1	aq	267.688			-41.2			
$AgBr_3^{2-}$ std. state, m = 1	aq	347.597			-68.0			
$AgBrO_3$	c	235.7772		-6.5	13.0		36.5	
std. state, m = 1	aq			5.2	18.8		56.4	
$AgCl_3Br^{3-}$ std. state, m = 1	aq	294.138			-111.3			
$AgClBr_3^{3-}$ std. state, m = 1	aq	383.050			-100.4			
AgI	c	234.7744		-14.78	-15.82		27.6	13.58
std. state, m = 1	aq			12.04	6.10		44.0	-28.8
undissoc.; std. state, m = 1	aq				-2.9			

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 37(4) SILVER

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
AgI_2^-	std. state, m = 1	aq	361.6788			-20.8			
AgI_3^{2-}	std. state, m = 1	aq	488.5832		-43.5	-36.8		60.5	
AgI_4^{3-}	std. state, m = 1	aq	615.4876			-50.1			
$AgIO_3$		c	282.7726		-40.9	-22.4		35.7	24.60
	std. state, m = 1	aq			-27.7	-12.2		45.7	
$3AgI \cdot HI \cdot 7H_2O$		c	958.3430		-538.1				
$Ag_2H_3IO_6$		c	441.6647					59.44	47.4
Ag_2S	α, orthorhombic	c	247.804	-8.126	-7.79	-9.72	4.136	34.42	18.29
	β	c			-7.03	-9.43		36.0	
$AgSO_3^-$	std. state, m = 1	aq	187.9322			-105.2			
$AgSO_4^-$	std. state, m = 1	aq	203.9316		-190.6	-161.3		32.	
$Ag(S_2O_3)_2^{3-}$		aq	332.1224		-307.3				
Ag_2SO_3		c	295.8022		-117.3	-98.3		37.8	
	std. state, m = 1	aq			-101.4	-79.4		27.8	
	undissoc.; std. state, m = 1	aq				-91.1			
Ag_2SO_4		c	311.8016		-171.10	-147.82		47.9	31.40
	std. state, m = 1	aq			-166.85	-141.10		39.6	-60.
$Ag_2S_2O_6$		aq	375.8644		-235.9				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 37(5) SILVER

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Ag_2S_2O_6 \cdot 2H_2O$	c	411.8951		-383.3				
Ag_2Se	c	294.70	-9.42	-9.	-10.6	4.48	36.02	19.54
Ag_2SeO_3	c	342.698		-87.3	-72.7		55.0	
std. state, m = 1	aq			-71.2	-51.5		38.	
Ag_2SeO_4	c	358.698		-100.5	-79.9		59.4	
std. state, m = 1	aq			-92.7	-68.6		47.7	
Ag_2Te	c	343.340	-9.31	-8.9	-10.3	4.62	37.0	20.9
AgN_3	c	149.8901		73.8	89.9		24.9	
std. state, m = 1	aq			90.99	101.6		43.2	
Ag_3N	c	337.6167		47.6				
$AgNO_2$	c	153.8755		-10.77	4.56		30.64	19.17
std. state, m = 1	aq			0.2	9.5		50.9	-18.1
in 400 H_2O	aq			-1.96				
$AgNO_3$	c	169.8749		-29.73	-8.00		33.68	22.24
nitrate; std. state, m = 1	aq			-24.33	-8.18		52.4	-15.5
undissoc.; std. state, m = 1	aq				-7.78			
in 50 H_2O	aq			-24.915				
100 H_2O	aq			-24.637				
200 H_2O	aq			-24.467				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 37(6) SILVER

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$AgNO_3$	in 400 H_2O	aq			-24.379				
	500 H_2O	aq			-24.362				
	1,000 H_2O	aq			-24.328				
	2,000 H_2O	aq			-24.314				
	5,000 H_2O	aq			-24.309				
	10,000 H_2O	aq			-24.311				
	50,000 H_2O	aq			-24.318				
	∞ H_2O	aq			-24.33				
	in 15,000 CH_3OH				-29.00				
$Ag(NO_2)_2^-$	std. state, m = 1	aq	199.8810			-2.4			
$Ag_2N_2O_2$		c	275.7522		20.5				
		aq			46.4				
$Ag(NH_3)^+$	std. state, m = 1	aq	124.9006			7.56			
$Ag(NH_3)_2^+$	std. state, m = 1	aq	141.9312		-26.60	-4.12		58.6	
$Ag(NH_3)_2NO_3$		c	203.9361		-85.0				
	std. state, m = 1	aq			-76.16	-30.73		93.6	
$Ag(NH_3)_3NO_3$		c	220.9667		-105.5				
$AgCl \cdot NH_3$		c	160.3536		-53.3	-31.5		33.4	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 37(7) SILVER

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$AgCl \cdot 3/2NH_3$	c	168.8689		-64.3	-33.8		39.1	
$Ag(NH_3)_2Cl$ std. state, m = 1	aq	177.3842		-66.55	-35.49		72.1	
undissoc.; std. state, m = 1	aq				-35.01			
$Ag(NH_3)_3Cl$	c	194.4148		-95.0	-38.6		56.8	
$Ag(NH_3)_2ClO_4$	c	241.3818		-67.3				
in 1,000 H_2O	aq			-57.4				
$Ag(NH_3)_3ClO_4$	c	258.4124		-87.0				
in 1,600 H_2O	aq			-76.7				
$AgBr \cdot NH_3$	c	204.8096		-45.7	-27.9		38.4	
$AgBr \cdot 3/2NH_3$	c	213.3249		-56.4	-30.1		44.7	
$Ag(NH_3)_2Br$ std. state, m = 1	aq	221.8402		-55.65	-28.97		78.3	
undissoc.; std. state, m = 1	aq				-29.26			
$Ag(NH_3)_3Br$	c	238.8708		-86.0	-35.0		66.4	
$Ag_3I(NO_3)_2$	c	574.5242		-77.5				
$AgI \cdot 1/2NH_3$	c	243.2897		-26.5				
$AgI \cdot NH_3$	c	251.8050		-36.5				
AgP_2	c	169.8176		-11.0				
AgP_3	c	200.7914		-16.6				
$AgPO_3$	aq	186.8420		-208.43				

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Table 37(8) SILVER

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$AgPO_3 \cdot 1/3H_2O$	c	192.8471		-233.1				
Ag_3PO_4	c	418.5814			-210.			
$Ag_4P_2O_7$	c	605.4234		-453.				
$AgI \cdot 1/2PH_3$	c	251.7733		-18.9				
Ag_3AsO_4	c	462.5292			-129.7			
std. state, m = 1	aq			-136.57	-99.70		13.3	
Ag_2C_2	c	239.7623		83.8				
Ag_2CO_3	c	275.7494		-120.9	-104.4		40.0	26.83
$Ag_2C_2O_4$	c	303.7599		-160.9	-139.6		50.	
$AgC_2H_4^+$ std. state, m = 1	aq	135.9242		26.6	35.2		31.	
$AgCH_3CO_2$	c	166.9150		-95.3	-73.56		35.8	
std. state, m = 1	aq			-90.93	-69.86		38.1	3.7
undissoc.; std. state, m = 1	aq				-70.85			
$Ag(CH_3CO_2)_2^-$ std. state, m = 1	aq	225.9600			-159.02			
$Ag_2(CH_3CO_2)^+$ std. state, m = 1	aq	274.7850			-52.97			
$Ag_2C_2 \cdot AgCl$	c	383.0853		50.1				

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Table 37(9) SILVER

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$2Ag_2C_2 \cdot AgCl$		c	622.8476		130.1				
$Ag_2C_2 \cdot AgI$		c	474.5367		67.7				
$Ag_2C_2 \cdot 2AgI$		c	709.3111		51.7				
$Ag_2C_2 \cdot Ag_2SO_4$		c	551.5639		-91.4				
$2Ag_2C_2 \cdot Ag_2SO_4$		c	791.3262		-17.0				
AgCN		c	133.8878	34.354	34.9	37.5	3.206	25.62	15.95
	std. state, m = 1	aq			61.2	59.6		39.9	
$AgCN_2$	silver cyanamide	c	147.8946		56.2				
$Ag(CN)_2^-$	std. state, m = 1	aq	159.9057		64.6	73.0		46.	
AgONC	silver fulminate	c	149.8872		43.				
AgOCN	silver cyanate	c			-22.8	-13.9		29.	
$Ag_2C_2 \cdot AgNO_3$		c	409.6372		47.9				
$AgCN \cdot NH_3$		c	150.9185		10.				
$Ag(CH_3NH_2)_2^+$	std. state, m = 1	aq	169.9854			19.0			
$Ag((CH_3)_2NH)_2^+$	std. state, m = 1	aq	198.0396			38.9			
$AgCNOH^-$	std. state, m = 1	aq	150.8952			3.7			
$Ag(NH_2CH_2COO)$	undissoc.; std. state, m = 1	aq	181.9297		-84.9	-61.6		69.	

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37 $Ag(NH_2CH_2COO)$

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Table 37(10) SILVER

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$AgCl\cdot CH_3NH_2$		c	174.3807		-48.31	-20.10		44.5	
$AgBr\cdot CH_3NH_2$		c	218.8367		-41.76	-16.84		47.1	
AgSCN		c	165.9518		21.0	24.23		31.3	15.
	std. state, m = 1	aq			43.50	40.58		51.9	-4.4
	undissoc.; std. state, m = 1	aq				34.1			
	in 200 C_5H_5N				16.64				
$Ag(SCN)_2^-$	std. state, m = 1	aq	224.0337			51.4			
$Ag(SCN)_3^{2-}$	std. state, m = 1	aq	282.1156			71.9			
$Ag(SCN)_4^{3-}$	std. state, m = 1	aq	340.1974			93.7			
$Ag(CS(NH_2)_2)_3^+$		aq	336.2313		-52.2				
AgSn		g	226.560	108.5	108.0				
$AgCl\cdot AlCl_3$		c	276.7035		-201.3				
$AgBr\cdot AlBr_3$		c	454.4875		-159.9				
$AgBr\cdot 2AlBr_3$		c	721.1960		-275.0				
Ag_2HgI_4		c	923.948						47.5
AgCu		g	171.410	107.8	107.63				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 38(1) GOLD

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
Au		c	196.967	0	0	0	1.436	11.33	6.075
		g		87.46	87.5	78.0	1.481	43.115	4.968
Au^+		g		300.20	301.73				
Au^{2+}		g		773.0	776.0				
Au_2		g	393.934	123.5	123.1		2.436		8.808
AuO_3^{3-}	std. state, m = 1	aq	244.9652			-12.4			
AuH		g	197.9750	70.9	70.5	63.5	2.068	50.441	6.968
$HAuO_3^{2-}$	std. state, m = 1	aq	245.9732			-34.0			
$H_2AuO_3^-$	std. state, m = 1	aq	246.9811			-52.2			
$Au(OH)_3$	precipitated	c	247.9891		-101.5	-75.77		45.3	
	undissoc.; std. state, m=1	aq				-67.75			
AuF_3		c	253.9622		-86.9				
AuCl		c	232.420		-8.3				
		g		47.	47.				
$AuCl_2^-$	std. state, m = 1	aq	267.873			-36.13			
$AuCl_3$		c	303.326		-28.1				
	in 900 H_2O	aq			-32.80				
$AuCl_3 \cdot 2H_2O$		c	339.357		-170.9				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 38(2) GOLD

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$AuCl_4^-$	std. state, m = 1	aq	338.779		-77.0	-56.22		63.8	
Au_2Cl_6		g	606.652		-23.2				
$HAuCl_4$	std. state, m = 1	aq	339.787		-77.0	-56.22		63.8	
$HAuCl_4 \cdot 3H_2O$		c	393.833		-284.9				
$HAuCl_4 \cdot 4H_2O$		c	411.848		-355.9				
AuBr		c	276.876		-3.34				
$AuBr_2^-$	std. state, m = 1	aq	356.785		-30.7	-27.49		52.5	
$AuBr_3$		c	436.694		-12.73				
		aq			-9.39				
$AuBr_4^-$	std. state, m = 1	aq	516.603		-45.8	-40.0		80.3	
$HAuBr_4$	std. state, m = 1	aq	517.611		-45.8	-40.0		80.3	
$HAuBr_4 \cdot 5H_2O$		c	607.688		-398.7				
AuI		c	323.8714		0.				
AuTe		g	324.567				2.414		8.78
$AuCl \cdot NH_3$		c	249.451		-43.7				
$AuCl \cdot 2NH_3$		c	266.481		-69.7				
$AuBr \cdot NH_3$		c	293.907		-36.9				
$AuBr \cdot 2NH_3$		c	310.937		-60.7				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 38(3) GOLD

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$AuBr \cdot 3NH_3$		c	327.968		-79.8				
$AuBr \cdot 4NH_3$		c	344.998		-98.7				
$AuBr \cdot 6NH_3$		c	379.060		-136.2				
$AuI \cdot NH_3$		c	340.9020		-26.2				
$AuI \cdot 2NH_3$		c	357.9326		-45.8				
$AuI \cdot 3NH_3$		c	374.9632		-65.5				
$AuI \cdot 6NH_3$		c	426.0551		-121.0				
Au_2P_3		g	486.855		-23.8				
$AuI \cdot PH_3$		c	357.8691		-9.6				
$AuSb_2$		c	440.467		-2.6				
$Au(CN)_2^-$	std. state, m = 1	aq	249.003		57.9	68.3		41.	
$Au(SCN)_2^-$	std. state, m = 1	aq	313.131			60.2			
$Au(SCN)_4^-$	std. state, m = 1	aq	429.294			134.2			
$Au(SCN)_5^{2-}$	std. state, m = 1	aq	487.376			156.4			
$Au(SCN)_6^{3-}$	std. state, m = 1	aq	515.458			178.5			

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 38(4) GOLD

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
AuSn	c	315.657		-7.28	-7.15		23.22	12.06
$AuSn_2$	c	434.347		-10.14	-9.07		32.4	
$AuSn_4$	c	671.727		-9.25	-9.04		59.9	
$AuPb_2$	c	611.347		-1.5				
Au_2Pb	c	601.124		-0.5				
AuIn	c	311.787		-10.8				
$AuIn_2$	c	426.607		-18.0				
AuCd	c	309.367		-9.28	-9.34		23.9	
AuCu	c	260.507		-4.46	-4.40		19.1	11.9
$AuCu_3$	c	387.587		-6.84	-6.97		35.7	24.0
$AgAuF_4$	c	380.8306		-153.3				

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Table 39(1) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — NICKEL

Substance: Formula and Description	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Ni	c	58.71	0	0	0	1.144	7.14	6.23
	g		102.213	102.7	91.9	1.631	43.519	5.583
Ni^+	g		278.275	280.243				
Ni^{2+}	g		696.87	700.32				
std. state, m = 1	aq			-12.9	-10.9		-30.8	
Ni^{3+}	g		1508.0	1512.9				
Ni_2	g	117.42	150.	150.				
NiO	c	74.709	-56.7	-57.3	-50.6	1.6	9.08	10.59
	g		75.	75.				
Ni_2O_3	c	165.418		-117.0				
$NiOH^+$ std. state, m = 1	aq	75.717		-68.8	-54.4		-17.	
$Ni(OH)_2$	c	92.725		-126.6	-106.9		21.	
std. state, m = 1	aq			-122.8	-86.1		-35.9	
$Ni(OH)_3$ precipitated	c	109.732		-160.				
NiF_2	c	96.707	-155.18	-155.7	-144.4	2.729	17.59	15.31
std. state, m = 1	aq			-171.9	-144.2		-37.4	
in 1,200 H_2O	aq			-170.5				
$NiF_2 \cdot 4H_2O$	c	168.768			-378.			
$NiCl_2$	c	129.616	-73.077	-72.976	-61.918	3.438	23.34	17.13

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Table 39(2) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
NICKEL

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$NiCl_2$	std. state, m = 1	aq			-92.8	-73.6		-3.6	
	in 20 H_2O	aq			-89.90				
	25 H_2O	aq			-90.37				
	30 H_2O	aq			-90.68				
	40 H_2O	aq			-91.00				
	50 H_2O	aq			-91.20				
	75 H_2O	aq			-91.46				
	100 H_2O	aq			-91.62				
	150 H_2O	aq			-91.79				
	200 H_2O	aq			-91.91				
	400 H_2O	aq			-92.12				
	500 H_2O	aq			-92.18				
	800 H_2O	aq			-92.28				
	1,000 H_2O	aq			-92.33				
	1,500 H_2O	aq			-92.40				
	2,000 H_2O	aq			-92.45				
	3,000 H_2O	aq			-92.51				
	5,000 H_2O	aq			-92.57				
	10,000 H_2O	aq			-92.66				
	50,000 H_2O	aq			-92.73				
	100,000 H_2O	aq			-92.75				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 39(3) NICKEL

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$NiCl_2$ in ∞ H_2O	aq			-92.8				
$NiCl_2 \cdot 2H_2O$	c	165.647		-220.4	-181.7		42.	
$NiCl_2 \cdot 4H_2O$	c	201.677		-362.5	-295.2		58.	
$NiCl_2 \cdot 6H_2O$	c	237.708		-502.67	-409.54		82.3	
$Ni(ClO_4)_2$ std. state, m = 1	aq	257.611		-74.7	-15.0		56.2	
in 10 H_2O	aq			-73.4				
20 H_2O	aq			-74.2				
1,000 H_2O	aq			-74.7				
$Ni(ClO_4)_2 \cdot 6H_2O$	c	365.703		-486.6				
$NiBr_2$	c	218.528		-50.7				
std. state, m = 1	aq			-71.0	-60.6		8.6	
$NiBr_2 \cdot 3H_2O$	c	272.574		-274.0				
NiI_2	c	312.519		-18.7				
std. state, m = 1	aq			-39.3	-35.6		22.4	
$Ni(IO_3)_2$	c	408.515		-116.9	-78.0		51.	
NiS	c	90.774		-19.6	-19.0		12.66	11.26
precipitated	c			-18.5				
Ni_3S_2	c	240.258		-48.5	-47.1		32.0	28.12
Ni_6S_5	c	512.580		-105.6				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 39(4) NICKEL

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Ni_7S_6	c	603.354		-133.5				
$NiSO_4$	c	154.772		-208.63	-181.6		22.	33.
std. state, m = 1	aq			-230.2	-188.9		-26.0	
undissoc.; std. state, m = 1	aq			-226.9	-192.0		-4.3	
in 200 H_2O	aq			-229.088				
300 H_2O	aq			-229.128				
400 H_2O	aq			-229.158				
500 H_2O	aq			-229.184				
800 H_2O	aq			-229.247				
1,000 H_2O	aq			-229.291				
1,500 H_2O	aq			-229.349				
2,000 H_2O	aq			-229.403				
3,000 H_2O	aq			-229.481				
4,000 H_2O	aq			-229.528				
5,000 H_2O	aq			-229.581				
7,000 H_2O	aq			-229.640				
10,000 H_2O	aq			-229.699				
15,000 H_2O	aq			-229.765				
20,000 H_2O	aq			-229.821				
50,000 H_2O	aq			-229.974				

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Table 39(5) NICKEL

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$NiSO_4$ in 100,000 H_2O	aq			-230.052				
200,000 H_2O	aq			-230.104				
500,000 H_2O	aq			-230.140				
∞ H_2O	aq			-230.2				
$NiSO_4 \cdot 4H_2O$	c	226.833		-502.9				
$NiSO_4 \cdot 6H_2O$ α, tetragonal, green	c	262.864	-628.887	-641.21	-531.78	12.391	79.94	78.36
β, monoclinic, blue	c			-638.7				
$NiSO_4 \cdot 7H_2O$	c	280.879	-697.670	-711.36	-588.49	14.085	90.57	87.14
NiS_2O_6	aq	218.834		-299.3				
$NiS_2O_6 \cdot 6H_2O$	c	326.926		-711.5				
$NiSO_4 \cdot 3Ni(OH)_2$	c	432.946		-585.4	-518.1		149.	
$3NiSO_4 \cdot 4Ni(OH)_2$	c	835.214			-815.			
NiSe	c	137.67		-14.1				
$NiSeO_3 \cdot 2H_2O$	c	221.699		-271.11				
precipitated	amorp			-264.4				
NiTe	c	186.31		-12.8				12.5
$NiTe_{1.1}$	c	199.07	-13.95	-13.9		2.805	20.1+x	12.99
$NiTe_2$	c	313.91				3.947	28.8+x	18.15
Ni_2Te_3	c	500.22	-34.46	-34.5		6.634	48.0+x	30.46

x = zero point entropy

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Table 39(6) NICKEL

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Ni(N_3)_2 \cdot H_2O$	c	160.766		45.3				
Ni_3N	c	190.137		0.2				
$Ni(NO_3)_2$	c	182.720		-99.2				
std. state, m = 1	aq			-112.0	-64.2		39.2	
in 50 H_2O	aq			-111.5				
100 H_2O	aq			-111.4				
200 H_2O	aq			-111.4				
400 H_2O	aq			-111.6				
1,000 H_2O	aq			-111.7				
$Ni(NO_3)_2 \cdot 3H_2O$	c	236.766		-317.0				
$Ni(NO_3)_2 \cdot 6H_2O$	c	290.812		-528.6				111.
$Ni(N_2H_4)^{2+}$ std. state, m = 1	aq	90.755			15.9			
$Ni(NH_3)_2^{2+}$ std. state, m = 1	aq	92.771		-58.9	-30.6		20.4	
$Ni(N_2H_4)_2^{2+}$ std. state, m = 1	aq	122.801			43.2			
$Ni(NH_3)_4^{2+}$ std. state, m = 1	aq	126.832		-104.9			61.8	
$Ni(N_2H_4)_3^{2+}$ std. state, m = 1	aq	154.846			70.9			

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 39(7) NICKEL

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$Ni(NH_3)_6^{2+}$	std. state, m = 1	aq	160.894		-150.6	-61.2		94.3	
$Ni(N_2H_4)_4^{2+}$	std. state, m = 1	aq	186.891			98.9			
$Ni(N_2H_4)_5^{2+}$	std. state, m = 1	aq	218.936			127.4			
$Ni(N_2H_4)_6^{2+}$	std. state, m = 1	aq	250.982			156.3			
$Ni(NH_3)_6(NO_3)_2$		c	284.903						96.
	in 400 H_2O	aq			-245.4				
$NiCl_2 \cdot NH_3$		c	163.677		-105.6				
$NiCl_2 \cdot 2NH_3$		c	180.708		-135.6				
$Ni(NH_3)_6Cl_2$		c	231.800		-237.6				
$NiBr_2 \cdot NH_3$		c	235.559		-82.5				
$NiBr_2 \cdot 2NH_3$		c	252.589		-114.5				
$Ni(NH_3)_6Br_2$		c	320.712		-220.8				
$NiI_2 \cdot 2NH_3$		c	346.580		-86.6				
$Ni(NH_3)_6I_2$		c	414.702		-193.2				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 39(8) NICKEL

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Ni(N_2H_4)_3SO_4$	c	250.907			-115.0			
Ni_3P	c	207.104		-50.2				
Ni_5P_2	c	355.498		-97.7				
$NiP_2O_7^{2-}$ std. state, m = 1	aq	232.653		-559.9	-479.1		-41.5	
$Ni_2P_2O_7$	c	291.363			-497.9			
$Ni_3(PO_4)_2$	c	366.073			-562.4			
$NiHP_2O_7^-$ std. state, m = 1	aq	233.661			-487.5			
$Ni_3(AsO_4)_2$	c	453.968			-377.5			
NiSb	c	180.46		-15.8				
Ni_3C	c	188.141		16.1				
$NiCO_3$	c	118.719			-146.4			
NiC_2O_4	c	146.730		-204.8				
std. state, m = 1	aq			-210.1	-172.0		-19.9	
undissoc.; std. state, m = .1	aq			-209.9	-179.0		4.3	
$Ni(CO)_4$	liq	170.752		-151.3	-140.6		74.9	48.9
	g		-144.877	-144.10	-140.36	7.074	98.1	34.70
$Ni(HCO_2)_2$	c	148.746		-208.4				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 39(9) NICKEL

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Ni(CH_3CO_2)^+$								
std. state, m = 1	aq	117.755			-101.1			
$Ni(CH_3CO_2)_2$								
std. state, m = 1	aq	176.800		-245.2	-187.5		10.6	
undissoc.; std. state, m = 1	aq				-191.7			
$NiBr_2 \cdot 6CH_3OH$	c	410.783		-411.3				
$Ni(CN)_2$ precipitated	c	110.746		30.5				
std. state, m = 1	aq			59.1	71.5		14.2	
$Ni(CN)_4^{2-}$ std. state, m = 1	aq	162.781		87.9	112.8		52.	
$Ni(CNO)_2$	c	142.744		-54.4				
$Ni(NH_2CH_2CH_2NH_2)^{2+}$								
nickel ethylenediamine	aq	118.809		-35.2				
$Ni(NH_2CH_2CH_2NH_2)_2^{2+}$	aq	178.909		-57.4				
$Ni(NH_2CH_2CH_2NH_2)_3^{2+}$	aq	239.008		-80.8				
$Ni(CH_3NH_2)_6^{2+}$								
std. state, m = 1	aq	245.056		-128.5	6.6		136.	

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 39(10) NICKEL

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Ni(NH_2CH_2COO)_2$ nickel glycinate	c	206.829		-232.5				
$Ni(C_2H_3O_2N_2)_2$ nickel glyoximate	c	232.827		-30.4				
$Ni(NH_2CH_2CH_2NH_2)_3Cl_2$ nickel ethylenediamine chloride	c	309.914		-158.0				
	aq			-155.75				
$Ni(NH_2CH_2CH_2NH_2)_3Cl_2 \cdot 2H_2O$	c	345.945		-305.0				
$Ni(NH_2CH_2CH_2NH_2)_3Br_2$	c	398.826		-142.9				
	aq			-133.95				
$Ni(NH_2CH_2CH_2NH_2)_3Br_2 \cdot 2H_2O$	c	434.857		-285.4				
$Ni(NH_2CH_2CH_2NH_2)_3I_2$	c	492.817		-113.6				
	aq			-102.23				
$Ni(NH_2CH_2CH_2NH_2)_3I_2 \cdot 2H_2O$	c	528.848		-253.8				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 39(11) NICKEL

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$NiCNS^+$ std. state, m = 1	aq	116.792		18.5	9.0		55.	
$Ni(CNS)_2$	c	174.874		22.8.				
NiSi	c	86.796		-20.6				10.9
Ni_2Si	c	145.506		-33.6				16.8
Ni_3Sn	c	294.82		-22.4				23.8
Ni_3Sn_2	c	413.51		-37.5				
$2NiI_2 \cdot PbI_2$	c	1086.036		-78.9				
$2NiI_2 \cdot PbI_2 \cdot 3H_2O$	c	1140.082		-335.2				
$Ni(BO_2)_2$	c	144.330			-347.3			
$Ni(OH)_2 \cdot 2H_3BO_3$	c	216.391			-603.7			
NiAl	c	85.692		-28.1				
$NiAl_2O_4$	c	176.670		-461.				

National Bureau of Standards — Washington, D. C.

Table 40(1) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — COBALT

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
Co	α, hexagonal	c	58.9332	0	0	0	1.139	7.18	5.93
	β, f. c. cubic	c			0.11	0.06		7.34	
		g		101.119	101.5	90.9	1.520	42.879	5.502
Co^+		g		282.486	284.348				
Co^{2+}		g		675.82	679.17				
	std. state, m = 1	aq			-13.9	-13.0		-27.	
Co^{3+}		g		1448.35	1453.18				
	std. state, m = 1	aq			22.	32.		-73.	
Co_2		g	117.8664	163.	163.2				
CoO		c	74.9326		-56.87	-51.20		12.66	13.20
Co_3O_4		c	240.7972		-213.	-185.		24.5	29.5
$HCoO_2^-$	std. state, m = 1	aq	91.9400			-97.4			
$Co(OH)_2$	blue, precipitated	c	92.9479			-107.6			
	pink, precipitated	c			-129.0	-108.6		19.	
	pink, precipitated, aged	c				-109.5			
	std. state, m = 1	aq			-123.8	-88.2		-32.	
	undissoc.; std. state, m = 1	aq				-100.8			

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(2) COBALT

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Co(OH)_3$ precipitated	c	109.9553		-171.3'				
CoF_2	c	96.9300	-165.13	-165.4	-154.7	2.978	19.59	16.44
in 2400 H_2O	aq			-171.4				
CoF_3	c	115.9284		-193.8				
$CoCl_2$	c	129.8392	-74.74	-74.7	-64.5	3.375	26.09	18.76
std. state, m = 1	aq			-93.8	-75.7		0.	
in 15 H_2O	aq			-89.86				
20 H_2O	aq			-90.88				
25 H_2O	aq			-91.33				
30 H_2O	aq			-91.66				
40 H_2O	aq			-92.06				
50 H_2O	aq			-92.30				
60 H_2O	aq			-92.46				
75 H_2O	aq			-92.60				
100 H_2O	aq			-92.74				
150 H_2O	aq			-92.87				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(3) COBALT

Substance			State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
					0 °K	298.15 °K (25 °C)				
					kcal/mol				cal/deg mol	
$CoCl_2$	in	200 H_2O	aq			-92.94				
		400 H_2O	aq			-93.10				
		500 H_2O	aq			-93.16				
		800 H_2O	aq			-93.33				
		1000 H_2O	aq			-93.38				
		2000 H_2O	aq			-93.54				
		5000 H_2O	aq			-93.66				
		∞ H_2O	aq			-93.8				
	in 2N HCl		aq			-91.5				
$CoCl_2 \cdot H_2O$			c	147.8545		-147.				
$CoCl_2 \cdot 2H_2O$			c	165.8699		-220.6	-182.8		45.	
$CoCl_2 \cdot 6H_2O$			c	237.9312		-505.6	-412.4		82.	
$Co(ClO_4)_2$	std. state, m = 1		aq	257.8344		-75.7	-17.1		60.	
	in	7.6 H_2O	aq			-73.83				
		10 H_2O	aq			-74.34				
		13 H_2O	aq			-74.81				
		20 H_2O	aq			-75.34				
		30 H_2O	aq			-75.59				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(4) COBALT

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Co(ClO_4)_2$ in 50 H_2O	aq			-75.70				
100 H_2O	aq			-75.70				
500 H_2O	aq			-75.70				
1000 H_2O	aq			-75.70				
∞ H_2O	aq			-75.7				
$Co(ClO_4)_2 \cdot 6H_2O$	c	365.9264		-487.2				
$CoBr_2$	c	218.7512		-52.8				19.0
std. state, m = 1	aq			-72.0	-62.7		12.	
in 1000 H_2O	aq			-17.6				
$CoBr_2 \cdot 6H_2O$	c	326.8432		-482.8				
CoI_2	c	312.7420		-21.2				
std. state, m = 1	aq			-40.3	-37.7		26.	
in 1000 H_2O	aq			-39.9				
$Co(IO_3)_2$ std. state, m = 1	aq	408.7384		-119.7	-74.2		30.	
$Co(IO_3)_2 \cdot 2H_2O$	c	444.7691		-258.6	-190.2		64.	

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(5) COBALT

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
CoS	c	90.9972		-19.8				
Co_2S_3 precipitated	c	214.0584		-35.2				
$CoSO_4$	c	154.9948		-212.3	-187.0		28.2	
std. state, m = 1	aq			-231.2	-191.0		-22.	
in 23.31 H_2O	aq			-229.8				
400 H_2O	aq			-230.3				
700 H_2O	aq			-230.4				
1000 H_2O	aq			-230.5				
∞ H_2O	aq			-231.2				
$CoSO_4 \cdot 6H_2O$	c	263.0868	-630.257	-641.4	-534.35	13.525	87.86	84.46
$CoSO_4 \cdot 7H_2O$	c	281.1022	-699.547	-712.22	-591.26	15.097	97.05	93.33
$CoSO_4 \cdot 3Co(OH)_2$	c	433.8386		-592.2	-524.8		149.	
CoSe	c	137.893		-14.6				
$CoSeO_3 \cdot 2H_2O$	c	221.922		-266.5				
$CoTe_2$	c	314.133		-31.				
Co_3Te_4	c	687.200		-77.				
Co_5Te_6	c	1060.266		-101.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(6) COBALT

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$Co(NO_3)_2$		c	182.9430		-100.5				
	std. state, m = 1	aq			-113.0	-66.2		43.	
	in 20 H_2O	aq			-112.76				
	400 H_2O	aq			-112.9				
$Co(NO_3)_2 \cdot 2H_2O$		c	218.9737		-244.2				
$Co(NO_3)_2 \cdot 3H_2O$		c	236.9890		-316.9				
$Co(NO_3)_2 \cdot 4H_2O$		c	255.0044		-389.7				
$Co(NO_3)_2 \cdot 6H_2O$		c	291.0350		-528.49				108.
$[Co(NO_2)_6]^{3-}$		aq	334.9662		-150.0				
$[Co(NH_3)]^{2+}$	std. state, m = 1	aq	75.9638		-34.7	-22.1		3.	
$[Co(NH_3)_2]^{2+}$	std. state, m = 1	aq	92.9944			-30.5			
$[Co(NH_3)_3]^{2+}$	std. state, m = 1	aq	110.0250			-38.1			
$[Co(NH_3)_4]^{2+}$	std. state, m = 1	aq	127.0556			-45.3			
$[Co(NH_3)_6]^{3+}$	std. state, m = 1	aq	161.1169		-139.8	-38.9		40.	
$[Co(NH_3)_6]N_3^{2+}$	std. state, m = 1	aq	203.1370		-77.0	41.6		65.	

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(7) COBALT

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$[Co(NH_3)_3(N_3)_3]$		c	236.0853		95.8				
$[Co(NH_3)_4(N_3)_2]N_3$	cis	c	253.1159		90.9				
	trans	c			90.4				
$[Co(NH_3)_5N_3](N_3)_2$		c	270.1466		50.4				
$[Co(NH_3)_6](N_3)_3$		c	287.1772		30.7				
$[Co(NH_3)_4(H_2O)_2]^{3+}$		aq	163.0863		-258.9				
$[Co(NH_3)_4(NO_3)H_2O]^{2+}$		aq	207.0759		-206.8				
$[Co(NH_3)_5H_2O]^{3+}$		aq	162.1016		-181.7				
$[Co(NH_3)_2(NO_2)_4]^-$		aq	277.0164		-157.6				
$[Co(NH_3)_3(NO_2)_3]$		c	248.0415		-162.0				
	in 24000 H_2O	aq			-152.8				
$[Co(NH_3)_4(NO_2)_2]^+$	cis	aq	219.0666		-153.1				
	trans	aq			-152.7				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(8) COBALT

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$[Co(NH_3)_5NO_2]^{2+}$ std. state, m = 1	aq	190.0918		-146.6	-41.3		43.	
$[Co(NH_3)_5NO_3]^{2+}$	aq	206.0912		-162.8				
$[Co(NH_3)_6]OH^{2+}$ std. state, m = 1	aq	178.1242			-79.			
$NH_4[Co(NH_3)_2(NO_2)_4]$	c	295.0550		-200.2				
in 12000 H_2O	aq			-189.3				
$[Co(NH_3)_4(NO_2)_2]NO_3$ cis	c	281.0715		-214.8				
trans	c			-214.2				
in 8000 H_2O cis	aq			-202.7				
in 16000 H_2O trans	aq			-202.3				
$[Co(NH_3)_4(NO_3)H_2O](NO_3)_2$	c	331.0857		-318.6				
in 13000 H_2O	aq			-305.9				
$[Co(NH_3)_5NO_2](NO_3)_2$	c	314.1016		-260.2	-100.0		83.	
std. state, m = 1	aq			-245.7	-94.5		113.	
$[Co(NH_3)_5NO_3](NO_3)_2$	c	330.1010		-276.7				
in 18000 H_2O	aq			-261.9				
$[Co(NH_3)_5H_2O](NO_3)_3$	c	348.1163		-345.8				
	aq			-330.4				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(9) COBALT

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$[Co(NH_3)_6](NO_3)_3$		c	347.1316		-306.4	-126.8		112.	
std. state, m = 1		aq			-288.5	-118.7		145.	
$[Co(NH_3)_5H_2O][Co(NO_2)_6]$		c	497.0678		-354.5				
$[Co(NH_3)_6][Co(NO_2)_6]$		c	496.0831		-311.3				
$[Co(NH_3)_4(NO_2)_2][Co(NH_3)_2(NO_2)_4]$	cis	c	496.0831		-331.0				
	trans	c			-331.0				
	cis	aq			-310.7				
	trans	aq			-310.3				
$[Co(NH_3)_5NO_2][Co(NH_3)_2(NO_2)_4]_2$		c	744.1246		-483.2				
		aq			-461.8				
$[Co(NH_3)_6][Co(NH_3)_2(NO_2)_4]_3$		c	992.1661		-653.2				
		aq			-612.6				
$[Co(NH_3)_5NO_2]_3[Co(NO_2)_6]_2$		c	1240.2076		-787.2				
$[Co(NH_3)_5H_2O]F_3$		c	219.0968		-413.				
		aq			-406.6				
$CoCl_2 \cdot NH_3$		c	146.8698		-107.7				
$CoCl_2 \cdot 2NH_3$	rose	c	163.9004		-137.4				
$CoCl_2 \cdot 2N_2H_4$		c	193.9298		-91.1				

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Table 40(10) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — COBALT

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$[Co(NH_3)_4Cl_2]^+$	cis	aq	197.9616		-189.7				
	trans	aq			-191.5				
$[Co(NH_3)_4Cl_2]Cl$	cis	c	233.4146		-238.3				
	trans	c			-238.9				
	cis	aq			-229.7				
	trans	aq			-231.5				
$[Co(NH_3)_5Cl]^{2+}$	std. state, m = 1	aq	179.5392		-150.1	-69.8		81.6	
$[Co(NH_3)_5Cl]Cl_2$		c	250.4452	-229.26	-243.1	-139.3	10.95	87.5	57.2
	std. state, m = 1	aq			-230.0	-132.5		108.6	
	in 5000 H_2O	aq			-230.0				
$[Co(NH_3)_6]Cl^{2+}$	std. state, m = 1	aq	196.5699		-184.1	-67.0		28.	
$[Co(NH_3)_6]Cl_2$		c	232.0229		-238.0				
$[Co(NH_3)_6]Cl_3$		c	267.4759		-268.7				76.6
	std. state, m = 1	aq			-259.7	-133.0		80.	
$[Co(NH_3)_4(H_2O)_2]Cl_3$		c	269.4453		-384.6				
	in 10000 H_2O	aq			-378.8				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(11) COBALT

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$[Co(NH_3)_5H_2O]Cl_3$		c	268.4606	-291.92	-307.8	-186.0	11.97	82.7	65.9
		aq			-301.6				
$[Co(NH_3)_4(NO_2)_2]Cl$	cis	c	254.5196		-202.5				
	trans	c			-203.2				
	in 10000 H_2O cis	aq			-193.1				
	in 11000 H_2O trans	aq			-192.7				
$[Co(NH_3)_5NO_2]Cl_2$		c	260.9978		-236.1				
		aq			-226.5				
$[Co(NH_3)_5NO_3]Cl_2$		c	276.9972		-254.2				
		aq			-242.7				
$[Co(NH_3)_5NO_2](ClO_4)_2$		c	388.9930		-230.				
		aq			-208.4				
$[Co(NH_3)_6](ClO_4)_3$		c	459.4687		-247.3	-54.3		152.	
	std. state, m = 1	aq			-232.5	-45.1		170.	
$[Co(NH_3)_5Cl](NO_3)_2$		c	303.5490		-266.0				
	std. state, m = 1	aq			-249.2	-123.0		151.6	
	in 25000 H_2O	aq			-249.2				

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Table 40(12) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — COBALT

Substance: Formula and Description	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$[Co(NH_3)_5Cl][Co(NH_3)_2(NO_2)_4]_2$	c	733.5721		-496.				
	aq			-465.3				
$CoBr_2 \cdot NH_3$	c	235.7818		-85.1				
$CoBr_2 \cdot 2NH_3$ rose	c	252.8124		-116.0				
$CoBr_2 \cdot 2N_2H_4$	c	282.8418		-71.3				
$[Co(NH_3)_5Br]^{2+}$	aq	223.9952		-141.1				
$[Co(NH_3)_5Br]Br_2$	c	383.8132		-211.9				
in 19000 H_2O	aq			-199.2				
$[Co(NH_3)_6]Br^{2+}$ std. state, m = 1	aq	241.0259		-171.7	-60.5		39.	
$[Co(NH_3)_6]Br_2$	c	320.9349		-216.4				
$[Co(NH_3)_6]Br_3$	c	400.8439	-217.52	-239.7	-119.8	12.18	77.7	78.1
std. state, m = 1	aq			-227.0	-113.4		99.	
$[Co(NH_3)_5H_2O]Br_3$	c	401.8286		-278.1				
in 10000 H_2O	aq			-268.8				
$[Co(NH_3)_5NO_2]Br_2$	c	349.9098		-217.3				
	aq			-204.7				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(13) COBALT

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$[Co(NH_3)_5Cl]Br_2$		c	339.3572		-222.2				
	std. state, m = 1	aq			-208.2	-119.5		121.0	
	in 19000 H_2O	aq			-208.2				
$CoI_2 \cdot 2NH_3$	blue	c	346.8032		-83.				
$[Co(NH_3)_5I]I_2$		c	524.7994		-169.0				
$[Co(NH_3)_6]I^{2+}$	std. state, m = 1	aq	288.0213		-155.1	-48.6		51.	
$[Co(NH_3)_6]I_2$		c	414.9257		-189.9				69.1
$[Co(NH_3)_6]I_3$		c	541.8301		-194.8				74.3
	std. state, m = 1	aq			-179.4	-75.9		118.	
$[Co(NH_3)_5H_2O]I_3$		c	542.8148		-233.9				
		aq			-221.3				
$[Co(NH_3)_4(NO_2)_2]I$	cis	c	345.9710		-178.2				
	trans	c			-178.0				
	in 20000 H_2O trans	aq			-165.8				
$[Co(NH_3)_5NO_2]I_2$		c	443.9006		-185.4				
		aq			-173.0				
$[Co(NH_3)_5NO_3]I_2$		c	459.9000		-203.2				
		aq			-189.2				
$[Co(NH_3)_5I](NO_3)_2$		c	395.0004		-243.2				

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Table 40(14) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — COBALT

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$[Co(NH_3)_5I]Cl_2$		c	341.8966		-216.5				
$[Co(NH_3)_5Cl]I_2$		c	433.3480		-192.1				
	in 12000 H_2O	aq			-176.5				
$[Co(NH_3)_5H_2O]SO_4^+$		aq	258.1632		-399.3				
$[Co(NH_3)_5SO_4]^+$		aq	240.1478		-327.5				
$[Co(NH_3)_5SO_4]NO_3$		c	302.1528		-388.9				
	in 17000 H_2O	aq			-377.1				
$[Co(NH_3)_6]SO_4^+$	std. state, m = 1	aq	257.1785		-356.7	-221.4		61.	
$[Co(NH_3)_4(NO_2)_2]SO_4$	cis	c	534.1949		-542.2				
	trans	c			-539.1				
	cis	aq			-523.5				
	trans	aq			-522.7				
$[Co(NH_3)_5SO_4]I$		c	367.0522		-350.6				
	in 15000 H_2O	aq			-340.7				
Co_2P		c	148.8402		-45.				
$Co_3(PO_4)_2$		c	366.7424			-573.3			
$CoHPO_4$		c	154.9126			-282.5			

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Table 40(15) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — COBALT

Substance: Formula and Description	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$CoAs$	c	133.8548		-9.7				
$CoAs_2$	c	208.7764		-14.7				
Co_2As	c	192.7880		-9.5				
Co_2As_3	c	342.6312		-23.3				
Co_3As_2	c	326.6428		-19.4				
Co_5As_2	c	444.5092		-19.0				
$Co_3(AsO_4)_2$	c	454.6380			-387.4			
$CoSb$	c	180.683		-10.				
$CoSb_2$	c	302.433		-13.				
$CoSb_3$	c	424.183		-16.				
Co_2C	c	129.8776		10.				
$CoCO_3$	c	118.9426		-170.4				
CoC_2O_4	c	146.9531		-203.5				
std. state, m = 1	aq			-211.1	-174.1		-16.	
undissoc.; std. state, m = 1	aq			-210.5	-180.6		7.6	
$Co(C_2O_4)_2^{2-}$ std. state, m = 1	aq	234.9730		-408.5	-344.8		26.	
$[Co(C_2O_4)_3]^{3-}$	aq			-571.3				
$Co(HCO_2)$ cobaltous formate	c	148.9690		-208.7				

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Table 40(16) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — COBALT

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
				0°K	298.15°K (25°C)				
Formula and Description				kcal/mol				cal/deg mol	
$CoCl_2 \cdot 2C_2H_5OH$		c	221.9782		-218.8				
$CoCl_2 \cdot 3C_2H_5OH$		c	268.0478		-292.0				
$CoCl_2 \cdot 3C_2H_4(OH)_2$		c	316.0460		-419.0				
$CoBr_2 \cdot 2CH_3OH$		c	282.8361		-180.2				
$CoBr_2 \cdot 2C_2H_5OH$		c	310.8902		-197.1				
$CoBr_2 \cdot 2C_2H_4(OH)_2$		c	342.8890		-287.6				
$CoBr_2 \cdot 3C_2H_5OH$		c	356.9598		-269.6				
$CoBr_2 \cdot 3C_2H_4(OH)_2$		c	404.9580		-399.2				
$Co(C_2H_5OSO_3)_2$	in 1200 H_2O.	aq	309.1807		-432.2				
$Co(CN)_6^{3-}$	std. state, m = 1	aq	215.0403					55.6	
$Co(CNO)_2$	cobaltous cyanate	c	142.9677		-51.8				
$[Co(C_2H_4(NH_2)_2)]^{2+}$		aq	119.0327		-34.1				
$[Co(C_2H_4(NH_2)_2)_2]^{2+}$		aq	179.1321		-54.5				
$[Co(C_2H_4(NH_2)_2)_3]^{2+}$		aq	239.2316		-76.0				
$[Co(C_2H_4(NH_2)_2)_3]^{3+}$		aq			-72.6				

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Table 40(17) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — COBALT

Substance: Formula and Description	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$[Co(NH_3)_5CO_3]^+$	aq	204.0956		-273.1				
$[Co(NH_3)_5HCO_2]^{2+}$	aq	189.1042		-215.4				
$[Co(NH_3)_5CO_3]NO_3$ in 11500 H_2O	aq	266.1005		-322.6				
$[Co(NH_3)_5CO_3]NO_3 \cdot H_2O$	c	284.1158		-403.2				
$[Co(NH_3)_5HCO_2](NO_3)_2$	c	313.1140		-330.9				
in 20000 H_2O	aq			-314.5				
$Co(NH_2CH_2COO)^+$ std. state, m = 1	aq	132.9929		-129.0	-95.2		15.	
$[Co(NH_3)_2(NO_2)_2C_2O_4]^-$	aq	273.0253		-296.1				
$[Co(NH_3)_4C_2O_4]^+$	aq	215.0755		-312.7				
$NH_4[Co(NH_3)_2(NO_2)_2C_2O_4]$	c	291.0639		-337.4				
in 13000 H_2O	aq			-327.8				
$[Co(C_2H_4(NH_2)_2)(NH_3)(NO_2)_3]$	c	274.0798		-139.6				
$[Co(NH_3)_5NO_2]C_2O_4$	c	278.1116		-353.2				
$Co(NH_2CH_2COO)_2$ std. state, m = 1	aq	207.0527		-238.5	-163.6		30.	
undissoc.; std. state, m = 1	aq			-244.8	-175.9		50.	

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 40(18) COBALT

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$[Co(C_2H_4(NH_2)_2)_2(NO_2)_2]^+$ cis	aq	271.1431		-104.9				
$[Co(C_2H_4(NH_2)_2)_2(NO_2)_2]NO_3$ cis	c	333.1480		-164.8				
in 13000 H_2O cis	aq			-154.5				
$[Co(C_2H_4(NH_2)_2)_3](NO_3)_3$	c	425.2463		-236.5				
in 16000 H_2O	aq			-221.3				
$[Co(NH_3)_6][Co(C_2O_4)_3]\cdot 3H_2O$	c	538.1558		-933.8				
$[Co(C_2H_4(NH_2)_2)]Cl_2$	c	189.9387		-113.0				
$CoCl_2\cdot 3/2C_2H_4(NH_2)_2$	c	219.9884		-106.5				
$[Co(C_2H_4(NH_2)_2)_2Cl_2]^+$ cis	aq	250.0381		-117.6				
trans	aq			-119.4				
$[Co(C_2H_4(NH_2)_2)_2Cl_2]Cl$ cis	c	285.4911		-162.8				
trans	c			-161.9				
cis	aq			-157.6				
trans	aq			-159.4				
$[Co(C_2H_4(NH_2)_2)_2Cl_2]Cl\cdot HCl\cdot 6H_2O$ trans	c	430.0441		-610.8				
$[Co(C_2H_4(NH_2)_2)_2Cl_2]Cl\cdot NH_3$ cis	c	302.5217		-190.				
trans	c			-185.				

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Table 40(19) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — COBALT

Substance: Formula and Description	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$[Co(C_2H_4(NH_2)_2)_2Cl_2]Cl \cdot 2NH_3$ cis	c	319.5523		-213.				
trans	c			-208.				
$[Co(C_2H_4(NH_2)_2)_2Cl_2]Cl \cdot 4NH_3$ cis	c	353.6136		-256.				
trans	c			-247.				
$[Co(C_2H_4(NH_2)_2)_2Cl_2]Cl \cdot 6NH_3$ cis	c	387.6748		-296.				
$[Co(C_2H_4(NH_2)_2)_3]Cl_2$	c	310.1376		-156.7				
$[Co(NH_3)_5Cl]C_2O_4$	c	267.5592		-357.0				
$[Co(C_2H_4(NH_2)_2)_2Cl_2]NO_3$ trans	c	312.0430		-179.5				
in 15000 H_2O trans	aq			-169.0				
$[Co(C_2H_4(NH_2)_2)_3](ClO_4)_3$	c	537.5834		-182.3				
$[Co(C_2H_4(NH_2)_2)_3]Br_2$	c	399.0496		-142.4				
$[Co(C_2H_4(NH_2)_2)_3]I_2$	c	493.0404		-113.6				
$[Co(C_2H_4(NH_2)_2)_3]I_3$	c	619.9448		-124.1				
in 25000 H_2O	aq			-112.2				
$[Co(NH_3)_5HCO_2]I_2$	c	442.9130		-256.5				
in 12500 H_2O	aq			-241.8				

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Table 40(20) COBALT

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$CoCNS^+$ std. state, m = 1	aq	117.0150			7.0			
$Co(CNS)_2$	c	175.0969		24.2				
$[Co(NH_3)_5CNS](NO_3)_2$	c	326.1779		-217.3				
CoSi	c	87.0192	-23.87	-24.0	-23.6	1.78	10.3	10.6
$CoSi_2$	c	115.1052		-24.6				
$CoSi_3$	c	143.1912		-25.6				
Co_2Si	c	145.9524		-27.6				
Co_2SiO_4	c	209.9500		-353.				
CoSn	c	177.623		-7.0				
$Co(BO_2)_2$	c	144.5528			-325.8			
CoAl β′	c	85.9147		-26.4				
$CoAl_2$	c	112.8962		-31.8				
$CoAl_4$	c	166.8592		-38.5				
Co_2Al_5	c	252.7739		-70.0				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 41(1) IRON

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Fe	α	c	55.847	0	0	0	1.073	6.52	6.00
		g		98.94	99.5	88.6	1.6374	43.112	6.137
Fe^+		g		281.12	283.16				
Fe^{2+}		g		654.2	657.8				
	std. state, m = 1	aq			-21.3	-18.85		-32.9	
Fe^{3+}		g		1360.8	1365.9				
	std. state, m = 1	aq			-11.6	-1.1		-75.5	
$Fe_{0.947}O$	wustite	c	68.8865	-63.85	-63.64	-58.59	2.26	13.74	11.50
FeO		c	71.8464		-65.0				
FeO_2^{2-}	std. state, m = 1	aq	87.8458			-108.8			
Fe_2O_3	hematite	c	159.6922	-195.4	-197.0	-177.4	3.719	20.89	24.82
Fe_3O_4	magnetite	c	231.5386	-265.80	-267.3	-242.7	5.87	35.0	34.28
$FeOH^+$	std. state, m = 1	aq	72.8544		-77.6	-66.3		-7.	
$FeOH^{2+}$	std. state, m = 1	aq			-69.5	-54.83		-34.	
FeO(OH)	goethite	c	88.8538		-133.6				
$HFeO_2^-$	std. state, m = 1	aq				-90.3			
$Fe(OH)_2$	precipitated	c	89.8617		-136.0	-116.3		21.	
		g			-89.				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 41(2) IRON

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$Fe(OH)_2^+$	std. state, m = 1	aq				-104.7			
$Fe(OH)_3$	precipitated	c	106.8691		-196.7.	-166.5		25.5	
	undissoc.; std. state, m = 1	aq				-157.6			
$Fe(OH)_3^-$	std. state, m = 1	aq				-147.0			
$Fe(OH)_4^{2-}$	std. state, m = 1	aq	123.8765			-184.0			
$Fe_2(OH)_2^{4+}$	std. state, m = 1	aq	145.7087		-146.3	-111.68		-85.	
FeF^{2+}	std. state, m = 1	aq	74.8454		-88.7	-77.1		-39.	
FeF_2		c	93.8438				3.049	20.79	16.28
		aq			-178.1				
	std. state, m = 1	aq			-180.3	-152.13		-39.5	
FeF_2^+	std. state, m = 1	aq			-166.4	-150.2		-15.	
FeF_3		aq	112.8422		-242.9				
	std. state, m = 1	aq			-250.1	-201.0		-85.4	
	in 1,700 H_2O + 1,000 HF	aq			-248.				
$FeCl^{2+}$	std. state, m = 1	aq	91.300		-43.1	-34.4		-27.	
$FeCl_2$		c	126.753	-82.313	-81.69	-72.26	3.889	28.19	18.32
		g			-35.5				
	std. state, m = 1	aq			-101.2	-81.59		-5.9	

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 41(3) IRON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$FeCl_2$ in 25 H_2O	aq			-98.58				
50 H_2O	aq			-99.43				
100 H_2O	aq			-99.88				
250 H_2O	aq			-100.2				
500 H_2O	aq			-100.32				
1,000 H_2O	aq			-100.38				
8,000 H_2O	aq			-101.2				
$FeCl_2 \cdot 2H_2O$	c	162.7837		-227.8				
$FeCl_2 \cdot 4H_2O$	c	198.8143		-370.3				
$FeCl_2^+$ std. state, m = 1	aq				-66.7			
$FeCl_3$	c	162.206	-95.828	-95.48	-79.84	4.710	34.0	23.10
	g			-60.7				
std. state, m = 1	aq			-131.5	-95.2		-35.0	
undissoc.; std. state, m = 1	aq				-96.7			
in 600 H_2O	aq			-126.9				
1,500 H_2O	aq			-127.4				
2,000 H_2O	aq			-127.5				
15,000 H_2O	aq			-127.0				
25,000 H_2O	aq			-125.2				
50,000 H_2O	aq			-124.0				
70,000 H_2O	aq			-123.5				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 41(4) IRON

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$FeCl_3$ in 1,500 H_2O + 430 HCl				-105.2				
1,500 H_2O + 380 HCl				-107.1				
1,500 H_2O + 325 HCl				-109.3				
1,500 H_2O + 270 HCl				-111.8				
1,500 H_2O + 215 HCl				-115.0				
1,500 H_2O + 135 HCl				-118.9				
1,500 H_2O + 108 HCl				-120.4				
1,500 H_2O + 81.0 HCl				-121.9				
1,500 H_2O + 54.0 HCl				-123.6				
1,500 H_2O + 27.0 HCl				-125.4				
1,500 H_2O + 13.5 HCl				-126.4				
in C_2H_5OH				-112.9				
in $SiCl_4$; std. state, $x_2 = 1$				-89.1	-72.26		30.0	
$FeCl_3 \cdot 6H_2O$	c	270.2980		-531.5				
$(FeCl_2)_2$	g	253.506		-105.				
Fe_2Cl_6	g	324.412		-156.5				
FeOCl	c	107.2994		-90.1				
$FeClO_4^{2+}$ std. state, m = 1	aq	155.2976			-4.			
$Fe(ClO_4)_2$ std. state, m = 1	aq	254.7482		-83.1	-22.97		54.1	

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Table 41(5) IRON

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Fe(ClO_4)_2$ in 200 H_2O	aq			-82.7				
500 H_2O	aq			-83.0				
1,000 H_2O	aq			-83.1				
$Fe(ClO_4)_2 \cdot 6H_2O$	c	362.8402		-494.4				
$FeBr^{2+}$ std. state, m = 1	aq	135.756		-34.6	-26.8		-33.	
$FeBr_2$	c	215.665		-59.7				
	g			-11.				
std. state, m = 1	aq			-79.4	-68.55		6.5	
in 1,650 H_2O	aq			-80.4				
11,500 H_2O	aq			-79.8				
in 2N HCl				-78.9				
$FeBr_3$	c	295.574		-64.1				
	g			-29.6				
std. state, m = 1	aq			-98.8	-75.7		-16.4	
in 10,000 H_2O	aq			-93.3				
20,000 H_2O	aq			-92.7				
40,000 H_2O	aq			-89.0				
$(FeBr_2)_2$	g	431.330		-63.				
Fe_2Br_6	g	591.148		-94.3				

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Table 41(6) IRON

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$FeBrCl_2$		c	206.662		-83.4				
	std. state, m=1	aq			-120.6	-88.7		-28.8	
	in 10,000 H_2O	aq			-115.0				
	15,000 H_2O	aq			-114.1				
	20,000 H_2O	aq			-113.5				
	40,000 H_2O	aq			-112.3				
	50,000 H_2O	aq			-111.8				
FeI^{2+}	std. state, m=1	aq	182.7514			-16.0			
FeI_2		c	309.6558		-27.0				
		g			14.5				
	std. state, m=1	aq			-47.7	-43.51		20.3	
	in 2N HCl				-46.0				
FeI_3		g	436.5602		17.				
	std. state, m=1	aq			-51.2	-38.1		4.3	
Fe_2I_4		g	619.3116		7.				
Fe_2I_6		g	873.1204		4.				

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Table 41(7) IRON

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$Fe_{1.000}S$	Iron-rich pyrrhotite, σ	c	87.911	-24.01	-23.9	-24.0	2.235	14.41	12.08
FeS_2	pyrite	c	119.975	-41.72	-42.6	-39.9	2.302	12.65	14.86
	markasite	c			-37.0				
Fe_7S_8	sulfur-rich pyrrhotite	c	647.441	-177.68	-176.0	-178.9	17.62	116.1	95.26
$FeSO_4$		c	151.9086		-221.9	-196.2		25.7	24.04
	std. state, m = 1	aq			-238.6	-196.82		-28.1	
	in 200 H_2O	aq			-237.1				
	40,000 H_2O	aq			-237.8				
$FeSO_4^+$	std. state, m = 1	aq			-222.7	-184.7		-31.	
$FeSO_4 \cdot H_2O$		c	169.9239		-297.25				
$FeSO_4 \cdot 4H_2O$		c	223.9700		-508.9				
$FeSO_4 \cdot 7H_2O$		c	278.0160		-720.50	-599.97		97.8	94.28
$Fe(SO_4)_2^-$	std. state, m = 1	aq	247.9702			-364.4			

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 41(8) — IRON

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$Fe_2(SO_4)_3$		c	399.8788		-617.0				
	std. state, m=1	aq			-675.2	-536.1		-136.6	
	in 400 H_2O	aq			-653.0				
	1000 H_2O	aq			-653.2				
	2000 H_2O	aq			-653.4				
	3000 H_2O	aq			-653.6				
	in 1N $HClO_4$	aq			-669.				
	0.5N H_2SO_4				-667.				
$Fe(HSO_4)_3$	in 600 H_2O	aq	347.0557		-646.5				
FeSe		c	134.807		-18.0				
		amorp			-15.2				
$FeSe_2$		c	213.767				3.281	20.75	17.42
$Fe_{1.042}Se$		c	137.153				2.587	17.23+x	13.65
Fe_3Se_4		c	483.381				9.943	66.87	52.60
Fe_7Se_8		c	1022.609				20.93	146.7	105.7
FeTe		c	183.447		-15.0				
$FeTe_2$	ε phase	c	311.047				3.567	23.94	17.60
$Fe_{1.111}Te$	η phase	c	189.646				2.855	21.27+x	13.15

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Table 41(9) — IRON

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
FeN_3^{2+}	std. state, m = 1	aq	97.8671		52.6	75.5		-32.8	
Fe_4N		c	237.3947		-2.5	0.9		37.	
$Fe(NO)^{2+}$	std. state, m = 1	aq	85.8531		-2.2	19.8		-51.	
$Fe(NO_3)^{2+}$	std. state, m = 1	aq	117.8519			-29.1			
$Fe(NO_3)_3$		aq	241.8617		-161.3				
	std. state, m = 1	aq			-160.3	-80.9		29.5	
$Fe(NO_3)_3 \cdot 9H_2O$		c	403.9998		-785.2				
$FeNOCl_2$		aq	156.7591		-89.6				
$FeCl_2 \cdot NH_3$		c	143.7836		-114.8				
$FeCl_2 \cdot 2NH_3$		c	160.8142		-144.6				
$FeCl_2 \cdot 6NH_3$		c	228.9367		-237.5				
$FeCl_3 \cdot 6NH_3$		c	264.3897		-213.7				
$FeCl_2 \cdot 10NH_3$		c	297.0591		-308.9				
$FeBr_2 \cdot NH_3$		c	232.6956		-91.1				
$FeBr_2 \cdot 2NH_3$		c	249.7262		-121.5				

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Table 41(10) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
IRON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$FeBr_2 \cdot 6NH_3$	c	317.8487		-218.8				
$FeBr_3 \cdot 6NH_3$	c	397.7577		-197.1				
$FeI_2 \cdot 2NH_3$	c	343.7170		-92.1				
$FeI_2 \cdot 6NH_3$	c	411.8395		-193.2				
$Fe(NO)SO_4$	aq	181.9147		-225.8				
$FeSO_4 \cdot NH_3$	c	168.9392		-253.4				
$FeSO_4 \cdot 2NH_3$	c	185.9698		-282.3				
$FeSO_4 \cdot 3NH_3$	c	203.0004		-307.4				
$FeSO_4 \cdot 4NH_3$	c	220.0310		-332.0				
$FeSO_4 \cdot 6NH_3$	c	254.0923		-379.5				
FeP	c	86.8208		-30.				
FeP_2	c	117.7946		-46.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 41(11) IRON

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Fe_2P		c	142.6678		-39.				
Fe_3P		c	198.5148		-39.				
$FePO_4$		c	150.8184		-310.1				
$FePO_4 \cdot 2H_2O$	strengite	c	186.8491	-445.28	-451.3	-396.2	6.607	40.93	43.15
FeAsS		c	162.8326		-10.	-12.		29.	
FeSb		c	177.597		-2.4				
$FeSb_2$		c	299.347		-3.6				
Fe_3C	α, cementite	c	179.5522		6.0	4.8		25.0	25.3
$FeCO_3$	siderite	c	115.8564		-177.00	-159.35		22.2	19.63
$FeC_2O_4 \cdot 2H_2O$		c	179.8976		-354.3				
$Fe(CO)_5$		liq	195.8998		-185.0	-168.6		80.8	57.5
		g			-175.4	-166.65		106.4	

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 41(12) IRON

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Fe_2(C_2O_4)_3$ std. state, m=1	aq	375.7537		-614.8	-485.5		-118.3	
in 100 H_2O	aq			-611.8				
$Fe(HC_2O_4)_3$	aq	322.9306		-600.6				
$Fe(C_2H_3O_2)_3$ std. state, m=1	aq	232.9820		-360.1	-266.0		-13.4	
in 300 H_2O	aq			-352.2				
600 H_2O	aq			-351.9				
1,200 H_2O	aq			-351.4				
2,000 H_2O	aq			-350.6				
$Fe(CO)_4Br_2$	c	327.7072		-192.9				
in 1,700 H_2O	aq			-185.2				
$Fe(CO)_4I_2$	c	421.6980		-175.7				
$Fe(CN)_6^{3-}$ std. state, m=1	aq	211.9541		134.3	174.3		64.6	

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 41(13) IRON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Fe(CN)_6^{4-}$ std. state, m = 1	aq	211.9541		108.9	166.09		22.7	
$Fe_4[Fe(CN)_6]_3$	c	859.2503		283.				
$FeCO(CN)_5^{3-}$ std. state, m = 1	aq	213.9468		46.1				
$Fe_2CO(CN)_5$	c	269.7938		99.				
$Fe(NH_2CH_2CH_2NH_2)^{2+}$ in 1 N KCl	aq	115.9465		-39.7				
$HFe(CN)_6^{3-}$ std. state, m = 1	aq	212.9621		108.9	160.40		42.	
$H_2Fe(CN)_6^{2-}$ std. state, m = 1	aq	213.9700		108.9	157.37		52.	
$H_3Fe(CN)_6$	aq	214.9780		135.9				
$H_3Fe(CN)_6^-$ std. state, m = 1	aq			108.9				
$H_4Fe(CN)_6$	c	215.9860		110.6				
	aq			110.2				
$(NH_4)_4Fe(CN)_6$	aq	284.1084		-14.8				
$(NH_4)_4Fe(CN)_6 \cdot 6H_2O$	c	392.2005		-430.9				
$HFeCO(CN)_5^{2-}$ std. state, m = 1	aq	214.9548		46.0				

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Table 41(14) IRON

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$H_2FeCO(CN)_5^-$									
	std. state, m = 1	aq	215.9627		46.3				
$H_3FeCO(CN)_5$		aq	216.9707		47.				
$H_3FeCO(CN)_5 \cdot H_2O$		c	234.9860		-16.				
$Fe(SCN)^{2+}$	thiocyanate;								
	std. state, m = 1	aq	113.9288		5.6	17.0		-31.	
FeSi		c	83.933	-17.67	-17.6	-17.6	1.91	11.0	11.4
$FeSi_2$	β- lebeanite	c	112.019	-19.19	-19.4	-18.7	2.40	13.3	15.79
$FeSi_{2.33}$	α- lebeanite	c	121.287	-14.03	-14.	-14.	2.89	16.6	17.62
Fe_3Si		c	195.627	-22.55	-22.4	-22.6	4.14	24.8	23.50
Fe_5Si_3		c	363.493				8.26	50.1	47.7
$FeSiO_3$		c	131.9312		-288.				
Fe_2SiO_4	fayalite	c	203.7776		-353.7	-329.6		34.7	31.76
$2FeI_2 \cdot PbI_2$		c	1080.310		-101.6				
$Pb_2Fe(CN)_6 \cdot 3H_2O$		c	680.380			-40.2			

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Table 41(15) IRON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$FeAl$	c	82.8285		-12.0				
$FeAl_2$	c	109.8100		-18.9				
$FeAl_3$	c	136.7915		-18.9				
$FeAl_2O_4$	c	173.8076		-470.	-442.		25.4	29.53
$TlFe(CN)_6^{3-}$ std. state, m = 1	aq	416.324		111.1	154.1		70.0	
$Tl_4Fe(CN)_6 \cdot 2H_2O$	c	1065.465			6.3			
$ZnFe_2O_4$	c	241.062	-277.55	-279.5	-254.2	5.691	36.25	34.17
$Zn_2Fe(CN)_6 \cdot 2H_2O$	c	378.725			-39.0			
$CdFe_2O_4$	c	288.092		-255.7				
$Cd_2Fe(CN)_6 \cdot 7H_2O$	c	562.861			-291.6			
$CuFeO_2$ cuprous ferrite	c	151.386		-127.3	-114.7		21.2	19.13
$CuFe_2O_4$ cupric ferrite	c	239.232		-230.69	-205.26		33.7	35.52

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Table 41(16) IRON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Cu_{0.75}Fe_{2.25}O_4$	c	237.308					36.2	36.13
$Cu_2Fe(CN)_6$	c	339.034			176.0			
$Ag_4Fe(CN)_6 \cdot H_2O$	c	661.4494			123.0			
$NiFe_2O_4$	c	234.402	-256.23	-258.4	-232.6	5.274	31.5	34.80
$Ni_{0.1}Zn_{0.9}Fe_2O_4$	c	240.396				5.614	36.8	33.89
$Ni_{0.2}Zn_{0.8}Fe_2O_4$	c	239.730				5.745	36.9	34.72
$Ni_{0.3}Zn_{0.7}Fe_2O_4$	c	239.064				5.772	36.6	35.54
$Ni_{0.4}Zn_{0.6}Fe_2O_4$	c	238.398				5.740	35.8	35.90
$FeCo_2O_4$	c	237.7110				5.228	30.0	34.24
$CoFe_2O_4$	c	234.6248	-270.58	-272.4	-246.8	5.611	32.2	36.53

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 42(1) PALLADIUM

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
Pd		c	106.4	0	0	0	1.299	8.98	6.21
		g		90.2	90.4	81.2	1.481	39.90	4.968
Pd^+		g		282.436	284.117				
Pd^{2+}		g		730.5	733.6				
	std. state, m = 1	aq			40.5	42.2		-28.	
Pd^{3+}		g		1490.	1494.				
PdO		c	122.40		-20.4				7.5
		g			83.4	77.9		52.	
Pd_2H		c	213.81		-4.7				
$Pd(OH)_2$	precipitated	c	140.41		-89.0				
$Pd(OH)_4$	precipitated	c	174.43		-156.0				
$PdCl^+$	std. state, m = 1	aq	141.85		-4.	5.4		-11.	
$PdCl_2$		c	177.31		-41.0	-29.9		25.	
	undissoc.; std. state, m = 1	aq				-30.8			
$PdCl_3^-$	std. state, m = 1	aq	212.76			-66.0			
$PdCl_4^{2-}$	std. state, m = 1; in 1N HCl	aq	248.21		-124.8	-99.6		62.	
$PdCl_6^{2-}$	std. state, m = 1; in 1N HCl	aq	319.12		-143.	-102.8		65.	
H_2PdCl_4		aq	250.23		-125.2				

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Table 42(2) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — PALLADIUM

Substance: Formula and Description	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$PdBr_2$	c	266.22		-24.9				
$PdBr_3^-$ std. state, m = 1	aq	346.13			-48.8			
$PdBr_4^{2-}$ std. state, m = 1	aq	426.04		-88.8	-76.0		70.	
$PdBr_6^{2-}$ std. state, m = 1	aq	585.85			-80.1			
PdI_2	c	360.21		-15.2	-15.0		36.	
PdI_4^{2-} std. state, m = 1	aq	614.02			-38.0			
PdI_6^{2-} std. state, m = 1	aq	867.83			-40.7			
PdS	c	138.46		-18.	-16.		11.	
PdS_2	c	170.53		-19.4	-17.8		19.	
Pd_4S	c	457.66		-16.	-16.		43.	
PdTe	c	234.00				2.807	21.42	12.23
$PdTe_2$	c	361.60				4.086	30.25	18.31
$Pd(NO_2)_4^{2-}$ std. state, m = 1	aq	290.42			-21.1			
$Pd(NH_3)_4^{2+}$ std. state, m = 1	aq	174.52			-18.			

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 42(3) PALLADIUM

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$PdCl_2 \cdot 2NH_3$		c	211.37		-103.				
$PdCl_2 \cdot 4NH_3$		c	245.43		-156.5				52.3
$Pd(N_3)_2Cl_2^{2-}$	std. state, m = 1	aq	261.35			133.			
$PdI_2 \cdot 2NH_3$		c	394.27		-71.				
$PdI_2 \cdot 4NH_3$		c	428.33		-119.2				
PdSb		c	228.15						11.9
$PdSb_2$		c	349.90						17.2
Pd_3Sb		c	440.95						23.2
$PdCl_3(C_2H_4)^-$	std. state, m = 1	aq	240.81		-81.8	-47.5		55.	
$Pd(CN^+$	std. state, m = 1	aq	132.42			69.			
$Pd(CN)_2$		c	158.44		56.9				
$Pd(CN)_4^{2-}$	std. state, m = 1	aq	210.47			+150.			
$Pd(CNS)_2$		c	222.56			56.0			
	undissoc.; std. state, m = 1	aq				75.1			
$Pd(CNS)_4^{2-}$	std. state, m = 1	aq	338.73			98.1			
$PdI_2(CNS)^-$	std. state, m = 1	aq	418.29			7.8			
AuPd		g	303.37	146.	145.10		1.83		8.8

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 43(1) RHODIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Rh	c	102.905	0	0	0	1.174	7.53	5.97
	g		132.79	133.1	122.1	1.483	44.383	5.022
Rh^+	g		304.90	306.69				
Rh^{++}	g		721.8	725.0				
Rh^{3+}	g		1438.	1443.				
RhO	g	118.9044		92.				
RhO^+	g			308.				
RhO_2	g	134.9038		44.				
RhO_2^+	g			216.				
Rh_2O_3	c	253.8082		-82.				24.8
$RhCl_2$	g	173.811		30.3				
$RhCl_3$	c	209.264		-71.5				
	g			16.0				
$RhCl_6^{3-}$	aq	315.623		-202.8				
$RhCl_3 \cdot 3(C_2H_5)_2S$	c	479.8289		-166.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 44(1) RUTHENIUM

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Ru	c	101.07	0	0	0	1.100	6.82	5.75
	g		153.210	153.6	142.4	1.490	44.550	5.144
Ru^+	g		323.07	324.94				
Ru^{++}	g		709.6	713.0				
Ru^{3+}	g		1366.0	1370.9				
RuO_2	c	133.069		-72.9				
hydrated	amorp				-51.3			
RuO_3	g	149.068		-18.7				
RuO_4	c	165.068		-57.2	-36.4		35.0	
	liq			-54.6	-36.4		43.8	
	g		-42.51	-44.0	-33.4	3.76	69.3	18.14
std. state, m = 1	aq			-57.3	-35.2		31.	
RuO_4^- std. state, m = 1	aq				-58.7			
RuO_4^{2-} std. state, m = 1	aq				-72.6			
$Ru(OH)_2^{2+}$ std. state, m = 1	aq	135.085			-51.			
RuF_5	c	196.062		-213.4				
	g			-189.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 44(2) RUTHENIUM

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$RuCl_3$	black	c	207.429		-49.				
		g			-0.3				
$RuCl_4$		g	242.882		-12.4				
$RuCl_5(OH)^{2-}$	std. state, m = 1	aq	295.342			-168.7			
$RuBr_3$		c	340.797		-33.				
RuI_3		c	481.783		-15.7				
RuS_2		c	165.198		-47.				
$RuCl_3 \cdot 3(C_2H_5)_2S$		c	477.994		-151.				
$(RuCl_3 \cdot 2(C_2H_5)_2S)_2$		c	775.611		-260.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 45(1). PLATINUM

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
Pt		c	195.09	0	0	0	1.372	9.95	6.18
		g		134.90	135.1	124.4	1.572	45.960	6.102
Pt^+		g		341.6	343.3				
Pt^{++}		g		769.7	772.9				
	std. state, m=1	aq				44.4			
PtO_2		g	227.089		41.0	40.1	62.		
Pt_3O_4		c	649.268		-39.				
$Pt(OH)_2$		c	229.105		-84.1				
PtF_6	cubic	c	309.080					56.3	
		g					5.678	83.23	29.35
PtCl		c	230.543		-9.				
$PtCl_2$		c	265.996		-26.5				
	std. state, m=1	aq				-18.3			
	undissoc., std. state, m=1	aq				-19.1			
$PtCl_3$		c	301.449		-41.6				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 45(2)

PLATINUM

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$PtCl_3^-$ std. state, m=1	aq				-54.6			
$PtCl_4$	c	336.902		-56.5				
	aq			-76.2				
$PtCl_4 \cdot 5H_2O$	c	426.979		-419.9				
$PtCl_4^{2-}$ std. state, m=1	aq	336.902		-120.3	-88.1		40.	
$PtCl_6^{2-}$ std. state, m=1	aq	407.808		-161.	-117.		52.6	
$HPtCl_5 \cdot 2H_2O$	c	409.394		-243.3				
H_2PtCl_6 std. state, m=1	aq	409.824		-161.	-117.		52.6	
$H_2PtCl_6 \cdot 6H_2O$	c	517.916		-566.1				
$[PtCl_2(OH)_2]^{2-}$ std. state, m = 1	aq	300.011			-114.2			
$[PtCl_2(OH)(H_2O)]^-$ std. state, m = 1	aq	301.019			-125.5			
$[PtCl_2(H_2O)_2]$ undissoc.; std. state, m = 1	aq	302.027			-132.5			
$[PtCl_3(OH)]^{2-}$ std. state, m = 1	aq	318.456			-101.8			
$[PtCl_3(H_2O)]^-$ std. state, m = 1	aq	319.464			-111.3			

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 45(3) PLATINUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$PtBr$	c	274.999		-11.				
$PtBr_2$	c	354.908		-23.1				
$PtBr_3$	c	434.817		-30.9				
$PtBr_4$	c	514.726		-38.0				
	aq			-48.0				
$PtBr_4^{2-}$	aq			-89.				
$PtBr_6^{2-}$	aq	674.544		-114.				
H_2PtBr_6	aq	676.560		-114.				
$H_2PtBr_6 \cdot 9H_2O$	c	838.698		-731.6				
PtI_4	c	702.708		-17.4				
PtI_6^{2-}	aq	956.516		-51.				
H_2PtI_6	aq	958.532		-51.				
PtS	c	227.154	-18.720	-19.5	-18.2	1.646	13.16	10.37
PtS_2	c	259.218	-25.333	-26.0	-23.8	2.813	17.85	15.75

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 45(4) PLATINUM

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
PtTe		c	322.69				2.642	19.41	11.93
$PtTe_2$		c	450.29				4.086	30.25	18.31
$[Pt(NH_3)_3]^{2+}$	std. state, m=1	aq	246.182			1.1			
$[Pt(NH_3)_4]^{2+}$	std. state, m=1	aq	263.212		-87.1	-13.5		10.7	
$[Pt(NH_3(OH)_2]$	cis, undissoc.; std. state, m=1	aq	263.166			-80.8			
$[Pt(NH_3)_2(OH)H_2O]^+$	cis, std. state, m=1	aq	264.174			-90.7			
$[Pt(NH_3)_2(H_2O)_2]^{2+}$	cis, std. state, m=1	aq	265.182			-98.2			
$[Pt(NH_3)_4(OH)_2]$		aq	297.227		-197.0				
$[Pt(NH_3)_4(NO_3)_2]$		c	387.222		-200.6				
$[Pt(NH_3)Cl_3]^-$	std. state. m=1	aq	318.480		-111.5	-73.3		47.	
$[Pt(NH_3)Cl_5]^-$	std. state, m=1	aq	389.386			-104.2			
$[Pt(NH_3)_2Cl_2]$	cis	c	300.057		-112.3				35.5
	trans	c			-115.5				35.5

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 45(5) — PLATINUM

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$[Pt(NH_3)_2Cl_2]$	cis, undissoc.; std. state, m = 1	aq				-55.6			
	trans, undissoc.; std. state, m = 1	aq				-54.1			
$NH_4[Pt(NH_3)Cl_3]$		c	336.518		-150.0				44.5
$[Pt(NH_3)_2Cl_4]$	cis, undissoc.; std. state, m = 1	aq	370.963			-87.0			
	trans, undissoc.; std. state, m = 1	aq				-85.4			
$(NH_4)_2PtCl_4$		c	372.979		-192.0				56.8
		aq			-183.6				
$[Pt(NH_3)_3Cl]^+$	std. state, m = 1	aq	281.635		-95.4	-35.1		28.	
$[Pt(NH_3)_3Cl]Cl$		c	317.088		-144.9				43.8
$[Pt(NH_3)_3Cl_3]^+$	std. state, m = 1	aq	352.541			-68.5			
$[Pt(NH_3)_4]Cl_2$		c	334.118		-174.0				53.4
		aq			-167.0				
$[Pt(NH_3)_4]Cl_2 \cdot H_2O$		c	352.134		-243.6				
$[Pt(NH_3)_4Cl_2]^{2+}$	std. state, m = 1	aq	334.118			-48.8			
$PtCl_2 \cdot 5NH_3$		c	351.149		-195.3				

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Table 45(6) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — PLATINUM

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$[Pt(NH_3)_4][PtCl_4]$	rose	c	600.114						66.7
	green	c							72.3
$[Pt(NH_3)_3Cl][Pt(NH_3)Cl_3]$		c	600.114		-224.9				67.0
$[Pt(NH_3)_4][Pt(NH_3)Cl_3]_2$		c	900.172		-339.4				105.
$[Pt(NH_3)_3Cl]_2[PtCl_4]$		c	900.172		-343.4				101.
$[Pt(NH_3)Cl_2(H_2O)]$	cis, undissoc.; std. state, m = 1	aq	301.042		-137.8	-94.7		44.	
	trans, undissoc.; std. state, m = 1	aq				-96.0			
$[Pt(NH_3)Cl(H_2O)_2]^+$	std. state, m = 1	aq	283.604			-114.0			
$[Pt(NH_3)_2Cl(H_2O)]^+$	cis, std. state, m = 1	aq	282.620			-77.5			
	trans, std. state, m = 1	aq				-74.6			
$[Pt(NH_3)_3Cl]ClO_4$		c	381.085		-138.7				
$[Pt(NH_3)_4Br_2]^{2+}$	std. state, m = 1	aq	423.030			-36.5			
$[Pt(NH_3)_2I_2]$	cis, undissoc.; std. state, m = 1	aq	482.960			-22.6			
	trans, undissoc.; std. state, m = 1	aq				-21.9			
$[Pt(NH_3)_4]I_2$		c	517.021		-128.4				
$[Pt(NH_3)_4I_2]^{2+}$	std. state, m = 1	aq				-18.3			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 45(7) PLATINUM

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$[Pt(NH_3)_4]SO_4$		aq	359.274		-303.9				
$[Pt(CN_4)]^{2-}$	std. state, m=1	aq	299.161			168.9			
$[Pt(CH_3NH_2)_2Cl]^+$	cis, std. state, m=1	aq	292.658			0.3			
	trans, std. state, m = 1	aq				1.7			
$[Pt(CH_3NH_2)_2Cl_2]$	cis, undissoc.; std. state, m=1	aq	328.111			-34.4			
	trans, undissoc.; std. state, m=1	aq				-34.7			
$[Pt(CH_3NH_2)_2I_2]$	cis, undissoc.; std. state, m=1	aq	511.014			-2.1			
	trans, undissoc.; std. state, m=1	aq				-1.4			
Ag_2PtCl_6		c	623.548		-124.5				
Ag_2PtBr_6		c	890.294		-95.1				

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Table 46(1) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — IRIDIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Ir	c	192.2	0	0	0	1.260	8.48	6.00
	g		158.78	159.0	147.7	1.481	46.240	4.968
Ir^+	g		373.	375.				
IrO_2	c	224.20		-65.5				13.7
IrO_3	g	240.20		1.9				
IrO_3^+	g			278.				
IrF_6	c	306.19		-138.54	-110.34		59.2	
	g		-128.0	-130.	-110.	5.59	85.5	28.94
IrCl	c	227.65		-19.5				
$IrCl_3$	c	298.56		-58.7				
$IrCl_6^{2-}$	aq	404.92		-148.1				
$IrCl_6^{3-}$	aq			-179.5				
IrS_2	c	256.33		-33.				
Ir_2S_3	c	480.59		-56.				
$IrCl_3 \cdot 3(C_2H_5)_2S$	c	569.12		-155.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 47(1) OSMIUM

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
Os		c	190.2	0	0	0		7.8	5.9
		g			189.	178.	1.481	46.000	4.968
Os^+		g			391.91				
Os^{2+}		g			785.				
OsO_3		g	238.20		-67.8				
OsO_3^+		g			217.				
OsO_4	yellow	c	254.20		-94.2	-72.9		34.4	
	white	c			-92.2	-72.6		40.1	
		g			-80.6	-70.0	3.70	70.2	17.7
	undissoc.; std. state, m = 1	aq			-90.4	-72.16		44.6	
	in CCl_4; std. state, X = 1					-72.35			
OsO_4^+		g			211.				
$HOsO_5^-$	std. state, m = 1	aq	271.20			-112.4			
$H_2OsO_5^-$	undissoc.; std. state, m = 1	aq	272.21			-128.84			
$Os(OH)_4$		amorp	258.23			-161.0			

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Table 47(2) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — OSMIUM

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
OsF_6 cubic	c	304.19					58.8	
	g					5.559	85.56	28.88
$OsCl_3$	c	296.56		-45.5				
$OsCl_4$	c	332.01		-60.9				
	g			-19.				
OsS_2	c	254.33		-34.9				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 48(1) MANGANESE

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
Mn	α	c	54.9380	0	0	0	1.194	7.65	6.29
	β	c					1.234	8.22	6.34
	γ	c		.343	.37	.34	1.221	7.75	6.59
		g		66.77	67.1	57.0	1.481	41.49	4.97
Mn^+		g		238.20	240.0				
Mn^{++}		g		598.87	602.1				
	std. state, m = 1	aq			-52.76	-54.5		-17.6	12.
Mn^{+++}		g		1376.	1381.				
MnO		c	70.9374		-92.07	-86.74		14.27	10.86
		g		29.8	29.6		2.12		
MnO_2		c	86.9368		-124.29	-111.18		12.68	12.94
	precipitated	amorp			-120.1				
MnO_4^-	std. state, m = 1	aq	118.9356		-129.4	-106.9		45.7	
MnO_4^{2-}	std. state, m = 1	aq			-156.	-119.7		14.	
Mn_2O_3		c	157.8742		-229.2	-210.6		26.4	25.73
Mn_3O_4		c	228.8116		-331.7	-306.7		37.2	33.38
MnH		g	55.9460				2.077	51.03	7.035
Mn^2H		g	56.9521				2.091	52.47	7.264

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 48(2) MANGANESE

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
MnOH		g	71.9454	3.0					
$MnOH^+$	std. state, m = 1	aq			-107.7	-96.8		-4.	
$Mn(OH)_2$	precipitated	amorp	88.9527		-166.2	-147.0		23.7	
$Mn(OH)_3^-$	std. state, m = 1	aq	105.9601			-177.9			
MnF		g	73.9364	-5.	-5.2				
MnF^+		aq				-122.3			
MnF_2		c	92.9348				3.11	22.05	15.96
	in 1200 H_2O	aq			-209.7				
MnCl		g	90.3910	10.54	10.1		2.28		8.05
$MnCl^+$		aq				-86.7			
$MnCl_2$		c	125.8440	-115.245	-115.03	-105.29	3.602	28.26	17.43
		g			-63.0				
	std. state, m = 1	aq			-132.66	-117.3		9.3	-53.
	in 40 H_2O	aq			-130.45				
	100 H_2O	aq			-131.23				
	200 H_2O	aq			-131.64				
	500 H_2O	aq			-132.00				
	1000 H_2O	aq			-132.16				
	2000 H_2O	aq			-132.27				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 48(3) MANGANESE

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$MnCl_2$ in 5000 H_2O	aq			-132.39				
∞ H_2O	aq			-132.66				
undissoc.; std. state, m = 1	aq				-117.6			
$MnCl_2 \cdot H_2O$	c	143.8593		-188.8	-166.4		41.6	
$MnCl_2 \cdot 2H_2O$	c	161.8747		-261.0	-225.2		52.3	
$MnCl_2 \cdot 4H_2O$	c	197.9054		-403.3	-340.3		72.5	
$MnCl_3^-$ std. state, m = 1	aq	161.2970			-148.2			
MnBr	g	134.8470	20.8	19.1				
$MnBr_2$	c	214.7560		-92.0				
std. state, m = 1	aq			-110.9				
$MnBr_2 \cdot H_2O$	c	232.7713		-168.5				
$MnBr_2 \cdot 4H_2O$	c	286.8174		-380.1				
MnI	g	181.8424	25.7	25.5				
MnI_2 std. state, m = 1	aq	308.7468		-79.1				
$MnI_2 \cdot 2H_2O$	c	344.7748		-201.4				
$MnI_2 \cdot 4H_2O$	c	380.8082		-34.39				
$Mn(IO_3)_2$	c	404.7432		-160.	-124.4		63.	

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Table 48(4) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — MANGANESE

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
MnS	green	c	87.0020		-51.2	-52.2		18.7	11.94
	precipitated, pink	amorp			-51.1				
$MnSO_4$		c	150.9996		-254.60	-228.83		26.8	24.02
	std. state, m = 1	aq			-270.1	-232.5			
	in 20 H_2O	aq			-267.58				
	30 H_2O	aq			-268.02				
	50 H_2O	aq			-268.18				
	100 H_2O	aq			-268.33				
	200 H_2O	aq			-268.49				
	400 H_2O	aq			-268.64				
	1,000 H_2O	aq			-268.85				
	2,000 H_2O	aq			-269.07				
	3,000 H_2O	aq			-269.14				
	5,000 H_2O	aq			-269.26				
	10,000 H_2O	aq			-269.40				
	20,000 H_2O	aq			-269.53				
	50,000 H_2O	aq			-269.68				
	100,000 H_2O	aq			-269.77				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 48(5) MANGANESE

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0°K	298.15°K (25°C)				
Formula and Description			kcal/mol				cal/deg mol	
$MnSO_4$ in ∞ H_2O	aq			-270.1				
undissoc.; std. state, m = 1	aq			-266.7	-235.6		8.7	
$MnSO_4 \cdot H_2O$ α	c	169.0149		-329.0				
β	c			-322.2				
$MnSO_4 \cdot 4H_2O$	c	223.0610		-539.7				
$MnSO_4 \cdot 5H_2O$	c	241.0763		-610.2				78.
$MnSO_4 \cdot 7H_2O$	c	277.1070		-750.3				
$MnS_2O_6 \cdot 2H_2O$	c	251.0931					66.7	57.68
$MnS_2O_6 \cdot 6H_2O$	c	323.1544		-751.0				
MnSe	c	133.898		-25.5	-26.7		21.7	12.20
MnTe	c	182.538					22.4	17.49
MnN_6 manganese azide	c	138.9782		92.2				
Mn_3N_2	c	302.7034		-48.8				
Mn_8N_2 $2Mn_4N$	c	467.5174		-61.5				
$Mn(NO_3)_2$	c	178.9478		-137.73				
std. state, m = 1	aq			-151.9	-107.8		52.	-29.

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Table 48(6) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — MANGANESE

Substance		Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State		0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Mn(NO_3)_2$ in 2.5 H_2O	aq			-142.93				
3 H_2O	aq			-143.99				
4 H_2O	aq			-145.53				
5 H_2O	aq			-146.61				
6 H_2O	aq			-147.38				
8 H_2O	aq			-148.42				
10 H_2O	aq			-149.08				
15 H_2O	aq			-150.05				
25 H_2O	aq			-150.86				
50 H_2O	aq			-151.46				
100 H_2O	aq			-151.80				
200 H_2O	aq			-151.94				
400 H_2O	aq			-152.01				
1,000 H_2O	aq			-152.06				
2,000 H_2O	aq			-152.08				
5,000 H_2O	aq			-152.10				
$Mn(NO_3)_2 \cdot 6H_2O$ glassy	amorp	287.0398		-566.9				
	liq			-557.27				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 48(7) MANGANESE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$MnCl_2 \cdot 2NH_4Cl \cdot 2H_2O$	c	268.8578		-412.2				
$MnBr_2 \cdot NH_3$	c	231.7866		-124.1				
$MnBr_2 \cdot 2NH_3$	c	248.8172		-154.7				
$MnBr_2 \cdot 6NH_3$	c	316.9397		-250.				
$(NH_4)_2Mn(SO_4)_2 \cdot 6H_2O$	c	391.2304		967.3				
MnP	c	85.9118		-27.				
MnP_3	c	147.8594		-51.				
$Mn_3(PO_4)_2$	c	354.7568		-744.9				
$MnHPO_4$	c	150.9174			-332.5			
MnAs	c	129.8596		-14.				
$Mn_3(AsO_4)_2$	c	442.6524		-512.8				
$MnHAsO_4$	c	194.8652		-263.5				
MnSb	c	176.688		-12.				
MnBi	c	263.9180		-5.				
Mn_3C	c	176.8252		1.1	1.3		23.6	22.33
Mn_7C_3	c	420.5995		-10.				

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Table 48(8) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — MANGANESE

Substance: Formula and Description	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$MnCO_3$ natural	c	114.9474		-213.7	-195.2		20.5	19.48
precipitated	c			-211.1				
MnC_2O_4	c	142.9579		-259.7				
undissoc.; std. state, m = 1	aq			-248.5	-221.0		16.1	
$MnC_2O_4 \cdot 2H_2O$	c	178.9886		-390.2	-338.2		45.	
$MnC_2O_4 \cdot 3H_2O$	c	197.0039		-457.0				
$Mn(C_2O_4)_2^{2-}$ std. state, m = 1	aq	230.9778		-447.4	-384.1		28.	
$Mn_2(CO)_{10}$	c	389.9815		-401.0				
	g			-386.0				
$MnHCO_3^-$	aq	115.9553			-196.			
$Mn(CHO_2)_2$	c	144.9738		-249.7				
	aq			-254.2				
$Mn(CHO_2)_2 \cdot 2H_2O$	c	181.0045		-393.2				
$Mn(C_2H_3O_2)^+$ std. state, m = 1	aq	113.9830			-144.7			
$Mn(C_2H_3O_2)_2$	c	173.0280		-274.4				
	aq			-286.6				
$Mn(C_2H_3O_2)_2 \cdot 4H_2O$	c			-558.8				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 48(9) MANGANESE

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$MnCl_2 \cdot CH_3OH$	c	157.8864		-177.3				
$MnCl_2 \cdot 2CH_3OH$	c	189.9289		-237.8				
$MnCl_2 \cdot 3CH_3OH$	c	221.9713		-294.7				
$MnBr_2 \cdot C_2H_5OH$	c	260.8255		-158.9				
$Mn(CN)_6^{4-}$	aq	211.0451		133.				
$MnCNS^+$ std. state, m = 1	aq	113.0200			-33.8			
$Mn(CNS)_2$ undissoc.; std. state, m = 1	aq	171.1017			-12.0			
$Mn(NH_2CH_2CH_2NH_2)^{2+}$	aq	115.0375		-68.9				
$Mn(NH_2CH_2CH_2NH_2)_2^{2+}$	aq	175.1369		-85.4				
$Mn(NH_2CH_2CH_2NH_2)_3^{2+}$	aq	235.2364		-103.8				
$MnSiO_3$	c	131.0222		-315.7	-296.5		21.3	20.66
glassy	amorp			-307.2				
Mn_2SiO_4	c	201.9596		-413.6	-390.1		39.0	31.04
$Pb(MnO_4)_2 \cdot 3PbO$	c	1114.629			-393.			
$Zn(MnO_4)_2$ std. state, m = 1	aq	303.241						-60.

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 48(10) MANGANESE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$MnFe_2O_4$	c	230.6296		-293. .				
$Mn_2Fe(CN)_6$	c	321.8301			38.8			

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 49(1) TECHNETIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Tc	c	98.906	0	0	0			
	g			162.		1.481	43.25	4.97
Tc^+	g			331.				
Tc_2O_7	c	309.8078		-266.				
$HTcO_4$	c	163.9115		-167.				
std. state, m = 1	aq			-173.				

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Table 50(1) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — RHENIUM

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Re	c	186.2	0	0	0	1.296	8.81	6.09
	g		183.8	184.0	173.2	1.481	45.131	4.968
Re^+	g		365.5	367.1				
std. state, m = 1	aq				-8.			
Re^- std. state, m = 1	aq			11.	2.4		55.	
ReO_2	c	218.20			-88.			
$ReO_2 \cdot 2H_2O$ precipitated	c	254.23		-236.				
ReO_3	c	234.20		-144.6				
ReO_4^- std. state, m = 1	aq	250.20		-188.2	-166.0		48.1	-3.2
Re_2O_7	c	484.40	-293.8	-296.4	-254.8	7.246	49.5	39.7
	g			-263.	-237.6		108.	
$HReO_4$	c	251.21		-182.2	-156.9		37.8	
	g			-159.				
std. state, m = 1	aq			-188.2	-166.0		48.1	-3.2
in 2,000 H_2O	aq			-188.145				
3,000 H_2O	aq			-188.142				
5,000 H_2O	aq			-188.142				
10,000 H_2O	aq			-188.145				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 50(2) RHENIUM

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$HReO_4$									
	in 50,000 H_2O	aq			-188.156				
	∞ H_2O	aq			-188.2				
$ReCl_3$		c	292.56	-62.73	-63.	-45.	4.319	29.6	22.08
$ReCl_5$		c	363.47		-89.				
		g			-76.				
$ReCl_6^{2-}$	std. state, m = 1	aq	398.92		-182.	-141.		60.	
Re_3Cl_9		g	877.68		-137.				
H_2ReCl_4		c	330.03		-152.				
$ReBr_3$		c	425.93		-40.				
Re_3Br_9		g	1277.78		-69.				
NH_4ReO_4		c	268.24		-226.0	-185.2		55.6	
ReS_2		c	250.33		-43.				
Re_2S_7		c	596.85		-107.				
$ReAs_2$		c	336.04		1.3				
Re_3Si		c	586.69		0.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 50(3) RHENIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Pb(ReO_4)_2 \cdot 2H_2O$	c	743.62		-534.	-455.		74.	
$AgReO_4$	c	358.07		-176.	-151.9		36.6	

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Table 51(1) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
CHROMIUM

Substance: Formula and Description	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Cr	c	51.996	0	0	0	0.970	5.68	5.58
	g		94.29	94.8	84.1	1.481	41.68	4.97
Cr^+	g		250.30	252.29				
Cr^{2+}	g		630.7	634.2				
std. state, m = 1	aq			-34.3				
Cr^{3+}	g		1345.	1350.				
Cr^{4+}	g		2488.	2495.				
Cr^{5+}	g		4174.	4182.				
Cr^{6+}	g		6264.	6273.				
Cr^{7+}	g		9980.	9991.				
CrO	g	67.9954	53.					
CrO_2	c	83.9948		-143.				
	g		-14.					
CrO_3	c	99.9942		-140.9				
	g			-92.2				
in 2 H_2O	aq			-142.17				
3 H_2O	aq			-142.46				
4 H_2O	aq			-142.67				
5 H_2O	aq			-142.83				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 51(2) CHROMIUM

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
CrO_3 in 6 H_2O	aq			-142.94				
8 H_2O	aq			-143.12				
10 H_2O	aq			-143.23				
15 H_2O	aq			-143.40				
25 H_2O	aq			-143.58				
50 H_2O	aq			-143.68				
80 H_2O	aq			-143.7				
CrO_4^{2-} std. state, m = 1	aq	115.9936		-210.60	-173.96		12.00	
Cr_2O_3	c	151.9902		-272.4	-252.9		19.4	28.38
$Cr_2O_3 \cdot H_2O$	c	170.0055		-360.				
$Cr_2O_3 \cdot 2H_2O$	c	188.0209		-441.				
$Cr_2O_3 \cdot 3H_2O$	c	206.0362		-519.				
$Cr_2O_7^{2-}$ std. state, m = 1	aq	215.9878		-356.2	-311.0		62.6	
Cr_3O_4	c	219.9856		-366.				
Cr_7H_2	c	365.9879		-3.8				
$HCrO_4^-$ std. state, m = 1	aq	117.0016		-209.9	-182.8		44.0	

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 51(3) CHROMIUM

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_2CrO_4 in 1 H_2O	aq	118.0095		-210.49				
2 H_2O	aq			-210.78				
3 H_2O	aq			-210.99				
4 H_2O	aq			-211.15				
5 H_2O	aq			-211.26				
7 H_2O	aq			-211.44				
9 H_2O	aq			-211.55				
25 H_2O	aq			-211.90				
80 H_2O	aq			-212.0				
$CrO_2(OH)_2$	g	118.0095		-174.				
$Cr(OH)_3$ precipitated	c	103.0181		-254.3				
$[Cr(H_2O)_4(OH)_2]^+$	aq	158.0721		-455.8				
$[Cr(H_2O)_5OH]^{2+}$	aq	159.0801		-463.6				
$[Cr(H_2O)_4(OH)_2]OH$	c	175.0795		-514.4				
$[Cr(H_2O)_6]^{3+}$	aq	160.0880		-477.8				
$[Cr(H_2O)_5OH](OH)_2$	c	193.0948		-586.7				
CrF_2	c	89.9928		-186.				
	g			-99.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 51(4) CHROMIUM

Substance: Formula and Description	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CrF_3	c	108.9912	-276.22	-277.	-260.	3.357	22.44	18.82
CrF_4	c	127.9896		-298.				
$[Cr(H_2O)_6]F_3$	aq	217.0832		-714.2				
$[Cr(H_2O)_6](HF_2)_3$	aq	277.1024		-943.7				
$CrCl_2$	c	122.902	-94.93	-94.5	-85.1	3.593	27.56	17.01
	g			-30.7				
	aq			-114.2				
$CrCl_2 \cdot 2H_2O$ light green	c	158.9327		-237.1				
$CrCl_2 \cdot 3H_2O$ pale blue	c	176.9480		-308.9				
$CrCl_2 \cdot 4H_2O$ dark blue	c	194.9634		-384.4				
$CrCl_3$	c	158.355	-132.96	-133.0	-116.2	4.22	29.4	21.94
$CrCl_4$	g	193.808		-102.				
$(CrCl_2)_2$	g	245.804		-111.				
CrO_2Cl_2	liq	154.9008		-138.5	-122.1		53.0	
	g		-127.68	-128.6	-119.9	4.32	78.8	20.2

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 51(5) CHROMIUM

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$[Cr(H_2O)_5Cl]^{2+}$	blue green	aq	177.5257		-444.5				
$[Cr(H_2O)_4(OH)_2]Cl$		aq	193.5251		-495.7				
$[Cr(H_2O)_4Cl_2]^{2+}$		aq	194.9634		-411.2				
$[Cr(H_2O)_5OH]Cl_2$		aq	229.9861		-543.5				
$[Cr(H_2O)_4Cl_2]Cl$	green	c	230.4164		-442.7				
		aq			-451.1				
$[Cr(H_2O)_4Cl_2]Cl \cdot 2H_2O$	green	c	266.4470		-587.7				
$[Cr(H_2O)_4Cl_2]Cl \cdot 6H_2O$	green	c	338.5084		-861.0				
$[Cr(H_2O)_5Cl]Cl_2$		aq	248.4317		-524.4				
$[Cr(H_2O)_6]Cl_3$	violet	c	266.4470		-586.2				
	violet	aq			-597.8				
$CrBr_2$		c	211.814		-72.2				
		g			-17.				
$(CrBr_2)_2$		g	423.628		-84.				
$[Cr(H_2O)_4Br_2]^+$	green	aq	283.8754		-387.6				
$[Cr(H_2O)_4Br_2]Br$	green	aq	363.7844		-416.7				
$[Cr(H_2O)_4Br_2]Br \cdot 2H_2O$	green	c	399.8150		-552.6				
$[Cr(H_2O)_6]Br_3$	purple	c	399.8150		-550.4				
	violet	aq			-564.8				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 51(6) CHROMIUM

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
CrI_2		c	305.8048		-37.5				
		g			24.				
		aq			-60.1				
CrI_3		c	432.7092		-49.0				
	in 1 M KCl	aq			-90.3				
$CrICl_2$		c	249.8064		-100.				
$CrIBr_2$		c	338.7184		-79.				
$Cr_2(SO_4)_3$		c	392.1768						67.5
$Cr_2(SO_4)_3 \cdot 18H_2O$		c	716.4529						223.
$[Cr_2(H_2O)_6(SO_4)_3]$	green	aq	500.2688		-1179.5				
$[Cr_2(H_2O)_6(SO_4)_3] \cdot 2H_2O$	green	c	536.2995		-1302.5				
$[Cr_2(H_2O)_8(SO_4)_2]SO_4$		aq	536.2995		-1319.7				
$[Cr_2(H_2O)_{10}SO_4](SO_4)_2$		aq	572.3302		-1463.5				
$[Cr(H_2O)_6]_2(SO_4)_3$	violet	aq	608.3609		-1605.5				
$[Cr(H_2O)_6]_2(SO_4)_3 \cdot 2H_2O$		c	644.3916		-1732.0				
$[Cr(H_2O)_6]_2(SO_4)_3 \cdot 3H_2O$		c	662.4069		-1802.1				
$[Cr(H_2O)_6]_2(SO_4)_3 \cdot 4H_2O$		c	680.4222		-1871.3				
$[Cr(H_2O)_6]_2(SO_4)_3 \cdot 5H_2O$		c	698.4376		-1940.7				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 51(7) CHROMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Cr_2Te_3	c	486.792				6.921	$49.86+_x$	30.81
Cr_3Te_4	c	666.388				9.859	$70.05+_x$	47.36
Cr_5Te_6	c	1025.580				15.736	$112.49+_x$	76.55
CrN	c	66.0027		-29.8				11.0
Cr_2N	c	117.9987		-30.5				17.3
$Cr(NO_3)_3 \cdot 9H_2O$	c	400.1488						109.2
NH_4HCrO_4 std. state, m = 1	aq	135.0402		-241.6	-201.8		71.1	
$(NH_4)_2CrO_4$	c	152.0708		-279.0				
std. state, m = 1	aq			-273.94	-211.90		66.2	
in 300 H_2O	aq			-273.5				
$(NH_4)_2Cr_2O_7$	c	252.0650		-431.8				
std. state, m = 1	aq			-419.5	-348.9		116.8	
in 50 H_2O	aq			-420.4				
75 H_2O	aq			-420.3				
100 H_2O	aq			-420.1				
200 H_2O	aq			-419.7				
300 H_2O	aq			-419.6				
400 H_2O	aq			-419.4				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 51(8) CHROMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(NH_4)_2Cr_2O_7$ in 500 H_2O	aq			-419.3				
600 H_2O	aq			-419.2				
800 H_2O	aq			-419.1				
1000 H_2O	aq			-419.0				
5000 H_2O + 0.05 $HClO_4$	aq			-417.2				
10000 H_2O + 0.1N $HClO_4$	aq			-416.8				
$(NH_4)_2Cr_3O_{10}$	c	352.0592		-584.3				
$CrCl_2 \cdot 3NH_3$	c	173.9938		-166.9				
$CrCl_2 \cdot 6NH_3$	c	225.0857		-233.2				
$NH_4Cr(SO_4)_2 \cdot 12H_2O$	c	478.3419				26.59	170.9	168.5
CrSb	c	173.746						12.7
$CrSb_2$	c	295.496						19.7
Cr_3C_2	c	180.0103	-19.51	-19.3	-19.5	3.621	20.42	23.53
Cr_7C_3	c	400.0054		-38.7	-39.9		48.0	49.92
$Cr_{23}C_6$	c	1267.9749		-87.2	-89.3		145.8	149.2

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 51(9) CHROMIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Cr(CO)_6$	c	220.0593		-257.4				
	g			-240.4				
CrSi	c	80.082		-15.				9.2
$CrSi_2$	c	108.168		-23.				12.7
Cr_3Si	c	184.074		-30.				19.3
Cr_5Si_3	c	344.238		-64.				34.9
$PbCrO_4$	c	323.184		-222.5				
$PbI_2 \cdot 2CrI_3$	c	1072.608		-141.7				
$PbI_2 \cdot 2CrI_3 \cdot 3H_2O$	c	1126.654		-369.4				
Tl_2CrO_4	c	524.734		-225.8	-205.9		67.5	
Ag_2CrO_4	c	331.7336		-174.89	-153.40		52.0	34.00
std. state, m = 1	aq			-160.13	-137.09		46.8	
CrAu	g	248.963	131.					
$FeCr_2O_4$	c	223.8366		-345.3	-321.2		34.9	31.94

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 52(1) MOLYBDENUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Mo	c	95.94	0	0	0	1.098	6.85	5.75
	g		156.92	157.3	146.4	1.4812	43.461	4.968
Mo^+	g		320.6	322.5				
Mo^{2+}	g		693.2	696.5				
Mo^{3+}	g		1319.0	1323.8				
Mo^{4+}	g		2388.9	2395.2				
Mo^{5+}	g		3799.4	3807.2				
Mo^{6+}	g		5369.	5378.				
Mo^{7+}	g		8287.	8298.				
Mo^{8+}	g		11818.	11830.				
MoO	g	111.939		101.				
MoO_2	c	127.939		-140.76	-127.40		11.06	13.38
	g			3.				
MoO_3	c	143.939		-178.08	-159.66		18.58	17.92
	g			-78.				
	aq			-172.5				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 52(2) MOLYBDENUM

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
MoO_4		aq	159.938		-158.0				
MoO_4^{2-}	std. state, m = 1	aq			-238.5	-199.9		6.5	
MoO_5		aq	175.937		-139.6				
$(MoO_3)_2$		g	287.876		-271.				
$(MoO_3)_3$		g	431.815		-451.				
$(MoO_3)_4$		g	575.753		-618.				
$(MoO_3)_5$		g	719.691		-783.				
H_2MoO_4	white	c	161.954		-250.0				
		g			-212.				
		aq			-240.8				
$H_2MoO_4 \cdot H_2O$	yellow	c	179.969		-325.				
MoF_6		liq	209.930	-381.733	-378.95	-352.08	10.205	62.06	40.58
		g		-370.608	-372.29	-351.88	5.74	83.75	28.82

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 52(3) MOLYBDENUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$MoCl_2$	c	166.846		-67.4				
$MoCl_3$	c	202.299		-92.5				
$MoCl_4$	c	237.752		-114.8				
	g			-90.				
$MoCl_5$	c	273.205		-126.0				
	g			-103.				
MoO_2Cl_2	c	198.845		-171.4				
	g			-151.6				
	aq			-190.4				
$MoO_2Cl_2 \cdot H_2O$	c	216.860		-245.4				
$MoOCl_4$	c	253.751		-153.0				
$MoBr_2$	c	255.758		-62.4				18.3
$MoBr_4$	c	415.576		-76.8				
MoO_2Br_2	c	287.757		-150.4				
	aq			-166.9				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 52(4) MOLYBDENUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
MoI_2	g	349.749		32.				
MoS_2	c	160.068	-55.52	-56.2	-54.0	2.528	14.96	15.19
Mo_2S_3	c	288.072		-87.				
Mo_2N	c	205.887		-19.50				
MoC	c	107.951		-2.4				
Mo_2C	c	203.891		-10.9				
$Mo(CO)_6$	c	264.003		-234.9	-209.8		77.9	57.90
	g		-218.6	-218.0	-204.6	9.4	117.	49.
$MoSi_2$	c	152.112		-28.				
Mo_3Si	c	315.906		-23.	-23.		25.4	22.33
Mo_5Si_3	c	563.958		-68.				
Mo_3Ge	c	360.41		-5.				
$PbMoO_4$	c	367.128		-251.4	-227.4		39.7	28.61
MoB	c	106.751		-21.				
Mo_2B	c	202.691		-29.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 52(5) MOLYBDENUM

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$CuMoO_4$	c	223.478		-225.				
Ag_2MoO_4	c	375.678		-200.9	-178.8		51.	
std. state, m = 1	aq			-188.0	-163.0		41.3	
$FeMoO_4$	c	215.785		-257.	-233.		30.9	28.31
$Fe_2(MoO_4)_3$	c	591.507		-702.				
$MnMoO_4$	c	214.876		-284.73				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 53(1) TUNGSTEN

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
W		c	183.85	0	0	0	1.190	7.80	5.80
		g		202.70	203.0	192.9	1.486	41.549	5.093
W^+		g		386.8	388.6				
WO		g	199.849		108.				
WO_2		c	215.849	-139.762	-140.94	-127.61	2.087	12.08	13.41
		g			11.				
1/18 ($W_{18}O_{49}$)		c	227.404		-185.				
1/20 ($W_{20}O_{58}$)		c	230.248		-196.				
WO_3		c	231.848	-200.100	-201.45	-182.62	2.952	18.14	17.63
		g			-71.				
WO_4^{2-}	std. state, m = 1	aq	247.848		-257.1				
$(WO_3)_2$		g	463.696		-277.				
$(WO_3)_3$		g	695.545		-468.				
$(WO_3)_4$		g	927.393		-649.				
H_2WO_4		c	249.864		-270.5				
		g			-229.				
$HW_6O_{21}^{5-}$		aq	1440.095		-1395.6				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 53(2) TUNGSTEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
WF_6	liq	297.840		-417.7	-389.93		60.1	
	g		-409.42	-411.5	-390.1	5.435	81.49	28.45
WCl_2	c	254.756		-61.				
WCl_4	c	325.662		-112.				
	g			-73.				
WCl_5	c	361.115		-118.6				
	g			-100.8				
WCl_6 α	c	396.568		-144.0				
	g			-122.8				
W_2Cl_{10}	g	722.230		-210.				
WO_2Cl_2	c	286.755		-187.2				
	g			-164.				
$WOCl_4$	c	341.661		-161.7				
	g			-140.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 53(3) TUNGSTEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
WBr_5	c	583.395		-75.6				
	g			-55.4				
WBr_6	c	663.304		-83.3				
WO_2Br_2	c	375.667		-170.3				
$WOBr_4$	c	519.485		-130.1				
WS_2	c	247.978		-50.				
WC	c	195.861		-9.69				
W_2C	c	379.711		-6.3				
$W(CO)_6$	c	351.913		-227.9				
	g			-208.3				
WSi_2	c	240.022		-22.				
$SnWO_4$	g	366.538	-411.					
Sn_2WO_5	g	501.227	-472.					
$PbWO_4$	c	455.038					40.2	28.63
$ZnWO_4$	c	313.218		-293.				30.0

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 53(4) TUNGSTEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$CuWO_4$	c	311.388		-264.				
$CuWO_4 \cdot 2H_2O$	c	347.418		-408.				
Ag_2WO_4	c	463.588		-221.2				
std. state, m = 1	aq			-206.6				
Ni_4W	c	418.69		-43.				29.0
$NiWO_4$	c	306.558		-270.9				29.1
Co_3W	c	360.650		-9.0	-7.5		24.	
$CoWO_4$	c	306.781						31.1
Fe_7W_6	c	1494.029						77.7
$FeWO_4$	c	303.695		-276.	-252.		31.5	27.39
$FeWO_4 \cdot 3H_2O$	c	357.741		-489.				
$Fe_2(WO_4)_3 \cdot 8H_2O$	c	999.360		-1355.				
$MnWO_4$	c	302.786		-311.9				29.7

Appendix

Errata for Technical Note 270-3

Page 22	HF(liq)	ΔHf^0_{298} = -71.65 kcal/mol
Page 32	HBr(g)	ΔHf^0_0 = -6.826 kcal/mol
Page 43	S(g)	ΔGf^0 = 56.951 kcal/mol
		S^0 = 40.084 cal/deg mol
Page 48	$H_2S^+(g)$	ΔHf^0_0 = 237.0 kcal/mol
Page 56	Se(g)	$H^0 - H^0_0$ = 1.4815 kcal/mol
		S^0 = 42.21 cal/deg/mol
		Cp^0 = 4.978 cal/deg/mol
Page 61	N(g)	ΔGf^0 = 108.886 kcal/mol
		S^0 = 36.613 cal/deg mol
Page 86	$H_2PO_4^-(aq)$	ΔGf^0 = -270.17 kcal/mol
Page 231	$Tl_2(SeO_3)_3$	instead of $Te(SeO_3)_3$
	Tl_2Se	formula weight = 487.70
Page 234	$ZnF_2(c)$	ΔGf^0 = -170.5 kcal/mol

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