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CONTRIBUTIONS TO THE DATA ON THEORETICAL METALLURGY

XVI. THERMODYNAMIC PROPERTIES OF NICKEL AND ITS INORGANIC COMPOUNDS

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CONTRIBUTIONS TO THE DATA ON THEORETICAL METALLURGY

XVI. THERMODYNAMIC PROPERTIES OF NICKEL AND ITS INORGANIC COMPOUNDS

by

Alla D. Mah[1] and L. B. Pankratz[1]

ABSTRACT

Thermodynamic data on nickel and its compounds were critically reviewed, evaluated, and compiled by the Federal Bureau of Mines. Values of the properties Cp°, S°, $H° - H°_{298}$, $-(G° - H°_{298})/T$, ΔHf°, ΔGf°, and log K are presented in tabular format; Cp°, $S° - S°_{298}$, $H° - H°_{298}$, ΔHf°, and ΔGf° are also expressed algebraically. Values of ΔH°, ΔG°, and log K are tabulated for selected reactions involving nickel compounds, with emphasis on reactions of metallurgical interest. Data on auxiliary compounds employed in the reactions are included.

INTRODUCTION

The compilation of thermodynamic properties of nickel and its inorganic compounds was undertaken as part of a continuing effort by the Federal Bureau of Mines to provide information for the extractive metallurgist to use as guidelines for research on improving established processes or developing new ones. This report also provides useful information for other areas of thermochemical research. The data presented are the result of critical review and evaluation of relevant thermodynamic data on nickel and its compounds through June 1974. Solutions and alloys that are not specific compounds were not included. Data on binary alloys have been compiled by Hultgren, Desai, Hawkins, Gleiser, and Kelley (*71*).[2]

The compilation consists of five chapters. Chapter 1 contains thermodynamic properties of nickel and its compounds. The first table in this section gives enthalpy of formation, Gibbs energy of formation, and entropy of substances at 298.15 K. This is followed by tabular data on properties of compounds (heat capacity, entropy, Gibbs energy function, enthalpy relative to 298.15 K, enthalpy of formation, Gibbs energy of formation, and logarithm of the equilibrium constant of formation) as a function of temperature. Concluding this section are tables of detailed low-temperature data and a few tables of high-temperature data.

Chapter 2 furnishes tabular data (enthalpy of reaction, Gibbs energy of reaction, and logarithm of the equilibrium constant of reaction) for selected chemical reactions over various temperature ranges, with emphasis on reactions of metallurgical interest. Chapter 3 gives formation properties (enthalpy of formation, Gibbs energy of formation, and logarithm of the equilibrium constant of formation) of all the auxiliary compounds used in the reactions. Sufficient information has been included for deriv-

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[2] Italic numbers in parentheses refer to items in the list of references preceding the index.

ing all the reaction data in this volume and for obtaining values for related reactions.

The last two chapters contain thermodynamic data in analytic form. Chapter 4 gives algebraic equations for nickel compounds representing relative enthalpy, heat capacity, and relative entropy as a function of temperature. Chapter 5 provides equations for both nickel and auxiliary compounds, expressing enthalpy of formation and Gibbs energy of formation as a function of temperature. Although less precise than tabular values, these equations furnish a convenient method for calculating reaction properties.

A detailed bibliography and a cross-referenced index by chemical formula complete the volume.

Sources of data upon which the reported values for nickel and its compounds are based are indicated on the tables in chapter 1. For simplicity, additional sources reviewed and considered less reliable are not included. Estimates are utilized where the necessary data are lacking. Unpublished values of new research from the Thermodynamics Laboratory at the Bureau of Mines Albany Metallurgy Research Center are included for nickel sulfate and two nickel sulfides. Sources of data for auxiliary elements and compounds are listed at the beginning of the chapters in which they are involved.

Methods of evaluation employed are the same as those given in the earlier compilation on copper and its compounds (*91*). Definition of symbols used are as follows:

P = pressure in atmospheres,
T = thermodynamic temperature (0° C = 273.15 K),
E = internal energy,
$H = E + PV$ = enthalpy,
$G = H - TS$ = Gibbs energy,
$Cp = (\delta H/\delta T)p$ = heat capacity,
$S = -(\delta G/\delta T)p = \int(Cp/T)dT$ = entropy,
$H - H_{298}$ = enthalpy increment between T and 298.15 K,
$(G - H_{298})/T = [(H - H_{298})/T] - S$ = Gibbs energy function,
ΔH = enthalpy change (ΔHf = enthalpy of formation),
ΔG = Gibbs energy change (ΔGf = Gibbs energy of formation),
and $\log K$ = logarithm to the base 10 of the equilibrium constant.

Standard state values are denoted by the superscript °. Values of constants used are in agreement with the 1963 report of the National Academy of Sciences (*116*). They are as follows:

R = gas constant = 1.987165 cal/deg mole,
k = Boltzmann constant = 1.38054×10^{-16} erg/deg,
h = Planck constant = 6.6256×10^{-27} erg sec,
N = Avogadro constant = 6.02252×10^{23}/mole,
c = velocity of light = 2.997925×10^{10} cm/sec,
F = Faraday constant = 96,487.0 coulombs/mole,

and thermochemical calorie = 4.1840 joules.

Although the unit for energy adopted by the International Committee on Weights and Measures is the joule, the present work has retained the calorie as the unit for energy in order to be consistent with the earlier volume (*91*) on copper and its compounds.

Molecular weights are based on the 1969 table of atomic weights (*73*). The physical states of substances are represented by the symbols s, l, and g, which refer to crystal, liquid, and gas, respectively. Where two or more crystalline forms exist, the Greek letters α, β, γ, and δ differentiate the various crystalline modifications.

CHAPTER 1.—THERMODYNAMIC PROPERTIES OF NICKEL COMPOUNDS

The first table in this section lists the enthalpy of formation, Gibbs energy of formation, and entropy of nickel compounds at 298.15 K. Following this are 73 tables listing thermodynamic properties of selected nickel compounds as a function of temperature, including 29 tables of detailed low-temperature data and 5 tables of high-temperature data only. The data in these tables are standard-state values except the formation data involving $S_2(g)$ below the boiling point of sulfur. Temperature and enthalpy of phase changes and sources of data are indicated below each table. For smoothness of results when the tabular values are combined in calculations, significant figures generally are retained to one place more than is warranted by the estimated accuracy of the data.

Thermodynamic data for auxiliary elements used in the calculations were taken from various sources. S°_{298} of $D_2(g)$ was from Woolley, Scott, and Brickwedde (*161*); $H^\circ - H^\circ_{298}$ and $S^\circ - S^\circ_{298}$ of $D_2(g)$ were from Kelley (*84*); $H^\circ - H^\circ_{298}$ and $S^\circ - S^\circ_{298}$ of S(s,l) were from West (*152*); ΔHf°_{298} of $S_2(g)$ was from the National Bureau of Standards (NBS) (*117*); S°_{298}, $H^\circ - H^\circ_{298}$, and $S^\circ - S^\circ_{298}$ of Se(s,l) were from Grønvold (*59*); S°_{298}, $H^\circ - H^\circ_{298}$, and $S^\circ - S^\circ_{298}$ of Al(s,l), Fe(s), Mg(s), Si(s,l), and W(s) were from Hultgren, Desai, Hawkins, Gleiser, Kelley, and Wagman (*72*); and the remaining thermodynamic properties of elements and electron gas were from the Dow Chemical Co. JANAF tables (*39*). Values for Al(s,l), Fe(s), Mg(s), S(s,l), Si(s,l), and W(s) were corrected to agree with the International Practical Temperature Scale of 1968 (*38*).

Thermodynamic Properties of Nickel Compounds at 298.15 K

Substance	ΔHf°_{298} kcal/mole	ΔGf°_{298} kcal/mole	S°_{298} cal/deg mole	References ΔHf° or ΔGf°	References S°
Ni(s)	0	0	7.14 ± 0.02		24, 83
Ni(g)	102.8 ± 0.2	92.0 ± 0.2	43.52 ± 0.01	114	113
Ni_2(g)	150. ± 5.			79	
Ni^+(g)	280.2 ± 0.5	268.4 ± 0.5	41.70 ± 0.01	113	139
Ni^{++}(g)	700.6 ± 0.5	687.1 ± 0.5	42.51 ± 0.01	139	113
NiAl(s)	-29. ± 1.	-28.7 ± 1.	12.8 ± 0.5	101, 135	136
$NiAl_3$(s)	-36. ± 4.			101	
Ni_2Al_3(s)	-69. ± 5.			101	
$NiAl_2Cl_8$(g)	-369. ± 4.	-343. ± 4.	146. ± 4.	37	37
$NiAl_2O_4$(s)	-463.6 ± 2.	-434.6 ± 2.	21.4 ± 3.	105	105
NiAs(s)	-17. ± 2.			129	
NiAu(g)	130. ± 5.			81	
NiB(s)	-24. ± 3.			57	
Ni_4B_3(s)	-74. ± 9.			57	
NiBr(g)	44. ± 3.	33. ± 3.	62.7 ± 0.5	21	18, 70, 139
$NiBr_2$(s)	-51.5 ± 0.5	-47.1 ± 0.8	28.9 ± 2.	138	est.
$NiBr_2$(g)	2.8 ± 0.6	-7.1 ± 0.7	76.7 ± 1.	110	18, 36, 146
Ni_3C(s)	9.2 ± 1.5	7.8 ± 1.5	27.4 ± 3.	20, 133	est.
$NiCO_3$(s)	-164.9 ± 1.	-146.4 ± 1.	20. ± 1.	85	99
$Ni(CO)_4$(l)	-145.6 ± 2.	-135.3 ± 2.	76. ± 3.	7	7
$Ni(CO)_4$(g)	-138.3 ± 1.5	-135.0 ± 1.5	99.3 ± 2.	94	12, 75
Ni_5Ce(s)			51.1 ± 0.5		109
NiCl(g)	43. ± 5.	35. ± 5.	60.1 ± 0.5	21	18, 70, 106, 139
$NiCl_2$(s)	-72.98 ± 0.05	-61.95 ± 0.06	23.42 ± 0.1	22	23, 98
$NiCl_2$(g)	-16.8 ± 0.6	-20.0 ± 0.7	71.3 ± 1.	110	18, 36, 66, 146
$NiCl_2 \cdot 6H_2O$(s)			82.3 ± 2.		95
$Ni(ClO_4)_2 \cdot 6H_2O$(s)	-486.3 ± 1.			104	
NiCu(g)	135. ± 5.			82	
$NiD_{.65}$(s)			10.06 ± 0.2		159
NiD(g)	94. ± 7.	86. ± 7.	51.68 ± 0.1	est.	4
NiF(g)	25. ± 5.	17. ± 5.	57.3 ± 0.5	est.	18, 112, 139

Thermodynamic Properties of Nickel Compounds at 298.15 K - Continued

Substance	ΔHf°_{298} kcal/mole	ΔGf°_{298} kcal/mole	S°_{298} cal/deg mole	References ΔHf° or ΔGf°	References S°
$NiF_2(s)$	-157.2 ± 0.4	-145.9 ± 0.4	17.59 ± 0.05	134	27
$NiF_2(g)$	-80.2 ± 1.5	-83.1 ± 1.5	65.2 ± 1.	26, 44	18, 69, 112, 113
$Ni_2Fe(CN)_6(s)$		126. ± 1.		9	
$NiFe_2Cl_8(g)$	-215. ± 3.	-196. ± 3.	170. ± 5.	37	37
$NiFe_2O_4(s)$	-255.3 ± 0.5	-229.2 ± 0.6	30.7 ± 0.5	122, 147	88
$NiGa_2O_4(s)$	-376. ± 2.			122	
$NiGe(g)$	125. ± 5.			80	
$Ni_2GeO_4(s)$	-256. ± 2.			122	
$Ni_5Gd(s)$			52.9 ± 0.5		109
$NiH_{.50}(s)$	-0.5 ± 0.1	1.4 ± 0.1	8.64 ± 0.1	35	158
$NiH_{.59}(s)$			8.88 ± 0.1		158
$NiH_{.68}(s)$			8.99 ± 0.1		158
$NiH(g)$	94. ± 7.	86. ± 7.	50.32 ± 0.1	52	4, 70
$NiI(g)$	59. ± 5.	46. ± 5.	64.6 ± 0.5	21	18, 139
$Ni_3K_2[Fe(CN)_6]_2(s)$		120.4 ± 1.		10	
$Ni_4K_4[Fe(CN)_6]_3(s)$		122.4 ± 1.		10	
$Ni_8K_{12}[Fe(CN)_6]_7(s)$		116.4 ± 1.		10	
$Ni_5La(s)$			51.0 ± 0.5		109
$NiMg_2(s)$	-9.5 ± 0.3			93	
$Ni_2Mg(s)$	-13.2 ± 0.6	-12.9 ± 0.6	21.2 ± 0.3	93	160
$Ni_3N(s)$	0.2 ± 0.1			67	
$Ni(NO_3)_2(s)$	-96.4 ± 0.7			29	
$Ni(NO_3)_2 \cdot 2H_2O(s)$	-242.7 ± 1.0			6	
$Ni(NO_3)_2 \cdot 4H_2O(s)$	-387.4 ± 0.5			5, 29	
$Ni(NO_3)_2 \cdot 6H_2O(s)$	-529.4 ± 0.5			5	
$NiNb(s)$	-10.7 ± 1.			3	
$Ni_3Nb(s)$	-30. ± 3.			3	
$Ni_5Nd(s)$			55.3 ± 0.5		109
$NiO(s)$	-57.3 ± 0.2	-50.6 ± 0.2	9.08 ± 0.04	15	87
$NiO(g)$	74. ± 5.	66. ± 5.	57.7 ± 0.5	58	17, 113, 132
$Ni(OH)_2(s)$	-129.8 ± 0.5	-109.5 ± 0.5	19.12 ± 0.1	49, 53	140
$Ni(OH)_2(g)$	-61. ± 5.	-56. ± 5.	69.6 ± 1.5	11	est.
$NiRbCl_3(s)$	-181.7 ± 0.5			42	

Thermodynamic Properties of Nickel Compounds at 298.15 K - Continued

Substance	ΔHf°_{298} kcal/mole	ΔGf°_{298} kcal/mole	S°_{298} cal/deg mole	References ΔHf° or ΔGf°	References S°
NiS(α)	-22.1 ± 1.2	-21.5 ± 1.2	12.66 ± 0.08	115	151
NiS(β)	-21.6 ± 1.2			est.	
Ni_3S_2(s)	-52.1 ± 0.5	-50.7 ± 0.5	32.0 ± 0.2	115	151
$NiSO_4$(s)	-208.63 ± 0.15	-182.22 ± 0.15	24.21 ± 0.1	2	150, 142
$NiSO_4 \cdot H_2O$(s)	-286.0 ± 1.	-245.5 ± 1.	32.7 ± 1.	54, 56	54
$NiSO_4 \cdot 6H_2O$(α)	-641.3 ± 1.	-531.8 ± 1.	79.94 ± 0.3	56	141
$NiSO_4 \cdot 7H_2O$(s)	-711.4 ± 1.	-588.5 ± 1.	90.57 ± 0.3	141	141
NiSb(s)	-15.4 ± 2.			97, 125	
$NiSe_{1.05}$(s)	-17.9 ± 0.2	-18.0 ± 0.2	17.98 ± 0.1	61	63
$NiSe_{1.14}$(s)	-19.0 ± 0.2	-18.9 ± 0.2	18.45 ± 0.1	61	63
$NiSe_{1.25}$(s)	-19.8 ± 0.2	-19.6 ± 0.2	19.14 ± 0.1	61	63
$NiSe_2$(s)	-20. ± 1.	-19. ± 1.	24.74 ± 0.1	61	64
$NiSeO_3$(s)	-126. ± 1.	-107. ± 1.	26. ± 1.	8	8
NiSi(s)	-20.6 ± 1.	-20.5 ± 1.	11.2 ± 0.3	126	78
NiSi(g)	134. ± 5.			148	
$Ni_{1.04}Si_{1.93}$(s)	-21.4 ± 1.5	-21.3 ± 1.5	15.6 ± 0.2	126	76
Ni_2Si(s)	-33.6 ± 1.5	-33.5 ± 1.5	18.3 ± 0.5	126	est.
Ni_3Si_2(s)	-54. ± 2.			126	
Ni_2SiO_4(s)	-336. ± 1.	-309. ± 1.	25.6 ± 0.4	120	25
Ni_3Sn(s)	-23. ± 3.			97	
Ni_3Sn_2(s)	-37. ± 4.			97	
$NiTe_{1.1}$(s)			20.09 ± 0.1		153
$NiTe_2$(s)			28.76 ± 0.1		153
$NiTeO_3 \cdot 2H_2O$(s)	-284. ± 3.	-238. ± 3.	49. ± 5.	51	51
NiTi(s)	-16. ± 1.			101	
$NiTi_2$(s)	-19. ± 1.5			101	
Ni_3Ti(s)	-33. ± 2.			101	
$NiTiO_3$(s)	-287.0 ± 2.	-266.7 ± 2.	19.9 ± 3.	45, 123, 124, 145	45, 123, 124, 145
$NiTi_2O_5$(s)		-447.8 ± 3.		45	
Ni_2TiO_4(s)		-315.2 ± 3.		45, 46, 123	
Ni_4W(s)	-7.5 ± 1.	-7.4 ± 1.	36. ± 1.	111	est.
$NiWO_4$(s)	-268.9 ± 1.	-243.7 ± 1.	28.5 ± 1.	121	est.
Ni_2Y(s)			23.95 ± 0.2		14

Thermodynamic Properties of Ni(s,l)

T, K	Cal/deg mole			Kcal/mole
	$C_p°$	$S°$	$-(G°-H°_{298})/T$	$H°-H°_{298}$
0	0	0	∞	-1.144
100	3.26	1.78	12.01	-1.023
200	5.37	4.82	7.68	-.571
298.15	6.21	7.14	7.14	0
300	6.22	7.18	7.14	.012
400	6.81	9.05	7.39	.664
500	7.42	10.63	7.88	1.374
600	8.33	12.05	8.46	2.156
631	9.52	12.49	8.65	2.425
700	7.36	13.29	9.07	2.954
800	7.41	14.27	9.66	3.691
900	7.55	15.15	10.22	4.439
1000	7.70	15.95	10.75	5.201
1100	7.87	16.70	11.26	5.979
1200	8.05	17.39	11.74	6.775
1300	8.25	18.04	12.20	7.590
1400	8.46	18.66	12.64	8.425
1500	8.68	19.25	13.06	9.282
1600	8.91	19.82	13.47	10.162
1700	9.15	20.36	13.85	11.064
1728	9.21	20.52	13.97	11.321
1728	9.30	22.89	13.97	15.421
1800	9.30	23.27	14.33	16.091
1900	9.30	23.77	14.81	17.021
2000	9.30	24.25	15.27	17.951

Phase changes: 631 K, Curie temperature of Ni; $\Delta H°$ = 0 kcal/mole.
1728 K, melting point of Ni; $\Delta H°$ = 4.10 kcal/mole.

Sources of data: Low-temperature heat capacity and entropy below 20 K (Keesom and Clark, 1935), and from 15 to 298 K (Busey and Giauque, 1952).
High-temperature enthalpy based on Braun, Kohlhaas, and Vollmer (1968); Bronson and Wilson (1936); Connelly, Loomis, and Mapother (1971); Kollie (1970); Krauss and Warncke (1955); Pawel and Stansbury (1965); Sykes and Wilkinson (1938); and Vollmer, Kohlhaas, and Braun (1966).

Thermodynamic Properties of Ni(g)

[Formation: Ni(s,l) = Ni(g)]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-1.631	102.31	102.31	∞
100	5.619	37.378	48.488	-1.111	102.71	99.15	-216.692
200	5.592	41.294	44.029	-.547	102.83	95.53	-104.390
298.15	5.583	43.519	43.519	0	102.80	91.95	-67.401
300	5.585	43.553	43.520	.010	102.80	91.89	-66.942
400	5.702	45.175	43.740	.574	102.71	88.26	-48.223
500	5.825	46.461	44.159	1.151	102.58	84.66	-37.005
600	5.912	47.531	44.634	1.738	102.38	81.09	-29.537
631	5.926	47.829	44.785	1.921	102.30	80.00	-27.708
700	5.957	48.446	45.115	2.332	102.18	77.57	-24.218
800	5.971	49.243	45.583	2.928	102.04	74.06	-20.232
900	5.961	49.946	46.029	3.525	101.89	70.57	-17.137
1000	5.937	50.573	46.453	4.120	101.72	67.10	-14.665
1100	5.904	51.137	46.853	4.712	101.53	63.65	-12.646
1200	5.865	51.649	47.232	5.301	101.33	60.22	-10.968
1300	5.823	52.117	47.590	5.885	101.10	56.79	-9.547
1400	5.781	52.547	47.929	6.465	100.84	53.40	-8.336
1500	5.739	52.944	48.250	7.041	100.56	50.02	-7.288
1600	5.698	53.313	48.555	7.613	100.25	46.66	-6.373
1700	5.659	53.658	48.846	8.181	99.92	43.31	-5.568
1728	5.649	53.750	48.924	8.339	99.82	42.39	-5.361
1728	5.649	53.750	48.924	8.339	95.72	42.39	-5.361
1800	5.622	53.980	49.122	8.745	95.45	40.18	-4.879
1900	5.588	54.283	49.385	9.306	95.09	37.11	-4.269
2000	5.556	54.569	49.638	9.863	94.71	34.07	-3.723

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation obtained by third law calculation from the vapor pressure of the liquid (Morris, Zellars, Payne, and Kipp, 1957).
Heat capacity, entropy, and enthalpy calculated from atomic energy levels and multiplicities of Ni I (Moore, 1952).

Thermodynamic Properties of $Ni^+(g)$

[Formation: $Ni(s,l) - e^-(g) = Ni^+(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	5.017	41.698	41.698	0	280.20	268.41	-196.750
300	5.018	41.729	41.699	.009	280.21	268.34	-195.485
400	5.139	43.188	41.896	.517	280.56	264.32	-144.418
500	5.288	44.350	42.274	1.038	280.87	260.23	-113.746
600	5.418	45.327	42.704	1.574	281.12	256.07	-93.273
631	5.446	45.601	42.840	1.742	281.17	254.78	-88.244
700	5.509	46.169	43.140	2.120	281.36	251.89	-78.644
800	5.562	46.909	43.567	2.674	281.68	247.65	-67.655
900	5.584	47.565	43.974	3.232	281.98	243.38	-59.101
1000	5.586	48.154	44.364	3.790	282.28	239.07	-52.249
1100	5.577	48.686	44.732	4.349	282.55	234.75	-46.641
1200	5.563	49.170	45.082	4.906	282.81	230.39	-41.960
1300	5.551	49.615	45.414	5.461	283.05	226.01	-37.996
1400	5.545	50.026	45.729	6.016	283.27	221.61	-34.595
1500	5.548	50.409	46.028	6.571	283.46	217.20	-31.646
1600	5.563	50.767	46.313	7.126	283.63	212.78	-29.064
1700	5.589	51.105	46.585	7.684	283.78	208.33	-26.783
1728	5.600	51.196	46.658	7.841	283.82	207.10	-26.193
1728	5.600	51.196	46.658	7.841	279.72	207.10	-26.193
1800	5.629	51.426	46.846	8.244	279.81	204.08	-24.779
1900	5.680	51.732	47.095	8.810	279.95	199.86	-22.989
2000	5.743	52.025	47.335	9.381	280.09	195.65	-21.380

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation calculated from the limit of the energy levels of Ni I (Moore, 1952).
Heat capacity, entropy, and enthalpy calculated from atomic energy levels and multiplicities of Ni II (Shenstone, 1970).

Thermodynamic Properties of $Ni^{++}(g)$

[Formation: $Ni(s,l) - 2e^-(g) = Ni^{++}(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	5.064	42.513	42.513	0	700.60	687.08	-503.643
300	5.067	42.544	42.514	.009	700.62	686.99	-500.472
400	5.263	44.027	42.715	.525	701.47	682.32	-372.802
500	5.492	45.226	43.100	1.063	702.30	677.44	-296.109
600	5.693	46.245	43.540	1.623	703.07	672.39	-244.918
631	5.738	46.533	43.680	1.800	703.28	670.81	-232.338
700	5.839	47.135	43.992	2.200	703.84	667.23	-208.319
800	5.930	47.921	44.435	2.789	704.68	661.94	-180.834
900	5.972	48.622	44.862	3.384	705.53	656.54	-159.430
1000	5.979	49.252	45.270	3.982	706.36	651.05	-142.287
1100	5.961	49.821	45.658	4.579	707.17	645.49	-128.247
1200	5.927	50.338	46.026	5.174	707.96	639.85	-116.533
1300	5.884	50.811	46.377	5.764	708.73	634.14	-106.609
1400	5.836	51.246	46.710	6.350	709.47	628.37	-98.093
1500	5.786	51.646	47.025	6.931	710.19	622.55	-90.705
1600	5.736	52.018	47.326	7.507	710.88	616.69	-84.236
1700	5.688	52.365	47.613	8.079	711.54	610.77	-78.520
1728	5.675	52.458	47.691	8.238	711.72	609.12	-77.039
1728	5.675	52.458	47.691	8.238	707.62	609.12	-77.039
1800	5.642	52.688	47.885	8.645	708.08	605.01	-73.458
1900	5.599	52.992	48.146	9.207	708.70	599.26	-68.931
2000	5.559	53.278	48.396	9.765	709.32	593.49	-64.854

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation calculated from the limit of the energy levels of Ni II (Shenstone, 1970).
Heat capacity, entropy, and enthalpy calculated from atomic energy levels and multiplicities of Ni III (Moore, 1952).

Thermodynamic Properties of $NiAl_2Cl_8(g)$

[Formation: $Ni(s) + 2Al(s,l) + 4Cl_2(g) = NiAl_2Cl_8(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	54.0	146.0	146.0	0	-369.0	-342.8	251.28
300	54.0	146.3	146.0	.10	-369.0	-342.6	249.58
400	57.1	162.3	148.1	5.67	-368.6	-333.9	182.43
500	58.7	175.3	152.4	11.47	-368.2	-325.3	142.19
600	59.6	186.0	157.0	17.38	-367.8	-316.7	115.36
631	59.8	189.0	158.5	19.23	-367.7	-314.1	108.79
700	60.2	195.3	161.9	23.38	-367.5	-308.3	96.26
800	60.7	203.4	166.6	29.43	-367.2	-299.9	81.93
900	61.2	210.5	171.0	35.52	-366.9	-291.4	70.76
933.5	61.3	212.7	172.5	37.57	-366.8	-288.6	67.57
933.5	61.3	212.7	172.5	37.57	-372.0	-288.6	67.57
1000	61.6	217.0	175.3	41.66	-371.8	-282.7	61.78

Phase changes: 631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.
933.5 K, melting point of Al; $\Delta H° = 2.58$ kcal/mole.

Sources of data: Enthalpy of formation and entropy obtained by second law calculation from equilibrium pressure data on the volatilization of nickel chloride in the presence of gaseous aluminum chloride (Dewing, 1970).
Heat capacity estimated.

Thermodynamic Properties of NiBr(g)

[Formation: $Ni(s,l) + 1/2Br_2(l,g) = NiBr(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G^\circ-H^\circ_{298})/T$	$H^\circ-H^\circ_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.32	45.8	45.8	∞
100	7.35	53.93	70.03	-1.61	46.0	41.4	-90.48
200	8.24	59.34	63.49	-.83	45.8	36.9	-40.32
298.15	8.65	62.71	62.71	0	44.0	32.9	-24.12
300	8.65	62.76	62.71	.02	44.0	32.8	-23.89
332.6	8.74	63.66	62.76	.30	43.8	31.6	-20.76
332.6	8.74	63.66	62.76	.30	40.3	31.6	-20.76
400	8.94	65.29	63.04	.90	40.1	29.8	-16.28
500	9.17	67.31	63.71	1.80	39.8	27.3	-11.93
600	9.36	69.00	64.45	2.73	39.6	24.8	-9.03
631	9.40	69.47	64.68	3.02	39.4	24.1	-8.35
700	9.49	70.45	65.21	3.67	39.2	22.4	-6.99
800	9.57	71.73	65.96	4.62	39.0	20.0	-5.46
900	9.61	72.86	66.66	5.58	38.8	17.6	-4.27
1000	9.63	73.87	67.32	6.55	38.5	15.3	-3.34
1100	9.64	74.79	67.96	7.51	38.3	13.0	-2.58
1200	9.64	75.63	68.57	8.47	38.0	10.7	-1.95
1300	9.65	76.40	69.14	9.44	37.7	8.4	-1.41
1400	9.65	77.11	69.68	10.40	37.4	6.2	-.97
1500	9.66	77.78	70.20	11.37	37.0	4.0	-.58
1600	9.69	78.41	70.70	12.34	36.6	1.8	-.25
1700	9.72	78.99	71.16	13.31	36.3	-.4	.05
1728	9.73	79.15	71.29	13.58	36.1	-1.0	.13
1728	9.73	79.15	71.29	13.58	32.0	-1.0	.13
1800	9.76	79.55	71.62	14.28	31.7	-2.3	.28
1900	9.81	80.08	72.05	15.26	31.3	-4.2	.48
2000	9.88	80.58	72.46	16.24	30.9	-6.1	.67

Phase changes: 332.6 K, boiling point of Br_2; ΔH° = 7.066 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation derived from flame photometry (Bulewicz, Phillips, and Sugden, 1961).
Heat capacity, entropy, and enthalpy calculated from molecular data: vibrational frequency (Herzberg, 1950), $\omega_e x_e$ and α_e estimated, electronic energy levels based on Ni II (Shenstone, 1970), and internuclear distance (Brewer, Somayajulu, and Brackett, 1963).

Thermodynamic Properties of $NiBr_2(s)$

[Formation: $Ni(s) + Br_2(l,g) = NiBr_2(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	17.7	28.9	28.9	0	-51.5	-47.1	34.53
300	17.7	29.0	28.9	.03	-51.5	-47.1	34.31
332.6	18.0	30.8	29.0	.61	-51.7	-46.6	30.62
332.6	18.0	30.8	29.0	.61	-58.8	-46.6	30.62
400	18.5	34.2	29.6	1.85	-58.6	-44.2	24.15
500	19.0	38.4	31.0	3.72	-58.3	-40.6	17.75
600	19.3	41.9	32.5	5.64	-58.1	-37.1	13.51
631	19.3	42.9	33.0	6.24	-58.0	-36.0	12.47
700	19.4	44.9	34.1	7.57	-57.8	-33.6	10.49
800	19.6	47.5	35.6	9.52	-57.5	-30.2	8.25
900	19.8	49.8	37.0	11.49	-57.2	-26.8	6.51
1000	20.2	51.9	38.4	13.49	-56.8	-23.4	5.11

Phase changes: 332.6 K, boiling point of Br_2; $\Delta H° = 7.066$ kcal/mole.
631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.

Sources of data: Enthalpy of formation derived from third law treatment of hydrogen reduction equilibrium data (Shchukarev, Tolmacheva, and Oranskaya, 1954).
Heat capacity, entropy, and enthalpy estimated.

Thermodynamic Properties of $NiBr_2(g)$

[Formation: $Ni(s,1) + Br_2(l,g) = NiBr_2(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-3.76	6.04	6.04	∞
100	12.35	61.8	89.4	-2.76	6.25	1.54	-3.366
200	14.06	70.9	78.1	-1.43	5.96	-3.08	3.366
298.15	15.01	76.7	76.7	0	2.80	-7.09	5.197
300	15.03	76.8	76.7	.03	2.79	-7.15	5.209
332.6	15.20	78.4	76.8	.52	2.49	-8.22	5.401
332.6	15.20	78.4	76.8	.52	-4.58	-8.22	5.401
400	15.55	81.2	77.3	1.56	-4.58	-8.96	4.896
500	15.82	84.7	78.4	3.13	-4.60	-10.05	4.393
600	15.96	87.6	79.7	4.72	-4.68	-11.14	4.058
631	15.98	88.4	80.1	5.22	-4.73	-11.47	3.973
700	16.02	90.1	81.1	6.32	-4.77	-12.22	3.815
800	16.04	92.2	82.3	7.92	-4.80	-13.26	3.622
900	16.05	94.1	83.5	9.53	-4.84	-14.32	3.477
1000	16.05	95.8	84.7	11.13	-4.90	-15.38	3.361
1100	16.05	97.3	85.7	12.74	-4.97	-16.38	3.254
1200	16.05	98.7	86.8	14.34	-5.07	-17.43	3.174
1300	16.06	100.0	87.7	15.95	-5.18	-18.47	3.105
1400	16.07	101.2	88.7	17.55	-5.32	-19.50	3.044
1500	16.07	102.3	89.5	19.16	-5.48	-20.50	2.987
1600	16.08	103.3	90.3	20.77	-5.66	-21.43	2.927
1700	16.08	104.3	91.1	22.37	-5.87	-22.47	2.889
1728	16.08	104.6	91.4	22.82	-5.93	-22.73	2.875
1728	16.08	104.6	91.4	22.82	-10.03	-22.73	2.875
1800	16.08	105.2	91.9	23.98	-10.20	-23.22	2.819
1900	16.07	106.1	92.6	25.59	-10.43	-23.99	2.759
2000	16.07	106.9	93.3	27.20	-10.66	-24.65	2.694

Phase changes: 332.6 K, boiling point of Br_2; ΔH° = 7.066 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation calculated by the third law method from sublimation pressure data (McCreary and Thorn, 1968).
Heat capacity, entropy, and enthalpy calculated from molecular data: vibrational frequencies ν_2, ν_3 (Thompson and Carlson, 1968), ν_1 estimated; electronic levels above 4,000 cm^{-1} (DeKock and Gruen, 1967), below 4,000 cm^{-1} estimated; and interatomic distance (Brewer, Somayajulu, and Brackett, 1963).

Thermodynamic Properties of $Ni(CO)_4(g)$

[Formation: $Ni(s) + 4C(s) + 2O_2(g) = Ni(CO)_4(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-7.29	-139.3	-139.3	∞
100	20.2	68.6	127.2	-5.86	-139.4	-137.7	300.94
200	30.6	86.0	102.4	-3.28	-139.0	-136.2	148.83
298.15	35.7	99.3	99.3	0	-138.3	-134.9	98.88
300	35.7	99.5	99.3	.07	-138.3	-134.9	98.27
350	37.2	105.2	99.8	1.89	-137.9	-134.4	83.92
400	38.3	110.2	100.8	3.78	-137.6	-133.9	73.16
450	39.2	114.8	102.1	5.72	-137.4	-133.5	64.84
500	40.0	119.0	103.6	7.70	-137.2	-133.1	58.18
550	40.7	122.8	105.1	9.72	-137.0	-132.6	52.69
600	41.4	126.4	106.8	11.78	-136.9	-132.2	48.15
631	41.8	128.5	107.8	13.06	-136.9	-132.0	45.72
650	42.0	129.7	108.4	13.86	-136.8	-131.8	44.32
700	42.5	132.9	110.1	15.97	-136.7	-131.5	41.06
750	43.1	135.8	111.7	18.11	-136.7	-131.1	38.20
800	43.5	138.6	113.3	20.28	-136.6	-130.7	35.71
850	44.0	141.3	114.9	22.47	-136.6	-130.4	33.53
900	44.4	143.8	116.4	24.67	-136.5	-130.0	31.57
950	44.7	146.2	117.9	26.90	-136.5	-129.7	29.84
1000	45.1	148.5	119.4	29.15	-136.5	-129.3	28.26

Phase change: 631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.

Sources of data: Enthalpy of formation calculated from equilibrium pressure data (Kipnis and Mikhailova, 1972) by the third law method.
Heat capacity, entropy, and enthalpy calculated from molecular data: vibrational frequencies (Jones, McDowell, and Goldblatt, 1968) and internuclear distances (Bigorgne, 1958).

Thermodynamic Properties of NiCl(g)

[Formation: $Ni(s,l) + 1/2Cl_2(g) = NiCl(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.26	43.0	43.0	∞
100	7.13	51.59	67.19	-1.56	43.2	40.5	-88.51
200	7.94	56.79	60.84	-.81	43.1	37.8	-41.31
298.15	8.45	60.06	60.06	0	43.0	35.2	-25.80
300	8.45	60.11	60.06	.02	43.0	35.1	-25.57
400	8.80	62.60	60.40	.88	42.8	32.5	-17.76
500	9.07	64.59	61.05	1.77	42.5	30.0	-13.11
600	9.28	66.26	61.78	2.69	42.3	27.5	-10.02
631	9.32	66.73	62.01	2.98	42.1	26.7	-9.25
700	9.42	67.70	62.51	3.63	42.0	25.1	-7.84
800	9.50	68.97	63.26	4.57	41.7	22.7	-6.20
900	9.55	70.09	63.95	5.53	41.5	20.3	-4.93
1000	9.58	71.10	64.62	6.48	41.2	17.9	-3.91
1100	9.58	72.01	65.25	7.44	41.0	15.6	-3.10
1200	9.58	72.84	65.84	8.40	40.7	13.4	-2.44
1300	9.59	73.61	66.41	9.36	40.4	11.1	-1.87
1400	9.59	74.32	66.95	10.32	40.0	8.8	-1.37
1500	9.61	74.98	67.46	11.28	39.7	6.6	-.96
1600	9.63	75.60	67.95	12.24	39.3	4.4	-.60
1700	9.67	76.19	68.43	13.20	38.9	2.3	-.30
1728	9.68	76.35	68.55	13.47	38.8	1.7	-.22
1728	9.68	76.35	68.55	13.47	34.7	1.7	-.22
1800	9.72	76.74	68.87	14.17	34.4	.3	-.04
1900	9.78	77.27	69.30	15.15	34.0	-1.6	.18
2000	9.85	77.77	69.71	16.13	33.6	-3.4	.37

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation derived from flame photometry (Bulewicz, Phillips, and Sugden, 1961).
Heat capacity, entropy, and enthalpy calculated from molecular data: vibrational frequency (Leroi, James, Hougen, and Klemperer, 1962), $\omega_e x_e$ and α_e estimated, electronic energy levels based on Ni II (Shenstone, 1970), and internuclear distance (Brewer, Somayajulu, and Brackett, 1963).

Thermodynamic Properties of $NiCl_2(s,l)$

[Formation: $Ni(s) + Cl_2(g) = NiCl_2(s,l)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-3.44	-73.08	-73.08	∞
100	10.46	7.72	37.42	-2.97	-73.43	-69.51	151.914
200	15.52	16.89	24.94	-1.61	-73.25	-65.63	71.717
298.15	17.13	23.42	23.42	0	-72.98	-61.95	45.411
300	17.15	23.53	23.43	.03	-72.98	-61.88	45.080
400	18.17	28.62	24.12	1.80	-72.69	-58.23	31.815
500	18.75	32.74	25.44	3.65	-72.40	-54.64	23.883
600	19.09	36.19	26.96	5.54	-72.16	-51.12	18.620
631	19.15	37.15	27.44	6.13	-72.11	-50.03	17.328
700	19.28	39.15	28.49	7.46	-71.92	-47.63	14.871
800	19.45	41.73	29.98	9.40	-71.60	-44.17	12.067
900	19.68	44.04	31.42	11.36	-71.28	-40.76	9.898
1000	20.07	46.13	32.79	13.34	-70.96	-37.40	8.174
1100	20.71	48.07	34.09	15.38	-70.59	-34.05	6.765
1200	21.70	49.91	35.34	17.49	-70.18	-30.75	5.600
1300	23.12	51.70	36.52	19.73	-69.65	-27.49	4.621
1304	23.19	51.77	36.57	19.82	-69.63	-27.35	4.584
1304	23.90	65.93	36.57	38.29	-51.16	-27.35	4.584
1400	23.90	67.63	38.64	40.58	-50.54	-25.63	4.001

Phase changes: 631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.
1304 K, melting point of $NiCl_2$; $\Delta H° = 18.47$ kcal/mole.

Sources of data: Enthalpy of formation calculated by means of the third law from hydrogen reduction equilibrium data (Busey and Giauque, 1953).
Low-temperature heat capacity and entropy below 15 K (Kostryukova, 1968), and from 15 to 298 K (Busey and Giauque, 1952).
High-temperature enthalpy from Coughlin (1951) corrected to the International Practical Temperature Scale of 1968 (Douglas, 1969).

Thermodynamic Properties of $NiCl_2(g)$

[Formation: $Ni(s,l) + Cl_2(g) = NiCl_2(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-3.55	-17.01	-17.01	∞
100	11.43	57.2	83.2	-2.60	-16.88	-17.91	39.142
200	13.24	65.7	72.6	-1.37	-16.83	-18.97	20.729
298.15	14.49	71.3	71.3	0	-16.80	-20.04	14.690
300	14.50	71.3	71.3	.03	-16.80	-20.03	14.592
400	15.20	75.6	71.8	1.52	-16.79	-21.12	11.539
500	15.58	79.1	73.0	3.06	-16.81	-22.23	9.717
600	15.78	81.9	74.2	4.63	-16.89	-23.28	8.480
631	15.81	82.7	74.6	5.12	-16.94	-23.60	8.174
700	15.88	84.4	75.5	6.21	-16.99	-24.37	7.609
800	15.91	86.5	76.8	7.80	-17.02	-25.41	6.942
900	15.92	88.4	78.0	9.39	-17.07	-26.48	6.430
1000	15.91	90.0	79.0	10.98	-17.14	-27.45	5.999
1100	15.90	91.5	80.1	12.57	-17.22	-28.45	5.652
1200	15.89	92.9	81.1	14.16	-17.33	-29.49	5.371
1300	15.89	94.2	82.1	15.75	-17.45	-30.54	5.134
1400	15.90	95.4	83.0	17.34	-17.60	-31.57	4.928
1500	15.90	96.5	83.9	18.93	-17.78	-32.56	4.744
1600	15.91	97.5	84.7	20.52	-17.97	-33.50	4.576
1700	15.92	98.5	85.5	22.11	-18.20	-34.53	4.439
1728	15.92	98.8	85.7	22.56	-18.26	-34.79	4.400
1728	15.92	98.8	85.7	22.56	-22.36	-34.79	4.400
1800	15.93	99.4	86.2	23.71	-22.53	-35.28	4.284
1900	15.94	100.2	86.9	25.30	-22.79	-35.87	4.126
2000	15.95	101.1	87.7	26.89	-23.04	-36.71	4.011

Phase changes: 631 K, Curie temperature of Ni; $\Delta H°$ = 0 kcal/mole.
1728 K, melting point of Ni; $\Delta H°$ = 4.10 kcal/mole.

Sources of data: Enthalpy of formation calculated by the third law method from sublimation pressure data (McCreary and Thorn, 1968).
Heat capacity, entropy, and enthalpy calculated from molecular data: vibrational frequencies ν_1 (Gruen, Clifton, and DeKock, 1968), ν_2 and ν_3 (Thompson and Carlson, 1968); electronic levels (DeKock and Gruen, 1967); and interatomic distance (Brewer, Somayajulu, and Brackett, 1963).

Thermodynamic Properties of NiD(g)

[Formation: $Ni(s,l) + 1/2D_2(g) = NiD(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.08	94.1	94.1	∞
100	6.96	44.06	57.86	-1.38	94.3	91.5	-199.97
200	6.97	48.88	52.33	-.69	94.2	88.6	-96.82
298.15	7.08	51.68	51.68	0	94.0	85.9	-62.97
300	7.08	51.73	51.70	.01	94.0	85.8	-62.51
400	7.32	53.79	51.97	.73	93.7	83.1	-45.40
500	7.60	55.46	52.50	1.48	93.4	80.5	-35.19
600	7.86	56.86	53.11	2.25	93.0	78.0	-28.41
631	7.93	57.26	53.31	2.49	92.9	77.2	-26.74
700	8.07	58.09	53.73	3.05	92.7	75.5	-23.57
800	8.25	59.18	54.34	3.87	92.4	73.1	-19.97
900	8.40	60.16	54.94	4.70	92.1	70.7	-17.17
1000	8.52	61.05	55.51	5.54	91.8	68.3	-14.93
1100	8.61	61.87	56.05	6.40	91.5	66.0	-13.11
1200	8.69	62.62	56.56	7.27	91.2	63.7	-11.60
1300	8.76	63.32	57.06	8.14	90.9	61.4	-10.32
1400	8.82	63.97	57.53	9.02	90.5	59.2	-9.24
1500	8.87	64.58	57.98	9.90	90.1	56.9	-8.29
1600	8.92	65.16	58.42	10.79	89.7	54.7	-7.47
1700	8.96	65.70	58.82	11.69	89.3	52.6	-6.76
1728	8.97	65.85	58.94	11.94	89.2	52.0	-6.58
1728	8.97	65.85	58.94	11.94	85.1	52.0	-6.58
1800	9.00	66.21	59.22	12.58	84.8	50.6	-6.14
1900	9.03	66.70	59.61	13.48	84.3	48.7	-5.60
2000	9.06	67.16	59.97	14.39	83.8	46.9	-5.12

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation estimated.
Heat capacity, entropy, and enthalpy calculated from molecular constants (Åslund, Neuhaus, Lagerquist, and Andersén, 1964).

Thermodynamic Properties of NiF(g)

[Formation: $Ni(s,l) + 1/2F_2(g) = NiF(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.14	25.1	25.1	∞
100	6.96	49.36	63.76	-1.44	25.3	22.6	-49.39
200	7.26	54.25	57.95	-.74	25.2	19.9	-21.75
298.15	7.80	57.25	57.25	0	25.0	17.3	-12.68
300	7.81	57.30	57.27	.01	25.0	17.2	-12.53
400	8.31	59.61	57.56	.82	24.8	14.7	-8.03
500	8.71	61.51	58.17	1.67	24.5	12.2	-5.33
600	9.01	63.13	58.86	2.56	24.2	9.8	-3.57
631	9.08	63.59	59.09	2.84	24.1	9.0	-3.12
700	9.22	64.54	59.58	3.47	23.9	7.4	-2.31
800	9.35	65.78	60.28	4.40	23.6	5.0	-1.37
900	9.44	66.88	60.95	5.34	23.4	2.7	-.66
1000	9.49	67.88	61.59	6.29	23.1	.4	-.09
1100	9.52	68.78	62.20	7.24	22.9	-1.8	.36
1200	9.53	69.61	62.79	8.19	22.6	-4.0	.73
1300	9.55	70.38	63.35	9.14	22.3	-6.3	1.06
1400	9.57	71.09	63.88	10.10	21.9	-8.4	1.31
1500	9.59	71.75	64.38	11.06	21.6	-10.6	1.54
1600	9.63	72.37	64.86	12.02	21.2	-12.7	1.73
1700	9.67	72.95	65.31	12.98	20.8	-14.8	1.90
1728	9.69	73.11	65.44	13.25	20.7	-15.4	1.95
1728	9.69	73.11	65.44	13.25	16.6	-15.4	1.95
1800	9.73	73.51	65.76	13.95	16.3	-16.8	2.04
1900	9.80	74.03	66.17	14.93	15.9	-18.6	2.14
2000	9.87	74.54	66.59	15.91	15.5	-20.4	2.23

Phase changes: 631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.
1728 K, melting point of Ni; $\Delta H° = 4.10$ kcal/mole.

Sources of data: Enthalpy of formation estimated.
Heat capacity, entropy, and enthalpy calculated from molecular data: vibrational frequency (Milligan, Jacox, and McKinley, 1965), $\omega_e x_e$ and α_e estimated, electronic energy levels based on levels of Ni II (Shenstone, 1970); and internuclear distance (Brewer, Somayajulu, and Brackett, 1963).

Thermodynamic Properties of $NiF_2(s)$

[Formation: $Ni(s) + F_2(g) = NiF_2(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.73	-156.68	-156.68	∞
100	6.93	5.29	29.09	-2.38	-157.14	-153.42	335.299
200	12.57	12.01	18.91	-1.38	-157.29	-149.62	163.497
298.15	15.31	17.59	17.59	0	-157.20	-145.87	106.926
300	15.35	17.69	17.59	.03	-157.20	-145.80	106.215
400	16.50	22.29	18.22	1.63	-157.02	-142.03	77.602
500	17.05	26.03	19.41	3.31	-156.86	-138.30	60.451
600	17.47	29.18	20.78	5.04	-156.74	-134.60	49.028
631	17.59	30.06	21.22	5.58	-156.73	-133.46	46.224
700	17.86	31.90	22.19	6.80	-156.63	-130.92	40.875
800	18.23	34.31	23.55	8.61	-156.42	-127.26	34.766
900	18.59	36.48	24.87	10.45	-156.21	-123.63	30.021
1000	18.95	38.45	26.12	12.33	-155.97	-120.02	26.230
1100	19.31	40.28	27.33	14.24	-155.73	-116.44	23.134
1200	19.71	41.97	28.48	16.19	-155.48	-112.87	20.556
1300	20.18	43.57	29.59	18.18	-155.20	-109.34	18.382
1400	20.80	45.09	30.64	20.23	-154.90	-105.83	16.521
1500	21.65	46.55	31.65	22.35	-154.54	-102.33	14.909
1600	22.86	47.98	32.62	24.57	-154.12	-98.86	13.504

Phase change: 631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.

Sources of data: Enthalpy of formation determined by fluorine bomb calorimetry (Rudzitis, Van DeVenter, and Hubbard, 1967).
Low-temperature heat capacity and entropy from Catalano and Stout (1955).
High-temperature enthalpy based on measurements of Binford and Hebert (1970).

Thermodynamic Properties of $NiF_2(g)$

[Formation: $Ni(s,l) + F_2(g) = NiF_2(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-3.05	-80.0	-80.0	∞
100	9.85	53.2	75.6	-2.24	-80.0	-81.1	177.24
200	11.32	60.5	66.4	-1.17	-80.1	-82.1	89.71
298.15	12.56	65.2	65.2	0	-80.2	-83.1	60.91
300	12.58	65.3	65.2	.02	-80.2	-83.1	60.54
400	13.55	69.1	65.8	1.33	-80.3	-84.1	45.95
500	14.26	72.2	66.8	2.72	-80.4	-85.0	37.15
600	14.77	74.8	67.8	4.18	-80.6	-85.8	31.25
631	14.88	75.5	68.1	4.64	-80.7	-86.1	29.82
700	15.12	77.1	69.0	5.67	-80.8	-86.7	27.07
800	15.36	79.2	70.2	7.20	-80.8	-87.6	23.93
900	15.50	81.0	71.3	8.74	-80.9	-88.4	21.47
1000	15.58	82.6	72.3	10.30	-81.0	-89.2	19.49
1100	15.62	84.1	73.3	11.86	-81.1	-90.0	17.88
1200	15.63	85.5	74.3	13.42	-81.2	-90.9	16.56
1300	15.62	86.7	75.2	14.98	-81.4	-91.6	15.40
1400	15.60	87.9	76.1	16.54	-81.6	-92.5	14.44
1500	15.57	89.0	76.9	18.10	-81.8	-93.3	13.59
1600	15.54	90.0	77.7	19.66	-82.0	-94.0	12.84
1700	15.50	90.9	78.4	21.21	-82.3	-94.7	12.17
1728	15.49	91.2	78.7	21.64	-82.4	-94.9	12.00
1728	15.49	91.2	78.7	21.64	-86.5	-94.9	12.00
1800	15.47	91.8	79.2	22.76	-86.7	-95.2	11.56
1900	15.44	92.6	79.8	24.30	-87.0	-95.7	11.01
2000	15.41	93.4	80.5	25.84	-87.3	-96.1	10.50

Phase changes: 631 K, Curie temperature of Ni; $\Delta H°$ = 0 kcal/mole.
1728 K, melting point of Ni; $\Delta H°$ = 4.10 kcal/mole.

Sources of data: Enthalpy of formation based on third law treatment of vapor pressure data from manometric measurements (Cantor, 1965) and mass spectrometric studies (Ehlert, Kent, and Margrave, 1964).
Heat capacity, entropy, and enthalpy calculated from molecular data: vibrational frequencies (Milligan, Jacox, and McKinley, 1965 and Hastie, Hauge, and Margrave, 1969-2), electronic energy levels based on Ni III (Moore, 1952), and interatomic distance (Brewer, Somayajulu, and Brackett, 1963).

Thermodynamic Properties of $NiFe_2Cl_8(g)$

[Formation: $Ni(s) + 2Fe(s) + 4Cl_2(g) = NiFe_2Cl_8(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	56.8	170.0	170.0	0	-215.0	-196.1	143.75
300	56.8	170.4	170.0	.11	-215.0	-196.0	142.79
400	58.9	187.0	172.2	5.91	-214.4	-189.7	103.65
500	60.0	200.3	176.6	11.86	-213.9	-183.7	80.30
600	60.6	211.3	181.5	17.89	-213.6	-177.6	64.69
631	60.7	214.4	183.1	19.77	-213.6	-175.8	60.89
700	61.0	220.7	186.5	23.97	-213.5	-171.7	53.61
800	61.3	228.8	191.2	30.09	-213.4	-165.6	45.24
900	61.7	236.1	195.8	36.24	-213.4	-159.7	38.78
1000	62.0	242.6	200.2	42.42	-213.9	-153.7	33.59

Phase change: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.

Sources of data: Enthalpy of formation and entropy obtained by second law calculation from equilibrium pressure data on the sublimation of nickel chloride in the presence of iron chloride gas (Dewing, 1970).
Heat capacity estimated.

Thermodynamic Properties of $NiFe_2O_4$(s)

[Formation: Ni(s,l) + 2Fe(s) + $2O_2$(g) = $NiFe_2O_4$(s)]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	.64	∞	-5.27	-253.1	-253.1	∞
100	10.86	6.10	55.10	-4.90	-254.5	-246.3	538.29
200	25.83	18.56	33.61	-3.01	-255.3	-237.8	259.86
298.15	34.81	30.70	30.70	0	-255.3	-229.2	168.01
300	34.96	30.92	30.70	.07	-255.3	-229.0	166.83
400	40.27	41.74	32.14	3.84	-254.8	-220.4	120.42
500	43.90	51.14	35.02	8.06	-254.2	-211.8	92.58
600	46.80	59.40	38.40	12.60	-253.4	-203.4	74.09
631	47.79	61.78	39.48	14.07	-253.1	-200.8	69.55
700	49.98	66.85	41.95	17.43	-252.5	-195.2	60.94
800	54.62	73.80	45.50	22.64	-251.4	-187.1	51.11
880	60.26	79.25	48.32	27.22	-250.2	-180.7	44.88
880	48.50	79.25	48.32	27.22	-250.2	-180.7	44.88
900	48.50	80.34	49.02	28.19	-250.1	-179.1	43.49
1000	48.50	85.45	52.41	33.04	-249.9	-171.2	37.42
1043	48.50	87.49	53.81	35.13	-250.2	-167.8	35.16
1100	48.50	90.08	55.63	37.89	-250.2	-163.3	32.44
1185	48.50	93.69	58.24	42.01	-250.0	-156.6	28.88
1185	48.50	93.69	58.24	42.01	-250.4	-156.6	28.88
1200	48.50	94.30	58.68	42.74	-250.3	-155.4	28.30
1300	48.50	98.18	61.57	47.59	-249.6	-147.6	24.81
1400	48.50	101.77	64.31	52.44	-249.0	-139.7	21.81
1500	48.50	105.12	66.93	57.29	-248.5	-131.9	19.22
1600	48.50	108.25	69.41	62.14	-248.0	-124.2	16.96
1667	48.50	110.24	71.01	65.39	-247.8	-119.0	15.60
1667	48.50	110.24	71.01	65.39	-248.2	-119.0	15.60
1700	48.50	111.19	71.78	66.99	-248.1	-116.5	14.98
1728	48.50	111.98	72.43	68.35	-248.0	-114.3	14.46
1728	48.50	111.98	72.43	68.35	-252.1	-114.3	14.46
1800	48.50	113.96	74.05	71.84	-252.1	-108.5	13.17

Phase changes:
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
880 K, α - β transition point of $NiFe_2O_4$; ΔH° = 0 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, α - γ transition point of Fe; ΔH° = 0.215 kcal/mole.
1667 K, γ - δ transition point of Fe; ΔH° = 0.200 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation derived from nickel sulfate dissociation equilibria in the presence of ferric oxide (Umetsu, Tozawa, and Sjukur, 1972), and calorimetric determinations (Navrotsky and Kleppa, 1968).
Low-temperature heat capacity and entropy from King (1956) with estimated zero point entropy.
High-temperature enthalpy based on enthalpy determinations of Landiya, Chachanidze, Chuprin, Pavlenishvili, Lezhava, and Varazashvili (1966).

Thermodynamic Properties of NiH(g)

[Formation: $Ni(s,l) + 1/2H_2(g) = NiH(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.07	94.1	94.1	∞
100	6.96	42.71	56.51	-1.38	94.3	91.4	-199.75
200	6.97	47.54	50.94	-.68	94.2	88.5	-96.71
298.15	6.99	50.32	50.32	0	94.0	85.8	-62.89
300	6.99	50.36	50.33	.01	94.0	85.7	-62.43
400	7.07	52.38	50.58	.72	93.7	83.0	-45.35
500	7.23	53.98	51.12	1.43	93.4	80.4	-35.14
600	7.43	55.31	51.71	2.16	93.0	77.8	-28.34
631	7.50	55.69	51.90	2.39	92.8	77.0	-26.67
700	7.64	56.47	52.30	2.92	92.6	75.3	-23.51
800	7.83	57.50	52.89	3.69	92.2	72.9	-19.92
900	8.00	58.44	53.46	4.48	91.9	70.5	-17.12
1000	8.15	59.29	54.00	5.29	91.6	68.1	-14.88
1100	8.29	60.07	54.52	6.11	91.3	65.8	-13.07
1200	8.40	60.80	55.01	6.95	91.0	63.5	-11.56
1300	8.50	61.47	55.48	7.79	90.6	61.2	-10.29
1400	8.58	62.11	55.94	8.64	90.3	59.0	-9.21
1500	8.66	62.70	56.36	9.51	89.9	56.8	-8.28
1600	8.73	63.26	56.77	10.38	89.5	54.6	-7.46
1700	8.79	63.79	57.17	11.25	89.1	52.4	-6.74
1728	8.80	63.93	57.27	11.50	88.9	51.8	-6.55
1728	8.80	63.93	57.27	11.50	84.8	51.8	-6.55
1800	8.84	64.30	57.56	12.13	84.5	50.4	-6.12
1900	8.89	64.78	57.93	13.02	84.1	48.5	-5.58
2000	8.93	65.23	58.28	13.91	83.6	46.7	-5.10

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation derived from the dissociation energy (Gaydon, 1968).
Heat capacity, entropy, and enthalpy calculated from molecular constants (Åslund, Neuhaus, Lagerquist, and Andersén, 1964 and Herzberg, 1950).

Thermodynamic Properties of NiI(g)

[Formation: $Ni(s,l) + 1/2I_2(s,l,g) = NiI(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.36	59.4	59.4	∞
100	7.58	55.56	72.06	-1.65	59.6	54.9	-119.98
200	8.43	61.13	65.33	-.84	59.4	50.4	-55.07
298.15	8.75	64.56	64.56	0	59.0	46.0	-33.72
300	8.76	64.61	64.56	.02	59.0	45.9	-33.44
386.8	8.97	66.87	64.85	.78	58.6	42.2	-23.84
386.8	8.97	66.87	64.85	.78	56.7	42.2	-23.84
400	9.00	67.17	64.92	.90	56.6	41.7	-22.78
458.4	9.13	68.40	65.26	1.44	56.2	39.6	-18.88
458.4	9.13	68.40	65.26	1.44	51.2	39.6	-18.88
500	9.22	69.20	65.56	1.82	51.1	38.5	-16.83
600	9.39	70.89	66.31	2.75	50.8	36.0	-13.11
631	9.43	71.36	66.54	3.04	50.7	35.3	-12.23
700	9.51	72.35	67.08	3.69	50.5	33.6	-10.49
800	9.58	73.63	67.82	4.65	50.3	31.2	-8.52
900	9.62	74.76	68.53	5.61	50.0	28.8	-6.99
1000	9.64	75.77	69.20	6.57	49.8	26.5	-5.79
1100	9.65	76.69	69.84	7.53	49.5	24.2	-4.81
1200	9.65	77.53	70.45	8.50	49.2	21.9	-3.99
1300	9.65	78.30	71.02	9.46	48.9	19.6	-3.30
1400	9.66	79.02	71.57	10.43	48.6	17.4	-2.72
1500	9.67	79.68	72.08	11.40	48.2	15.2	-2.21
1600	9.70	80.31	72.59	12.36	47.9	13.0	-1.78
1700	9.74	80.90	73.05	13.34	47.5	10.8	-1.39
1728	9.75	81.06	73.18	13.61	47.4	10.2	-1.29
1728	9.75	81.06	73.18	13.61	43.3	10.2	-1.29
1800	9.79	81.46	73.51	14.31	43.0	8.8	-1.07
1900	9.85	81.99	73.94	15.29	42.5	7.0	-.81
2000	9.92	82.49	74.35	16.28	42.1	5.1	-.56

Phase changes:
386.8 K, melting point of I_2; ΔH° = 3.709 kcal/mole.
458.4 K, boiling point of I_2; ΔH° = 10.026 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation derived from flame photometry (Bulewicz, Phillips, and Sugden, 1961).
Heat capacity, entropy, and enthalpy calculated from molecular data: vibrational frequency, ωexe, and αe estimated; electronic energy levels based on Ni II (Shenstone, 1970); and internuclear distance (Brewer, Somayajulu, and Brackett, 1963).

Thermodynamic Properties of $Ni_2Mg(s)$

[Formation: $2Ni(s) + Mg(s) = Ni_2Mg(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	$Cp°$	$S°$	$-(G°-H°_{298})/T$	$H°-H°_{298}$	$\Delta Hf°$	$\Delta Gf°$	
298.15	17.6	21.2	21.2	0	-13.20	-12.93	9.478
300	17.6	21.3	21.2	.03	-13.21	-12.93	9.419
350	18.1	24.1	21.4	.93	-13.24	-12.90	8.055
400	18.6	26.5	21.9	1.85	-13.30	-12.82	7.005
450	18.9	28.7	22.5	2.78	-13.38	-12.76	6.197
467	19.0	29.4	22.7	3.11	-13.40	-12.73	5.957
500	19.2	30.7	23.2	3.74	-13.47	-12.68	5.542
550	19.5	32.6	24.1	4.70	-13.60	-12.63	5.019

Phase change: 467 K, second order transition of Ni_2Mg; $\Delta H° = 0$ kcal/mole.

Sources of data: Enthalpy of formation obtained by tin solution calorimetry (King and Kleppa, 1964).
Heat capacity and entropy from Wollam and Wallace (1960).

Thermodynamic Properties of NiO(s)

[Formation: $Ni(s,1) + 1/2O_2(g) = NiO(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-1.61	-56.73	-56.73	∞
100	3.35	1.52	16.52	-1.50	-57.09	-54.99	120.181
200	7.93	5.38	9.98	-.92	-57.31	-52.80	57.697
298.15	10.59	9.08	9.08	0	-57.30	-50.57	37.069
300	10.63	9.15	9.08	.02	-57.30	-50.53	36.811
400	12.31	12.44	9.52	1.17	-57.16	-48.29	26.384
500	15.53	15.48	10.42	2.53	-56.87	-46.12	20.159
525	16.91	16.27	10.67	2.94	-56.74	-45.58	18.974
525	13.07	16.27	10.67	2.94	-56.74	-45.58	18.974
565	14.68	17.29	11.11	3.49	-56.65	-44.74	17.306
565	12.85	17.29	11.11	3.49	-56.65	-44.74	17.306
600	12.82	18.06	11.49	3.94	-56.62	-44.00	16.027
631	12.80	18.71	11.83	4.34	-56.61	-43.34	15.011
700	12.76	20.03	12.57	5.22	-56.53	-41.89	13.079
800	12.75	21.73	13.61	6.50	-56.38	-39.81	10.876
900	12.81	23.24	14.61	7.77	-56.27	-37.76	9.169
1000	12.94	24.59	15.53	9.06	-56.15	-35.70	7.802
1100	13.14	25.83	16.40	10.37	-56.04	-33.64	6.684
1200	13.38	26.99	17.25	11.69	-55.94	-31.62	5.759
1300	13.65	28.07	18.04	13.04	-55.84	-29.60	4.976
1400	13.95	29.09	18.79	14.42	-55.72	-27.59	4.307
1500	14.25	30.06	19.51	15.83	-55.61	-25.58	3.727
1600	14.54	30.99	20.20	17.27	-55.48	-23.58	3.221
1700	14.80	31.88	20.86	18.74	-55.36	-21.60	2.777
1728	14.86	32.12	21.03	19.16	-55.32	-21.03	2.660
1728	14.86	32.12	21.03	19.16	-59.42	-21.03	2.660
1800	15.01	32.73	21.49	20.23	-59.34	-19.43	2.359
1900	15.16	33.55	22.11	21.74	-59.21	-17.23	1.982
2000	15.23	34.33	22.70	23.26	-59.07	-15.02	1.641

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation determined by combustion calorimetry (Boyle and King, 1954).
Low-temperature heat capacity and entropy from King (1957).
High-temperature enthalpy from King and Christensen (1958) corrected to the International Practical Temperature Scale of 1968 (Douglas, 1969).

Thermodynamic Properties of NiO(g)

[Formation: $Ni(s,l) + 1/2O_2(g) = NiO(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.18	74.0	74.0	∞
100	6.98	49.60	64.40	-1.48	74.2	71.5	-156.26
200	7.47	54.56	58.36	-.76	74.2	68.8	-75.18
298.15	8.09	57.66	57.66	0	74.0	66.2	-48.53
300	8.10	57.71	57.66	.02	74.0	66.2	-48.23
400	8.64	60.12	58.00	.85	73.8	63.6	-34.75
500	9.08	62.09	58.61	1.74	73.6	61.1	-26.71
600	9.41	63.78	59.33	2.67	73.4	58.6	-21.35
631	9.48	64.26	59.57	2.96	73.3	57.8	-20.02
700	9.65	65.25	60.08	3.62	73.2	56.2	-17.55
800	9.81	66.55	60.81	4.59	73.0	53.7	-14.67
900	9.90	67.71	61.51	5.58	72.8	51.3	-12.46
1000	9.95	68.76	62.19	6.57	72.7	48.9	-10.69
1100	9.96	69.70	62.82	7.57	72.5	46.6	-9.26
1200	9.95	70.57	63.44	8.56	72.2	44.2	-8.05
1300	9.94	71.37	64.02	9.56	72.0	41.9	-7.04
1400	9.91	72.10	64.56	10.55	71.7	39.6	-6.18
1500	9.88	72.78	65.09	11.54	71.4	37.4	-5.45
1600	9.85	73.42	65.59	12.53	71.1	35.1	-4.79
1700	9.82	74.02	66.07	13.51	70.7	32.8	-4.22
1728	9.81	74.18	66.21	13.78	70.6	32.2	-4.07
1728	9.81	74.18	66.21	13.78	66.5	32.2	-4.07
1800	9.79	74.58	66.53	14.49	66.2	30.8	-3.74
1900	9.76	75.11	66.97	15.47	65.8	28.8	-3.31
2000	9.73	75.61	67.39	16.44	65.4	26.9	-2.94

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation obtained from third law calculation of vaporization data (Grimley, Burns, and Inghram, 1961).
Heat capacity, entropy, and enthalpy calculated from molecular data: vibrational frequency (Rosen, 1951), $\omega_e x_e$ and α_e estimated, electronic energy levels based on Ni III (Moore, 1952), and internuclear distance (Brewer and Chandrasekharaiah, 1960).

Thermodynamic Properties of $Ni(OH)_2(g)$

[Formation: $Ni(s,l) + O_2(g) + H_2(g) = Ni(OH)_2(g)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-3.13	-58.9	-58.9	∞
100	9.0	57.4	80.5	-2.31	-59.6	-58.6	128.07
200	11.7	64.4	70.8	-1.28	-60.4	-57.3	62.61
298.15	14.3	69.6	69.6	0	-61.0	-55.7	40.83
300	14.3	69.7	69.6	.03	-61.0	-55.7	40.58
400	16.4	74.1	70.2	1.57	-61.5	-53.8	29.39
500	18.0	77.9	71.3	3.29	-61.9	-51.8	22.64
600	19.2	81.3	72.7	5.16	-62.3	-49.8	18.14
631	19.5	82.3	73.2	5.76	-62.4	-49.1	17.01
700	20.2	84.4	74.2	7.13	-62.6	-47.7	14.89
800	20.9	87.1	75.6	9.19	-62.8	-45.5	12.43
900	21.5	89.6	77.0	11.31	-63.0	-43.3	10.51
1000	22.0	91.9	78.4	13.48	-63.1	-41.1	8.98
1100	22.4	94.0	79.7	15.70	-63.2	-38.9	7.73
1200	22.7	96.0	81.0	17.95	-63.3	-36.8	6.70
1300	23.0	97.8	82.2	20.24	-63.5	-34.5	5.80
1400	23.3	99.5	83.4	22.56	-63.6	-32.2	5.03
1500	23.5	101.1	84.5	24.90	-63.8	-30.0	4.37
1600	23.7	102.6	85.6	27.26	-63.9	-27.7	3.78
1700	23.9	104.1	86.7	29.64	-64.1	-25.5	3.28
1728	24.0	104.5	87.0	30.31	-64.2	-24.9	3.15
1728	24.0	104.5	87.0	30.31	-68.3	-24.9	3.15
1800	24.1	105.5	87.7	32.04	-68.4	-23.1	2.80
1900	24.2	106.8	88.7	34.45	-68.7	-20.6	2.37
2000	24.3	108.0	89.6	36.88	-68.9	-17.9	1.96

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation calculated by the third law method from equilibrium pressure data on the volatilization of nickel in water vapor and hydrogen (Belton and Jordan, 1967).
Heat capacity, entropy, and enthalpy calculated from estimated molecular constants.

Thermodynamic Properties of NiS(s,1)

[Formation: Ni(s) + S(s,1) = NiS(s)]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.05	-22.0	-22.0	∞
100	5.54	3.07	21.47	-1.84	-22.0	-21.9	47.86
200	9.71	8.45	13.65	-1.04	-22.1	-21.7	23.71
298.15	11.26	12.66	12.66	0	-22.1	-21.5	15.76
300	11.29	12.73	12.66	.02	-22.1	-21.5	15.66
368.54	11.89	15.12	12.90	.82	-22.1	-21.3	12.63
368.54	11.89	15.12	12.90	.82	-22.2	-21.3	12.63
388.36	12.05	15.74	13.01	1.06	-22.2	-21.3	11.99
388.36	12.05	15.74	13.01	1.06	-22.6	-21.3	11.99
400	12.14	16.10	13.10	1.20	-22.7	-21.2	11.58
500	12.83	18.89	14.01	2.44	-23.1	-20.8	9.09
600	13.45	21.28	15.01	3.76	-23.4	-20.3	7.39
623	13.59	21.79	15.26	4.07	-23.5	-20.2	7.09
623	13.64	22.91	15.26	4.77	-22.8	-20.2	7.09
631	13.70	23.08	15.35	4.88	-22.8	-20.2	7.00
700	14.21	24.54	16.20	5.84	-22.9	-19.9	6.21
717.8	14.34	24.90	16.42	6.09	-22.9	-19.8	6.03
800	14.95	26.48	17.36	7.30			
900	15.69	28.29	18.48	8.83			
1000	16.43	29.98	19.54	10.44			
1066.5	16.92	31.05	20.22	11.55			
1066.5	17.00	37.61	20.22	18.55			
1100	17.00	38.14	20.76	19.12			
1200	17.00	39.62	22.27	20.82			
1300	17.00	40.98	23.66	22.52			
1400	17.00	42.24	24.94	24.22			
1500	17.00	43.41	26.13	25.92			
1600	17.00	44.51	27.25	27.62			
1700	17.00	45.54	28.29	29.32			
1800	17.00	46.51	29.28	31.02			

Phase changes:
368.54 K, rhombic-monoclinic transition point of S; ΔH° = 0.096 kcal/mole.
388.36 K, melting point of S; ΔH° = 0.41 kcal/mole.
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
717.8 K, boiling point of S.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.

Sources of data:
Enthalpy of formation obtained by third law calculation from equilibrium S_2 pressure over Ni-S melts (Nagamori and Ingraham, 1970).
Low-temperature heat capacity and entropy from Weller and Kelley (1964).
High-temperature enthalpy from 298 to 1066.5 K (Ferrante, 1974); enthalpy of α-β transition, enthalpy of fusion, and heat capacity of the liquid estimated.

Thermodynamic Properties of NiS(s,l)

[Formation: $Ni(s,l) + 1/2S_2(g) = NiS(s,l)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf	ΔGf	
0	0	0	∞	-2.05	-37.3	-37.3	∞
100	5.54	3.07	21.47	-1.84	-37.5	-35.3	77.15
200	9.71	8.45	13.65	-1.04	-37.5	-33.1	36.17
298.15	11.26	12.66	12.66	0	-37.4	-31.0	22.72
300	11.29	12.73	12.66	.02	-37.4	-30.9	22.51
400	12.14	16.10	13.10	1.20	-37.3	-28.8	15.74
500	12.83	18.89	14.01	2.44	-37.2	-26.7	11.67
600	13.45	21.28	15.01	3.76	-37.1	-24.5	8.92
623	13.59	21.79	15.26	4.07	-37.1	-24.1	8.45
623	13.64	22.91	15.26	4.77	-36.4	-24.1	8.45
631	13.70	23.08	15.35	4.88	-36.4	-23.9	8.28
700	14.21	24.54	16.20	5.84	-36.2	-22.6	7.06
800	14.95	26.48	17.36	7.30	-35.9	-20.6	5.63
900	15.69	28.29	18.48	8.83	-35.6	-18.7	4.54
1000	16.43	29.98	19.54	10.44	-35.2	-16.9	3.69
1066.5	16.92	31.05	20.22	11.55	-34.9	-15.7	3.22
1066.5	17.00	37.61	20.22	18.55	-27.9	-15.7	3.22
1100	17.00	38.14	20.76	19.12	-27.7	-15.3	3.04
1200	17.00	39.62	22.27	20.82	-27.3	-14.2	2.59
1300	17.00	40.98	23.66	22.52	-26.8	-13.1	2.20
1400	17.00	42.24	24.94	24.22	-26.4	-12.0	1.87
1500	17.00	43.41	26.13	25.92	-26.0	-11.0	1.60
1600	17.00	44.51	27.25	27.62	-25.6	-10.0	1.37
1700	17.00	45.54	28.29	29.32	-25.3	-9.1	1.17
1728	17.00	45.81	28.56	29.80	-25.2	-8.8	1.11
1728	17.00	45.81	28.56	29.80	-29.3	-8.8	1.11
1800	17.00	46.51	29.28	31.02	-29.1	-8.0	.97

Phase changes:
623 K, α-β transition point of NiS; ΔH° = 0.7 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data:
Enthalpy of formation obtained by third law calculation from equilibrium S_2 pressure over Ni-S melts (Nagamori and Ingraham, 1970).
Low-temperature heat capacity and entropy from Weller and Kelley (1964).
High-temperature enthalpy from 298 to 1066.5 K (Ferrante, 1974); enthalpy of α-β transition, enthalpy of fusion, and heat capacity of the liquid estimated.

Thermodynamic Properties of Ni_3S_2(s,l)

[Formation: $3Ni(s) + 2S(s,l) = Ni_3S_2(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-5.13	-51.69	-51.69	∞
100	13.89	8.05	54.05	-4.60	-51.85	-51.53	112.619
200	24.29	21.49	34.49	-2.60	-52.05	-51.21	55.960
298.15	28.12	32.00	32.00	0	-52.10	-50.70	37.164
300	28.17	32.17	32.00	.05	-52.11	-50.70	36.935
368.54	29.80	38.15	32.61	2.04	-52.21	-50.37	29.870
368.54	29.80	38.15	32.61	2.04	-52.40	-50.37	29.870
388.36	30.20	39.71	32.91	2.64	-52.44	-50.25	28.278
388.36	30.20	39.71	32.91	2.64	-53.26	-50.25	28.278
400	30.43	40.61	33.14	2.99	-53.32	-50.16	27.406
500	31.95	47.57	35.35	6.11	-54.21	-49.28	21.540
600	33.35	53.52	37.89	9.38	-55.00	-48.22	17.564
631	33.86	55.21	38.71	10.41	-55.27	-47.86	16.577
700	35.13	58.79	40.50	12.80	-55.57	-47.02	14.680
717.8	35.54	59.68	40.97	13.43	-55.61	-46.80	14.249
800	37.60	63.63	43.09	16.43			
840	38.81	65.48	44.11	17.95			
840	45.98	81.40	44.11	31.32			
900	45.55	84.56	46.72	34.06			
1000	44.84	89.32	50.74	38.58			
1064	44.39	92.08	53.14	41.43			
1064	45.20	96.50	53.14	46.13			
1100	45.20	98.01	54.59	47.76			
1200	45.20	101.94	58.37	52.28			
1300	45.20	105.56	61.87	56.80			
1400	45.20	108.91	65.11	61.32			
1500	45.20	112.02	68.13	65.84			
1600	45.20	114.94	70.97	70.36			
1700	45.20	117.68	73.63	74.88			
1800	45.20	120.27	76.16	79.40			

Phase changes:
368.54 K, rhombic-monoclinic transition point of S; ΔH° = 0.096 kcal/mole.
388.36 K, melting point of S; ΔH° = 0.41 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
717.8 K, boiling point of S.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.

Sources of data:
Enthalpy of formation obtained by third law calculation from equilibrium S_2 pressure over Ni-S melts (Nagamori and Ingraham, 1970).
Low-temperature heat capacity and entropy from Weller and Kelley (1964).
High-temperature enthalpy from 298 to 1200 K (Ferrante, 1974); above 1200 K extrapolated.

Thermodynamic Properties of Ni_3S_2(s,l)

[Formation: $3Ni(s,l) + S_2(g) = Ni_3S_2(s,l)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf	ΔGf	
0	0	0	∞	-5.13	-82.34	-82.34	∞
100	13.89	8.05	54.05	-4.60	-82.87	-78.47	171.496
200	24.29	21.49	34.49	-2.60	-82.93	-74.03	80.896
298.15	28.12	32.00	32.00	0	-82.78	-69.68	51.077
300	28.17	32.17	32.00	.05	-82.78	-69.60	50.704
400	30.43	40.61	33.14	2.99	-82.59	-65.24	35.645
500	31.95	47.57	35.35	6.11	-82.43	-60.92	26.628
600	33.35	53.52	37.89	9.38	-82.35	-56.63	20.627
631	33.86	55.21	38.71	10.41	-82.39	-55.30	19.153
700	35.13	58.79	40.50	12.80	-82.19	-52.34	16.341
800	37.60	63.63	43.09	16.43	-81.64	-48.12	13.146
840	38.81	65.48	44.11	17.95	-81.36	-46.45	12.085
840	45.98	81.40	44.11	31.32	-67.99	-46.45	12.085
900	45.55	84.56	46.72	34.06	-67.13	-44.95	10.915
1000	44.84	89.32	50.74	38.58	-65.78	-42.56	9.301
1064	44.39	92.08	53.14	41.43	-64.98	-41.09	8.440
1064	45.20	96.50	53.14	46.13	-60.28	-41.09	8.440
1100	45.20	98.01	54.59	47.76	-59.82	-40.43	8.033
1200	45.20	101.94	58.37	52.28	-58.57	-38.73	7.054
1300	45.20	105.56	61.87	56.80	-57.39	-37.14	6.244
1400	45.20	108.91	65.11	61.32	-56.27	-35.62	5.561
1500	45.20	112.02	68.13	65.84	-55.21	-34.18	4.980
1600	45.20	114.94	70.97	70.36	-54.23	-32.80	4.480
1700	45.20	117.68	73.63	74.88	-53.32	-31.52	4.052
1728	45.20	118.42	74.35	76.15	-53.07	-31.12	3.936
1728	45.20	118.42	74.35	76.15	-65.37	-31.12	3.936
1800	45.20	120.27	76.16	79.40	-64.78	-29.72	3.608

Phase changes:
631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.
840 K, α - β transition point of Ni_3S_2; $\Delta H° = 13.37$ kcal/mole.
1064 K, melting point of Ni_3S_2; $\Delta H° = 4.70$ kcal/mole.
1728 K, melting point of Ni; $\Delta H° = 4.10$ kcal/mole.

Sources of data:
Enthalpy of formation obtained by third law calculation from equilibrium S_2 pressure over Ni-S melts (Nagamori and Ingraham, 1970).
Low-temperature heat capacity and entropy from Weller and Kelley (1964).
High-temperature enthalpy from 298 to 1200 K (Ferrante, 1974); above 1200 K extrapolated.

Thermodynamic Properties of $NiSO_4(s)$

[Formation: $Ni(s) + S(s,l) + 2O_2(g) = NiSO_4(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-3.18	-205.46	-205.46	∞
100	9.02	6.76	40.96	-3.42	-207.38	-199.30	435.570
200	17.84	15.99	26.19	-2.04	-208.26	-190.88	208.584
298.15	23.33	24.21	24.21	0	-208.63	-182.22	133.571
300	23.42	24.35	24.22	.04	-208.64	-182.06	132.631
350	25.77	28.15	24.49	1.28	-208.70	-177.62	110.911
368.54	26.42	29.50	24.72	1.76	-208.71	-175.97	104.353
368.54	26.42	29.50	24.72	1.76	-208.81	-175.97	104.353
388.36	27.10	30.90	25.00	2.29	-208.81	-174.21	98.037
388.36	27.10	30.90	25.00	2.29	-209.22	-174.21	98.037
400	27.51	31.71	25.19	2.61	-209.24	-173.16	94.610
450	28.90	35.03	26.10	4.02	-209.36	-168.64	81.903
500	30.05	38.14	27.14	5.50	-209.46	-164.11	71.732
550	31.04	41.05	28.29	7.02	-209.51	-159.58	63.411
600	31.91	43.79	29.46	8.60	-209.51	-155.04	56.473
631	32.39	45.40	30.20	9.59	-209.52	-152.22	52.722
650	32.68	46.37	30.66	10.21	-209.50	-150.50	50.603
700	33.37	48.82	31.86	11.87	-209.39	-145.95	45.568
717.8	33.59	49.66	32.29	12.47	-209.35	-144.34	43.947
750	34.00	51.14	33.07	13.55			
800	34.57	53.36	34.29	15.26			
850	35.09	55.47	35.46	17.01			
900	35.56	57.49	36.63	18.77			
950	35.99	59.42	37.78	20.56			
1000	36.38	61.28	38.91	22.37			
1050	36.72	63.06	40.01	24.20			
1100	37.03	64.78	41.11	26.04			
1150	37.30	66.43	42.17	27.90			
1200	37.53	68.02	43.21	29.77			

Phase changes: 368.54 K, rhombic-monoclinic transition point of S; ΔH° = 0.096 kcal/mole.
388.36 K, melting point of S; ΔH° = 0.41 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
717.8 K, boiling point of S.

Sources of data: Enthalpy of formation derived from hydrochloric acid solution calorimetry (Adami and King, 1965).
Low-temperature heat capacity and entropy from 5 to 50 K (Stuve, 1974); and from 50 to 298 K (Weller, 1965).
High-temperature enthalpy from Ferrante (1974).

Thermodynamic Properties of $NiSO_4(s)$

[Formation: $Ni(s) + 1/2S_2(g) + 2O_2(g) = NiSO_4(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf	ΔGf	
0	0	0	∞	-3.18	-220.79	-220.79	∞
100	9.02	6.76	40.96	-3.42	-222.88	-212.77	465.008
200	17.84	15.99	26.19	-2.04	-223.70	-202.30	221.063
298.15	23.33	24.21	24.21	0	-223.97	-191.71	140.527
300	23.42	24.35	24.22	.04	-223.98	-191.51	139.515
350	25.77	28.15	24.49	1.28	-223.96	-186.10	116.206
400	27.51	31.71	25.19	2.61	-223.88	-180.70	98.730
450	28.90	35.03	26.10	4.02	-223.75	-175.31	85.142
500	30.05	38.14	27.14	5.50	-223.57	-169.93	74.276
550	31.04	41.05	28.29	7.02	-223.39	-164.59	65.402
600	31.91	43.79	29.46	8.60	-223.19	-159.24	58.003
631	32.39	45.40	30.20	9.59	-223.08	-155.94	54.011
650	32.68	46.37	30.66	10.21	-222.99	-153.92	51.753
700	33.37	48.82	31.86	11.87	-222.70	-148.61	46.398
750	34.00	51.14	33.07	13.55	-222.40	-143.34	41.769
800	34.57	53.36	34.29	15.26	-222.08	-138.09	37.724
850	35.09	55.47	35.46	17.01	-221.73	-132.84	34.155
900	35.56	57.49	36.63	18.77	-221.39	-127.62	30.990
950	35.99	59.42	37.78	20.56	-221.02	-122.42	28.163
1000	36.38	61.28	38.91	22.37	-220.64	-117.25	25.625
1050	36.72	63.06	40.01	24.20	-220.26	-112.08	23.329
1100	37.03	64.78	41.11	26.04	-219.87	-106.94	21.247
1150	37.30	66.43	42.17	27.90	-219.47	-101.81	19.348
1200	37.53	68.02	43.21	29.77	-219.08	-96.70	17.611

Phase change: 631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.

Sources of data: Enthalpy of formation derived from hydrochloric acid solution calorimetry (Adami and King, 1965).
Low-temperature heat capacity and entropy from 5 to 50 K (Stuve, 1974); and from 50 to 298 K (Weller, 1965).
High-temperature enthalpy from Ferrante (1974).

Thermodynamic Properties of $NiSe_{1.05}(s)$

[Formation: $Ni(s) + 1.05Se(s,l) = NiSe_{1.05}(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	12.64	17.98	17.98	0	-17.90	-17.96	13.165
300	12.65	18.05	17.98	.02	-17.90	-17.96	13.084
400	13.19	21.77	18.47	1.32	-17.90	-17.97	9.818
494.3	13.61	24.61	19.39	2.58	-17.95	-17.99	7.954
494.3	13.61	24.61	19.39	2.58	-19.49	-17.99	7.954
500	13.64	24.77	19.45	2.66	-19.51	-17.98	7.859
600	14.11	27.29	20.54	4.05	-19.78	-17.64	6.425
631	14.28	28.01	20.89	4.49	-19.88	-17.52	6.068
700	14.65	29.51	21.68	5.48	-20.00	-17.27	5.392
800	15.30	31.51	22.79	6.98	-20.07	-16.87	4.609
900	15.95	33.34	23.85	8.54	-20.10	-16.46	3.997
1000	16.88	35.07	24.89	10.18	-20.10	-16.07	3.512
1050	17.72	35.91	25.39	11.05	-20.07	-15.85	3.299

Phase changes: 494.3 K, melting point of Se; ΔH° = 1.472 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.

Sources of data: Enthalpy of formation derived from high-temperature reaction calorimetry (Grønvold, 1972).
Low-temperature heat capacity and entropy from Grønvold and Thurmann-Moe (1960).
High-temperature heat capacity from Grønvold (1970).

Thermodynamic Properties of $NiSe_{1.14}(s)$

[Formation: $Ni(s) + 1.14Se(s,l) = NiSe_{1.14}(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	13.13	18.45	18.45	0	-19.00	-18.92	13.869
300	13.15	18.53	18.46	.02	-19.00	-18.93	13.790
400	14.03	22.44	18.97	1.39	-18.99	-18.90	10.326
494.3	21.29	25.56	19.94	2.78	-18.96	-18.89	8.352
494.3	21.29	25.56	19.94	2.78	-20.64	-18.89	8.352
500	21.73	25.81	20.01	2.90	-20.61	-18.87	8.248
503	23.54	25.90	20.01	3.00	-20.57	-18.80	8.168
600	14.95	28.65	21.23	4.45	-20.80	-18.51	6.742
631	15.10	29.41	21.61	4.92	-20.90	-18.39	6.369
700	15.42	30.98	22.45	5.97	-21.01	-18.09	5.648
800	15.98	33.08	23.66	7.54	-21.08	-17.68	4.830
900	16.69	34.99	24.80	9.17	-21.11	-17.24	4.186
1000	17.53	36.80	25.92	10.88	-21.11	-16.83	3.678
1050	17.99	37.66	26.45	11.77	-21.11	-16.59	3.453

Phase changes: 494.3 K, melting point of Se; ΔH° = 1.472 kcal/mole.
503 K, second order transition of $NiSe_{1.14}$; ΔH° = 0 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.

Sources of data: Enthalpy of formation derived from high-temperature reaction calorimetry (Gronvøld, 1972).
Low-temperature heat capacity and entropy from Grønvold and Thurmann-Moe (1960).
High-temperature heat capacity from Grønvold (1970).

Thermodynamic Properties of $NiSe_{1.25}(s)$

[Formation: $Ni(s) + 1.25Se(s,l) = NiSe_{1.25}(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	13.59	19.14	19.14	0	-19.80	-19.60	14.367
300	13.60	19.22	19.14	.03	-19.80	-19.59	14.271
400	14.46	23.27	19.70	1.43	-19.82	-19.53	10.671
494.3	15.14	26.39	20.68	2.82	-19.85	-19.46	8.604
494.3	15.14	26.39	20.68	2.82	-21.69	-19.46	8.604
500	15.18	26.56	20.74	2.91	-21.71	-19.43	8.493
589	18.88	29.27	21.80	4.40	-21.85	-19.00	7.050
600	16.14	29.58	21.96	4.57	-21.88	-18.96	6.906
631	16.23	30.40	22.37	5.07	-21.96	-18.81	6.515
700	16.42	32.08	23.24	6.19	-22.07	-18.45	5.760
800	16.97	34.31	24.49	7.86	-22.13	-17.93	4.898
900	17.88	36.35	25.68	9.60	-22.15	-17.40	4.225
995	18.93	38.22	26.80	11.36	-22.09	-16.92	3.716
1000	18.76	38.31	26.85	11.46	-22.08	-16.88	3.689
1050	19.13	39.23	27.42	12.40	-22.08	-16.62	3.459

Phase changes: 494.3 K, melting point of Se; ΔH° = 1.472 kcal/mole.
589 K, second order transition of $NiSe_{1.25}$; ΔH° = 0 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
995 K, second order transition of $NiSe_{1.25}$; ΔH° = 0 kcal/mole.

Sources of data: Enthalpy of formation derived from high-temperature reaction calorimetry (Grønvold, 1972).
Low-temperature heat capacity and entropy from Grønvold and Thurmann-Moe (1960).
High-temperature heat capacity from Grønvold (1970).

Thermodynamic Properties of NiSi(s,l)

[Formation: Ni(s) + Si(s) = NiSi(s,l)]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-1.9	-20.6	-20.6	∞
100	4.9	2.3	19.3	-1.7	-20.6	-20.5	44.80
200	9.0	7.2	12.2	-1.0	-20.6	-20.5	22.40
298.15	10.7	11.2	11.2	0	-20.6	-20.5	15.03
300	10.7	11.2	11.2	.0	-20.6	-20.5	14.93
400	11.8	14.5	11.5	1.2	-20.6	-20.4	11.15
500	12.4	17.2	12.4	2.4	-20.6	-20.3	8.87
600	12.8	19.5	13.5	3.6	-20.8	-20.3	7.39
631	12.9	20.1	13.8	4.0	-20.8	-20.3	7.03
700	13.0	21.5	14.5	4.9	-20.9	-20.2	6.31
800	13.2	23.2	15.5	6.2	-20.9	-20.1	5.49
900	13.4	24.8	16.4	7.6	-20.9	-20.0	4.86
1000	13.5	26.2	17.3	8.9	-21.0	-19.9	4.35
1100	13.7	27.5	18.1	10.3	-21.0	-19.7	3.91
1200	13.8	28.7	19.0	11.6	-21.1	-19.7	3.59
1265	13.9	29.4	19.5	12.5	-21.2	-19.6	3.39
1265	19.1	37.7	19.5	23.0	-10.7	-19.6	3.39
1300	19.1	38.2	20.0	23.7	-10.5	-19.8	3.33
1400	19.1	39.7	21.4	25.6	-10.1	-20.6	3.22
1500	19.1	41.0	22.7	27.5	-9.7	-21.4	3.12

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1265 K, melting point of NiSi; ΔH° = 10.5 kcal/mole.

Sources of data: Enthalpy of formation from Oelsen and Samson-Himmelstjerna (1936).
Heat capacity and entropy from Kalishevich, Gel'd, and Putintsev (1968).

Thermodynamic Properties of $Ni_{1.04}Si_{1.93}(s)$

[Formation: $1.04Ni(s) + 1.93Si(s) = Ni_{1.04}Si_{1.93}(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G^\circ-H^\circ_{298})/T$	$H^\circ-H^\circ_{298}$	ΔHf°	ΔGf°	
0	0	0	∞	-2.66	-21.39	-21.39	∞
100	6.39	3.07	27.47	-2.44	-21.42	-21.36	46.682
200	13.03	9.87	16.97	-1.42	-21.41	-21.30	23.276
298.15	15.65	15.62	15.62	0	-21.40	-21.25	15.577
300	15.69	15.71	15.62	.03	-21.40	-21.25	15.481
400	17.24	20.48	16.26	1.69	-21.40	-21.21	11.589
500	17.95	24.41	17.51	3.45	-21.43	-21.16	9.249
600	18.44	27.73	18.95	5.27	-21.53	-21.10	7.686
631	18.58	28.66	19.40	5.84	-21.58	-21.08	7.301
700	18.90	30.61	20.41	7.14	-21.63	-21.02	6.563
800	19.37	33.16	21.85	9.05	-21.65	-20.93	5.718
900	19.84	35.47	23.24	11.01	-21.67	-20.84	5.061
1000	20.32	37.59	24.57	13.02	-21.66	-20.74	4.533
1100	20.77	39.54	25.83	15.08	-21.64	-20.64	4.101
1200	21.16	41.37	27.06	17.17	-21.62	-20.56	3.744
1245	21.31	42.15	27.59	18.13	-21.60	-20.52	3.602

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1245 K, incongruent melting point of $Ni_{1.04}Si_{1.93}$.

Sources of data: Enthalpy of formation from Oelsen and Samson-Himmelstjerna (1936).
Low-temperature heat capacity and entropy from Kalishevich, Gel'd, and Krentsis (1968).
High-temperature enthalpy from Kalishevich, Gel'd, and Putintsev (1968).

Thermodynamic Properties of $Ni_2Si(s,l)$

[Formation: $2Ni(s,l) + Si(s,l) = Ni_2Si(s,l)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	16.97	18.30	18.30	0	-33.60	-33.46	24.527
300	17.01	18.41	18.31	.03	-33.60	-33.46	24.376
400	17.95	23.47	19.00	1.79	-33.65	-33.41	18.254
500	18.16	27.50	20.30	3.60	-33.81	-33.33	14.569
600	18.41	30.83	21.78	5.43	-34.12	-33.21	12.097
631	18.55	31.76	22.25	6.00	-34.26	-33.16	11.485
700	18.87	33.70	23.29	7.29	-34.44	-33.02	10.309
800	19.50	36.26	24.75	9.21	-34.60	-32.81	8.963
900	20.26	38.60	26.17	11.19	-34.74	-32.59	7.914
1000	21.11	40.77	27.51	13.26	-34.82	-32.33	7.066
1100	22.06	42.83	28.81	15.42	-34.85	-32.07	6.372
1200	23.13	44.79	30.06	17.68	-34.83	-31.82	5.795
1300	24.41	46.70	31.28	20.05	-34.74	-31.59	5.311
1400	26.02	48.56	32.44	22.57	-34.55	-31.34	4.892
1490	27.90	50.23	33.46	24.99	-34.26	-31.15	4.569
1490	26.20	51.43	33.46	26.78	-32.48	-31.15	4.569
1500	26.20	51.61	33.58	27.04	-32.45	-31.15	4.539
1560	26.20	52.64	34.30	28.61	-32.33	-31.09	4.356
1560	27.70	59.43	34.30	39.21	-21.73	-31.09	4.356
1600	27.70	60.13	34.93	40.32	-21.60	-31.33	4.279
1687	27.70	61.60	36.27	42.73	-21.35	-31.87	4.129
1687	27.70	61.60	36.27	42.73	-33.43	-31.87	4.129
1700	27.70	61.81	36.46	43.09	-33.38	-31.85	4.095
1728	27.70	62.26	36.87	43.87	-33.29	-31.80	4.022
1728	27.70	62.26	36.87	43.87	-41.49	-31.80	4.022
1800	27.70	63.39	37.91	45.86	-41.28	-31.39	3.811

Phase changes: 631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.
1490 K, $\alpha - \beta$ transition point of Ni_2Si; $\Delta H° = 1.78$ kcal/mole.
1560 K, melting point of Ni_2Si; $\Delta H° = 10.60$ kcal/mole.
1687 K, melting point of Si; $\Delta H° = 12.082$ kcal/mole.
1728 K, melting point of Ni; $\Delta H° = 4.10$ kcal/mole.

Sources of data: Enthalpy of formation from Oelsen and Samson-Himmelstjerna (1936).
Heat capacity from Frolov, Putintsev, Sidorenko, Gel'd, and Krentsis (1972).
Entropy estimated.

Thermodynamic Properties of Ni_2SiO_4(s)

[Formation: $2Ni(s,l) + Si(s,l) + 2O_2(g) = Ni_2SiO_4(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	30.47	25.60	25.60	0	-336.0	-308.8	226.36
300	30.57	25.79	25.60	.06	-336.0	-308.6	224.81
400	36.22	35.37	26.87	3.40	-335.9	-299.5	163.64
500	40.56	43.95	29.45	7.25	-335.5	-290.5	126.98
600	43.33	51.61	32.51	11.46	-334.9	-281.6	102.57
631	43.81	53.80	33.50	12.81	-334.8	-278.8	96.56
700	44.89	58.42	35.73	15.88	-334.2	-272.7	85.14
800	45.67	64.47	38.96	20.41	-333.4	-264.0	72.12
900	46.06	69.88	42.10	25.00	-332.5	-255.4	62.02
1000	46.35	74.74	45.12	29.62	-331.7	-246.8	53.94
1100	46.73	79.18	48.03	34.27	-330.9	-238.4	47.37
1200	47.33	83.27	50.80	38.97	-330.2	-230.0	41.89
1300	48.20	87.09	53.44	43.75	-329.4	-221.7	37.27
1400	49.36	90.70	55.97	48.62	-328.6	-213.4	33.31
1500	50.81	94.16	58.41	53.63	-327.7	-205.2	29.90
1600	52.52	97.49	60.75	58.79	-326.7	-197.1	26.92
1687	54.27	100.31	62.71	63.43	-325.7	-190.1	24.63
1687	54.27	100.31	62.71	63.43	-337.8	-190.1	24.63
1700	54.53	100.73	63.00	64.14	-337.7	-188.9	24.28
1728	55.19	101.63	63.62	65.68	-337.3	-186.4	23.58
1728	55.19	101.63	63.62	65.68	-345.5	-186.4	23.58
1800	56.87	103.91	65.18	69.71	-344.5	-179.8	21.83

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1687 K, melting point of Si; ΔH° = 12.082 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

Sources of data: Enthalpy of formation derived from molten oxide solution calorimetry (Navrotsky, 1971).
Entropy calculated from the free energy of the reaction of nickel with silica and oxygen (Campbell and Roeder, 1968).
High-temperature enthalpy based on enthalpy determinations of Egorov and Smirnova (1965).

Thermodynamic Properties of $Ni_4W(s)$

[Formation: $4Ni(s) + W(s) = Ni_4W(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	29.4	36.0	36.0	0	-7.5	-7.4	5.42
300	29.4	36.2	36.0	.1	-7.5	-7.4	5.39
400	30.4	44.8	37.3	3.0	-7.8	-7.4	4.04
500	31.4	51.7	39.5	6.1	-8.1	-7.2	3.15
600	32.3	57.5	42.0	9.3	-8.7	-7.0	2.55
631	32.6	59.1	42.8	10.3	-8.9	-6.9	2.39
700	33.3	62.5	44.5	12.6	-9.2	-6.6	2.06
800	34.3	67.0	47.0	16.0	-9.3	-6.2	1.69
900	35.2	71.1	49.5	19.4	-9.6	-5.9	1.43
1000	36.2	74.9	51.9	23.0	-9.7	-5.5	1.20
1100	37.2	78.4	54.1	26.7	-9.7	-5.0	.99

Phase change: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.

Sources of data: Enthalpy of formation derived from e.m.f. studies on the Ni-W system (Meshkov, Guzey, Kazakov, and Sokolovoskaya, 1972).
High-temperature enthalpy based on enthalpy determinations of Proshina and Rezukhina (1962).
Entropy estimated.

Thermodynamic Properties of $NiWO_4(s)$

[Formation: $Ni(s) + W(s) + 2O_2(g) = NiWO_4(s)$]

T, K	Cal/deg mole			Kcal/mole			Log Kf
	Cp°	S°	$-(G°-H°_{298})/T$	$H°-H°_{298}$	ΔHf°	ΔGf°	
298.15	29.0	28.5	28.5	0	-268.9	-243.7	178.64
300	29.0	28.7	28.5	.1	-268.8	-243.5	177.39
400	30.9	37.3	29.6	3.1	-268.5	-235.1	128.45
500	32.4	44.3	31.9	6.2	-268.2	-226.9	99.18
600	33.8	50.4	34.6	9.5	-267.8	-218.7	79.66
631	34.2	52.1	35.3	10.6	-267.7	-216.2	74.88
700	35.2	55.7	37.1	13.0	-267.3	-210.5	65.72
800	36.5	60.5	39.8	16.6	-266.6	-202.4	55.29
900	37.8	64.9	42.3	20.3	-266.0	-194.4	47.21
1000	39.1	68.9	44.8	24.1	-265.2	-186.5	40.76
1100	40.4	72.7	47.2	28.1	-264.3	-178.7	35.50

Phase change: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.

Sources of data: Enthalpy of formation derived from molten oxide solution calorimetry (Navrotsky and Kleppa, 1969).
High-temperature enthalpy based on enthalpy determinations of Zharkova and Rezukhina (1958).
Entropy estimated.

Low-Temperature Thermodynamic Data for Ni(s)

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	C_p°	S°	$H^\circ-H_0^\circ$		C_p°	S°	$H^\circ-H_0^\circ$
1	.002	.000	.001	130	4.164	2.755	233.4
2	.003	.002	.003	140	4.401	3.073	276.4
3	.005	.004	.008	150	4.614	3.384	321.5
4	.007	.006	.015	160	4.802	3.688	368.6
5	.009	.007	.023	170	4.969	3.984	417.4
10	.023	.018	.102	180	5.118	4.272	467.8
15	.043	.033	.270	190	5.250	4.552	519.7
20	.081	.050	.580	200	5.370	4.824	572.6
25	.142	.074	1.125	210	5.477	5.089	627.1
30	.234	.107	2.040	220	5.573	5.346	682.2
40	.534	.213	5.080	230	5.662	5.596	738.5
50	.956	.375	13.15	240	5.747	5.839	795.6
60	1.448	.592	25.08	250	5.831	6.075	853.3
70	1.953	.853	42.07	260	5.914	6.305	912.1
80	2.433	1.145	64.00	270	5.996	6.530	971.7
90	2.868	1.456	95.45	280	6.078	6.750	1032
100	3.258	1.778	121.1	290	6.151	6.965	1093
110	3.605	2.105	155.4	298.15	6.211	7.140	1144
120	3.903	2.432	193.0				

Sources of data: Keesom and Clark, 1935 (below 15 K); Busey and Giauque, 1952 (15 to 298 K).

Low-Temperature Thermodynamic Data for NiAl(s)

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	C_p°	S°	$H^\circ-H_0^\circ$		C_p°	S°	$H^\circ-H_0^\circ$
20	.174	.059	.864	160	8.556	6.639	658.9
30	.535	.190	4.227	180	9.152	7.682	836.2
40	1.098	.417	12.24	200	9.641	8.672	1024
50	1.816	.737	26.70	220	10.02	9.610	1221
60	2.626	1.139	48.86	240	10.32	10.50	1425
80	4.292	2.124	118.2	260	10.56	11.33	1633
100	5.765	3.245	219.2	280	10.79	12.12	1847
120	6.934	4.404	346.7	298.15	10.99	12.81	2045
140	7.836	5.544	494.8				

Source of data: Sandakova, Sandakov, Kalishevich, and Gel'd, 1971.

Low-Temperature Thermodynamic Data for $Ni_5Ce(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	H°-H°$_0$		Cp°	S°	H°-H°$_0$
10	.162	.118	.645	150	30.55	27.60	2428
15	.490	.233	2.119	175	32.27	32.43	3212
20	1.209	.460	6.142	200	33.65	36.84	4037
25	2.414	.848	15.20	225	34.75	40.87	4893
50	10.39	4.878	172.7	250	35.66	44.58	5775
75	18.03	10.54	528.2	275	36.40	48.01	6195
100	23.75	16.56	1055	298.15	37.02	51.11	7565
125	27.64	22.30	1700				

Source of data: Marzouk, Craig, and Wallace, 1973.

Low-Temperature Thermodynamic Data for $NiCl_2(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	H°-H°$_0$		Cp°	S°	H°-H°$_0$
10	.225	.125	.808	140	13.29	11.73	954.0
20	.787	.434	5.604	160	14.22	13.57	1230
30	1.719	.916	17.80	180	14.92	15.28	1521
40	3.126	1.593	41.60	200	15.52	16.89	1826
50	5.385	2.503	82.76	220	15.97	18.39	2141
52.35	6.825	2.683	95.80	240	16.34	19.79	2464
60	6.017	3.554	140.4	260	16.65	21.11	2794
80	8.411	5.612	284.7	280	16.91	22.36	3130
100	10.46	7.716	474.0	298.15	17.13	23.42	3439
120	12.07	9.771	699.9				

Transition: 52.35 K, heat capacity maximum.

Sources of data: Kostryukova, 1968 (below 15 K); Busey and Giauque, 1952 (15 to 298 K).

Low-Temperature Thermodynamic Data for $NiD_{.65}(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	H°-H°$_0$		Cp°	S°	H°-H°$_0$
20	.152	.058	.844	160	6.958	5.174	518.3
30	.402	.160	3.447	180	7.347	6.018	661.5
40	.828	.331	9.479	200	7.655	6.808	811.6
50	1.367	.572	20.39	220	7.922	7.550	967.5
60	1.961	.873	37.00	240	8.132	8.249	1128
80	3.204	1.607	88.60	260	8.299	8.907	1292
100	4.429	2.455	165.0	280	8.448	9.527	1460
120	5.528	3.362	264.9	298.15	8.540	10.06	1614
140	6.380	4.282	384.5				

Source of data: Wolf and Stroka, 1971 (below 220 K); extrapolated above 220 K.

Low-Temperature Thermodynamic Data for $NiF_2(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
20	.232	.093	1.21	140	9.592	8.049	675.7
30	.891	.295	6.42	160	10.73	9.407	879.4
40	1.969	.692	20.47	180	11.72	10.73	1104
50	3.354	1.275	46.87	200	12.57	12.01	1347
60	5.013	2.027	88.34	220	13.31	13.24	1606
73.22	9.230	3.320	175.2	240	13.90	14.43	1879
80	5.943	3.878	217.8	260	14.41	15.56	2162
100	6.925	5.290	344.8	280	14.89	16.65	2455
120	8.286	6.672	496.8	298.15	15.31	17.59	2729

Transition: 73.22 K, heat capacity maximum.

Source of data: Catalano and Stout, 1955.

Low-Temperature Thermodynamic Data for $NiFe_2O_4(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
50	2.870	1.781	40.84	180	23.37	15.97	1769
60	4.242	2.422	76.21	200	25.83	18.56	2261
80	7.434	4.069	192.3	220	28.04	21.13	2800
100	10.86	6.096	375.2	240	30.04	23.66	3381
120	14.30	8.382	627.0	260	31.86	26.14	4001
140	17.57	10.84	946.0	280	33.46	28.56	4654
160	20.61	13.38	1328	298.15	34.81	30.70	5275

Source of data: King, 1956; estimated zero point entropy.

Low-Temperature Thermodynamic Data for $Ni_5Gd(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
10	1.171	.617	4.034	150	29.22	30.08	2403
15	2.337	1.305	12.71	175	31.07	34.74	3158
20	3.681	2.158	27.71	200	32.61	38.99	3954
25	5.120	3.129	49.67	225	33.99	42.90	4786
50	10.40	8.243	239.4	250	34.90	46.54	5650
75	17.27	13.79	587.0	275	35.52	49.90	6530
100	22.54	19.51	1087	298.15	35.95	52.91	7395
125	26.53	24.99	1703				

Transitions: Heat capacity maxima at 29.8 and 30.6 K, quantitative data not available.

Source of data: Marzouk, Craig, and Wallace, 1973.

Low-Temperature Thermodynamic Data for $NiH_{.50}(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H_0°$		Cp°	S°	$H°-H_0°$
10	.027	.015	.104	140	5.26	3.74	331.3
20	.119	.057	.754	160	5.77	4.47	441.8
30	.338	.141	2.91	180	6.15	5.18	561.2
40	.729	.287	8.10	200	6.47	5.84	687.5
50	1.27	.507	18.0	220	6.74	6.47	819.6
60	1.83	.788	33.6	240	6.97	7.07	956.8
80	2.88	1.46	80.9	260	7.18	7.63	1098
100	3.81	2.21	148.0	280	7.36	8.17	1244
120	4.61	2.97	232.4	298.15	7.52	8.64	1379

Source of data: Wolf and Baranowski, 1971 (below 200 K); extrapolated above 200 K.

Low-Temperature Thermodynamic Data for $NiH_{.59}(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H_0°$		Cp°	S°	$H°-H_0°$
10	.032	.017	.121	140	5.40	3.90	344.5
20	.128	.063	.838	160	5.88	4.66	457.4
30	.366	.154	3.16	180	6.24	5.37	578.7
40	.783	.313	8.78	200	6.54	6.04	706.6
50	1.33	.543	19.2	220	6.82	6.68	840.3
60	1.94	.841	35.6	240	7.06	7.29	979.2
80	3.02	1.55	85.5	260	7.27	7.86	1123
100	3.95	2.33	155.4	280	7.46	8.40	1270
120	4.75	3.12	242.7	298.15	7.63	8.88	1407

Source of data: Wolf and Baranowski, 1971 (below 200 K); extrapolated above 200 K.

Low-Temperature Thermodynamic Data for $NiH_{.68}(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H_0°$		Cp°	S°	$H°-H_0°$
10	.030	.017	.125	140	5.46	3.91	345.5
20	.122	.060	.800	160	5.98	4.68	460.2
30	.361	.149	3.06	180	6.37	5.41	584.0
40	.797	.308	8.70	200	6.69	6.09	714.7
50	1.35	.544	19.4	220	6.97	6.74	851.4
60	1.95	.844	35.9	240	7.22	7.36	993.5
80	3.01	1.55	85.7	260	7.43	7.95	1140
100	3.95	2.33	155.4	280	7.63	8.51	1291
120	4.78	3.12	242.8	298.15	7.81	8.99	1431

Source of Data: Wolf and Baranowski, 1971 (below 200 K); extrapolated above 200 K.

Low-Temperature Thermodynamic Data for $Ni_5La(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
10	.105	.105	.454	150	30.43	27.48	2429
15	.490	.220	1.775	175	32.31	32.32	3214
20	1.207	.454	5.722	200	33.65	36.72	4039
25	2.266	.918	14.35	225	34.69	40.74	4894
50	10.37	4.711	166.5	250	35.59	44.45	5775
75	18.21	10.41	525.2	275	36.42	47.88	6675
100	23.81	16.43	1055	298.15	37.05	50.98	7560
125	27.71	22.18	1700				

Source of data: Marzouk, Craig, and Wallace, 1973.

Low-Temperature Thermodynamic Data for $Ni_2Mg(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
10	.030	.010	.074	140	13.04	9.399	838.8
20	.245	.081	1.209	160	14.13	11.22	1111
30	.834	.276	6.233	180	14.98	12.93	1402
40	1.864	.648	19.39	200	15.66	14.54	1709
50	3.175	1.202	44.48	220	16.20	16.06	2028
60	4.629	1.909	83.46	240	16.63	17.49	2356
80	7.414	3.630	204.4	260	17.00	18.84	2693
100	9.765	5.546	377.0	280	17.31	20.11	3036
120	11.62	7.497	591.7	298.15	17.55	21.20	3352

Source of data: Wollam and Wallace, 1960.

Low-Temperature Thermodynamic Data for $Ni_5Nd(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
10	1.219	2.741	15.78	150	30.45	31.79	2500
15	1.386	3.234	21.88	175	32.32	36.64	3286
20	2.084	3.724	30.48	200	33.62	41.04	4111
25	3.035	4.285	43.17	225	34.66	45.08	4965
50	10.95	8.628	211.4	250	35.55	48.76	5845
75	18.57	14.57	584.5	275	36.38	52.20	6740
100	24.01	20.70	1120	298.15	37.14	55.29	7630
125	27.78	26.48	1770				

Transition: Heat capacity maximum at 6.4 K, quantitative data not available.

Source of data: Marzouk, Craig, and Wallace, 1973.

Low-Temperature Thermodynamic Data for NiO(s)

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H_0°$		Cp°	S°	$H°-H_0°$
50	.723	.254	9.410	180	7.204	4.586	540.7
60	1.176	.425	18.85	200	7.930	5.383	692.2
80	2.226	.904	52.64	220	8.578	6.170	857.4
100	3.352	1.521	108.4	240	9.160	6.942	1035
120	4.452	2.230	186.5	260	9.688	7.696	1223
140	5.470	2.994	285.9	280	10.18	8.432	1422
160	6.387	3.786	404.7	298.15	10.59	9.084	1611

Source of data: King, 1957.

Low-Temperature Thermodynamic Data for $Ni(OH)_2(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H_0°$		Cp°	S°	$H°-H_0°$
10	.392	.178	1.247	140	9.844	8.025	597.3
20	1.812	.804	11.07	160	11.49	9.449	810.9
30	1.583	1.745	34.11	180	12.99	10.89	1056
40	1.818	2.224	50.79	200	14.36	12.33	1330
50	2.286	2.675	71.15	220	15.63	13.76	1630
60	2.899	3.145	96.99	240	16.78	15.17	1954
80	4.418	4.178	169.6	260	17.82	16.55	2300
100	6.200	5.352	275.5	280	18.78	17.91	2666
120	8.057	6.647	418.1	298.15	19.60	19.12	3015

Transition: Heat capacity maximum at 24.8 K, quantitative data not available.

Source of data: Sorai, Kosaki, Suga, and Seki, 1969.

Low-Temperature Thermodynamic Data for NiS(s)

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H_0°$		Cp°	S°	$H°-H_0°$
50	1.720	.675	24.70	180	9.209	7.456	819.8
60	2.509	1.058	45.80	200	9.710	8.454	1009
80	4.102	1.999	112.0	220	10.14	9.400	1208
100	5.540	3.073	208.8	240	10.51	10.30	1415
120	6.766	4.196	332.3	260	10.83	11.15	1628
140	7.769	5.317	478.0	280	11.06	11.97	1847
160	8.572	6.409	641.7	298.15	11.26	12.66	2050

Source of data: Weller and Kelley, 1964.

Low-Temperature Thermodynamic Data for Ni_3S_2(s)

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
50	4.500	1.969	70.17	180	22.99	19.00	2062
60	6.442	2.958	124.7	200	24.29	21.49	2535
80	10.34	5.350	292.9	220	25.33	23.86	3032
100	13.89	8.046	535.9	240	26.22	26.10	3548
120	16.92	10.85	844.8	260	26.96	28.23	4080
140	19.41	13.66	1209	280	27.61	30.25	4625
160	21.41	16.38	1618	298.15	28.12	32.00	5130

Source of data: Weller and Kelley, 1964.

Low-Temperature Thermodynamic Data for $NiSO_4$(s)

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
10	.150	.049	.368	140	13.12	10.47	835.5
20	1.157	.407	6.100	160	14.86	12.34	1116
30	3.069	1.197	26.23	180	16.42	14.18	1429
40	2.450	2.240	62.22	200	17.84	15.99	1772
50	3.015	2.830	88.69	220	19.14	17.75	2142
60	4.131	3.472	124.1	240	20.35	19.47	2537
80	6.665	5.018	232.7	260	21.46	21.14	2955
100	9.018	6.761	389.8	280	22.47	22.77	3394
120	11.18	8.599	592.1	298.15	23.33	24.21	3810

Transition: Heat capacity maximum at 35.5 K, quantitative data not available.

Sources of data: Stuve, 1974 (below 50 K); Weller, 1965 (50 to 298 K).

Low-Temperature Thermodynamic Data for $NiSO_4 \cdot 6H_2O(\alpha)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
10	.491	2.141	7.360	140	41.34	35.76	2781
20	2.395	2.922	19.70	160	46.66	41.63	3661
30	5.801	4.519	60.24	180	51.77	47.42	4646
40	9.609	6.708	137.2	200	56.68	53.13	5730
50	13.36	9.255	252.1	220	61.43	58.75	6910
60	17.03	12.02	404.2	240	66.00	64.30	8185
80	23.78	17.86	813.3	260	70.42	69.76	9550
100	29.98	23.84	1352	280	74.66	75.13	11000
120	35.76	29.82	2010	298.15	78.36	79.94	12390

Source of data: Stout, Archibald, Brodale, and Giauque, 1966.

Low-Temperature Thermodynamic Data for $NiSO_4 \cdot 7H_2O(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	H°-H°$_0$		Cp°	S°	H°-H°$_0$
10	.469	2.151	6.06	140	47.75	40.36	3189
20	2.512	2.975	19.10	160	53.70	47.13	4204
30	6.360	4.709	63.18	180	59.40	53.79	5335
40	10.50	7.097	147.2	200	64.80	60.33	6575
50	14.83	9.906	273.9	220	69.87	66.74	7925
60	19.12	12.99	443.6	240	74.66	73.03	9370
80	27.36	19.65	910.3	260	79.20	79.19	10910
100	34.70	26.55	1532	280	83.48	85.21	12535
120	41.53	33.49	2295	298.15	87.14	90.57	14085

Source of data: Stout, Archibald, Brodale, and Giauque, 1966.

Low-Temperature Thermodynamic Data for $NiSe_{1.05}(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	H°-H°$_0$		Cp°	S°	H°-H°$_0$
10	.057	.023	.164	140	10.29	9.218	766.0
20	.447	.155	2.282	160	10.83	10.63	977.5
30	1.328	.488	10.79	180	11.23	11.93	1198
40	2.531	1.030	29.93	200	11.56	13.13	1426
50	3.822	1.734	61.70	220	11.83	14.24	1660
60	5.047	2.541	106.1	240	12.08	15.28	1899
80	7.092	4.286	228.5	260	12.31	16.26	2143
100	8.541	6.034	385.8	280	12.49	17.18	2391
120	9.548	7.687	567.2	298.15	12.64	17.98	2619

Source of data: Grønvold and Thurmann-Moe, 1960; Gronvøld, 1970.

Low-Temperature Thermodynamic Data for $NiSe_{1.14}(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	H°-H°$_0$		Cp°	S°	H°-H°$_0$
10	.062	.024	.171	140	10.59	9.406	782.6
20	.465	.162	2.383	160	11.17	10.86	1000
30	1.358	.505	11.15	180	11.61	12.20	1228
40	2.561	1.055	30.58	200	11.95	13.44	1464
50	3.863	1.767	62.70	220	12.24	14.60	1706
60	5.117	2.584	107.7	240	12.48	15.67	1953
80	7.217	4.358	232.1	260	12.69	16.68	2205
100	8.729	6.141	392.4	280	12.91	17.63	2461
120	9.803	7.834	578.3	298.15	13.13	18.45	2698

Source of data: Grønvold and Thurmann-Moe, 1960; Gronvøld, 1970.

Low-Temperature Thermodynamic Data of $NiSe_{1.25}$(s)

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
10	.061	.023	.164	140	11.02	9.712	809.2
20	.484	.163	2.430	160	11.66	11.23	1036
30	1.413	.521	11.56	180	12.12	12.63	1274
40	2.649	1.092	31.71	200	12.48	13.92	1521
50	3.972	1.825	64.82	220	12.79	15.13	1773
60	5.236	2.662	110.9	240	13.03	16.25	2032
80	7.419	4.480	238.3	260	13.24	17.30	2294
100	9.050	6.321	404.0	280	13.43	18.29	2561
120	10.18	8.078	596.9	298.15	13.59	19.14	2806

Sources of data: Grønvold and Thurmann-Moe, 1960; Grønvold, 1970.

Low-Temperature Thermodynamic Data for $NiSe_2$(s)

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
10	.063	.027	.194	140	14.55	12.24	1043
20	.440	.155	2.240	160	15.40	14.24	1342
30	1.481	.508	11.28	180	16.05	16.09	1657
40	3.059	1.141	33.67	200	16.55	17.81	1983
50	4.847	2.014	73.14	220	16.97	19.41	2319
60	6.610	3.055	130.5	240	17.31	20.90	2661
80	9.620	5.388	294.1	260	17.58	22.30	3010
100	11.81	7.784	509.7	280	17.83	23.61	3364
120	13.39	10.09	762.6	298.15	18.04	24.74	3690

Source of data: Grønvold and Westrum, 1962.

Low-Temperature Thermodynamic Data for $Ni_{1.04}Si_{1.93}$(s)

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H°_0$		Cp°	S°	$H°-H°_0$
60	2.54	.87	41.8	200	13.0	9.87	1240
80	4.47	1.87	112	220	13.7	11.1	1510
100	6.39	3.07	221	240	14.3	12.4	1790
120	8.19	4.40	367	260	14.8	13.5	2080
140	9.76	5.78	547	280	15.3	14.6	2380
160	11.1	7.17	755	298.15	15.6	15.6	2660
180	12.2	8.54	988				

Source of data: Kalishevich, Gel'd, and Krentsis, 1968.

Low-Temperature Thermodynamic Data for $NiTe_{1.1}(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H_0°$		Cp°	S°	$H°-H_0°$
10	.080	.027	.210	140	11.02	10.98	879.6
20	.687	.227	3.402	160	11.46	12.48	1105
30	1.928	.724	16.13	180	11.79	13.85	1337
40	3.450	1.485	42.92	200	12.05	15.11	1576
50	4.929	2.415	84.94	220	12.25	16.26	1819
60	6.245	3.434	140.9	240	12.43	17.34	2066
80	8.226	5.519	286.9	260	12.60	18.34	2316
100	9.534	7.508	465.6	280	12.82	19.28	2570
120	10.40	9.326	665.3	298.15	12.99	20.09	2804

Source of data: Westrum, Chou, Machol, and Grønvold, 1958.

Low-Temperature Thermodynamic Data for $NiTe_2(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H_0°$		Cp°	S°	$H°-H_0°$
10	.183	.060	.450	140	15.36	15.97	1244
20	1.326	.468	6.960	160	16.04	18.06	1558
30	3.309	1.365	29.79	180	16.54	19.98	1884
40	5.385	2.607	73.44	200	16.94	21.74	2219
50	7.245	4.011	136.8	220	17.26	23.37	2561
60	8.859	5.478	217.4	240	17.54	24.89	2909
80	11.40	8.397	421.4	260	17.77	26.30	3262
100	13.20	11.15	668.7	280	17.98	27.62	3620
120	14.43	13.67	945.4	298.15	18.15	28.76	3947

Source of data: Westrum, Chou, Machol, and Grønvold, 1958.

Low-Temperature Thermodynamic Data for $Ni_2Y(s)$

T, K	Cal/deg mole		Cal/mole	T, K	Cal/deg mole		Cal/mole
	Cp°	S°	$H°-H_0°$		Cp°	S°	$H°-H_0°$
10	.078	.032	.222	140	13.85	12.17	1019
20	.560	.200	2.917	160	14.59	14.07	1304
30	1.652	.615	13.50	180	15.17	15.82	1602
40	3.207	1.295	37.52	200	15.62	17.44	1910
50	4.941	2.196	78.23	220	15.97	18.95	2226
60	6.604	3.246	136.1	240	16.23	20.35	2548
80	9.416	5.550	297.6	260	16.48	21.66	2875
100	11.46	7.884	507.5	280	16.78	22.89	3208
120	12.87	10.11	751.7	298.15	17.06	23.95	3515

Source of data: Bloch, Camphausen, Voiron, Ayasse, Berton, and Chaussy, 1972.

High-Temperature Thermodynamic Data for $Ni_3Fe(s)$

T, K	Cal/deg mole		Kcal/mole	T, K	Cal/deg mole		Kcal/mole
	$Cp°$	$S°-S°_{298}$	$H°-H°_{298}$		$Cp°$	$S°-S°_{298}$	$H°-H°_{298}$
298.15	24.68	0	0	700	29.44	22.74	10.84
300	24.72	.15	.046	800	73.80	27.59	14.56
400	25.84	7.42	2.572	817	114.1	29.65	16.23
500	26.96	13.30	5.210	850	42.88	32.42	18.57
600	28.12	18.31	7.965	900	33.00	34.40	20.31

Transitions: 817 K, order-disorder transition; $\Delta H° = 0$ kcal/mole.
850 K, Curie temperature; $\Delta H° = 0$ kcal/mole.

Source of data: Hultgren, Desai, Hawkins, Gleiser, and Kelley, 1973.

High-Temperature Thermodynamic Data for $Ni_3Sn(s)$

T, K	Cal/deg mole		Kcal/mole	T, K	Cal/deg mole		Kcal/mole
	$Cp°$	$S°-S°_{298}$	$H°-H°_{298}$		$Cp°$	$S°-S°_{298}$	$H°-H°_{298}$
298.15	23.82	0	0	600	27.00	17.67	7.680
300	23.84	.15	.044	650	27.49	19.85	9.045
350	24.39	3.86	1.250	700	27.97	21.90	10.43
400	24.94	7.16	2.483	750	28.44	23.85	11.84
450	25.47	10.13	3.744	800	28.90	25.70	13.27
500	25.99	12.84	5.030	850	29.34	27.46	14.73
550	26.50	15.34	6.345	900	29.77	29.15	16.21

Source of data: Schübel, 1914.

High-Temperature Thermodynamic Data for $Ni_{2.86}Te_2(s)$

T, K	Cal/deg mole		Kcal/mole	T, K	Cal/deg mole		Kcal/mole
	$Cp°$	$S°-S°_{298}$	$H°-H°_{298}$		$Cp°$	$S°-S°_{298}$	$H°-H°_{298}$
298.15	29.88	0	0	600	39.23	23.75	10.37
300	29.92	.19	.056	630.4	65.00	25.98	11.74
400	33.31	9.10	3.168	700	38.47	30.00	14.41
405	-	9.52	3.332	800	39.60	35.20	18.30
405	-	10.23	3.620	900	42.82	40.02	22.40
500	34.12	17.21	6.770	960	46.00	42.89	25.06

Transitions: 405 K, first order transition; $\Delta H° = 0.288$ kcal/mole. Cp data not given.
630.4 K, second order transition; $\Delta H° = 0$ kcal/mole.

Source of data: Grønvold, Kveseth, and Sveen, 1972.

High-Temperature Thermodynamic Data for Ni_3Te_2(s)

T, K	Cal/deg mole		Kcal/mole	T, K	Cal/deg mole		Kcal/mole
	Cp°	$S^\circ-S^\circ_{298}$	$H^\circ-H^\circ_{298}$		Cp°	$S^\circ-S^\circ_{298}$	$H^\circ-H^\circ_{298}$
298.15	30.62	0	0	600	43.14	24.81	10.95
300	30.65	.19	.057	609	62.00	25.62	11.44
400	32.51	9.26	3.215	700	38.30	30.88	14.87
490.6	391.0	16.16	6.280	800	39.94	36.09	18.78
490.6	391.0	17.10	6.740	900	45.50	41.04	23.00
500	37.31	17.79	7.085				

Transitions: 490.6 K, first order transition; ΔH° = 0.460 kcal/mole.
609 K, second order transition; ΔH° = 0 kcal/mole.

Source of data: Grønvold, Kveseth, and Sveen, 1972.

High-Temperature Thermodynamic Data for $NiUO_4$(s)

T, K	Cal/deg mole		Kcal/mole	T, K	Cal/deg mole		Kcal/mole
	Cp°	$S^\circ-S^\circ_{298}$	$H^\circ-H^\circ_{298}$		Cp°	$S^\circ-S^\circ_{298}$	$H^\circ-H^\circ_{298}$
298.15	28.61	0	0	700	34.17	26.45	12.61
300	28.63	.18	.053	800	35.55	31.11	16.10
400	30.02	8.60	2.985	900	36.94	35.37	19.72
500	31.40	15.45	6.059	1000	38.32	39.34	23.49
600	32.78	21.30	9.265				

Source of data: Jakes and Schauer, 1967.

CHAPTER 2.—THERMODYNAMIC DATA FOR REACTIONS

This chapter gives enthalpy, Gibbs energy, and logarithm of the equilibrium constant of selected reactions involving nickel compounds. The properties in these tables were calculated by combining entropy and enthalpy data on nickel and its compounds with similar data on auxiliary elements and compounds. These values may also be obtained by combining the tabular values presented in this volume of the enthalpy of formation and Gibbs energy of formation of the compounds involved. Minor variations in values obtained by the two different methods are due to decimal rounding. Another method of calculation, less accurate but convenient, is by means of the enthalpy and Gibbs energy of formation equations given in the last two tables of this compilation.

The reactions are grouped into nine categories. These are (1) reduction of nickel compounds to the metal by means of carbon or carbon monoxide, (2) reaction with chlorine, (3) conversion to nickel sulfides, (4) formation of sulfur dioxide from nickel sulfides, (5) miscellaneous reactions involving nickel sulfides, (6) reduction to metallic nickel by means of iron, (7) addition and substitution reactions involving other oxides, (8) hydrogen reduction, and (9) vaporization. A cross-referenced formula index is given at the end of the volume as an aid to locating reactions.

$NiO(s) + C(s) = Ni(s,l) + CO(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	29.53	29.53	∞	1000	29.38	-12.16	2.658
100	30.22	26.25	-57.369	1100	29.13	-16.32	3.242
200	30.71	22.08	-24.128	1200	28.88	-20.42	3.719
298.15	30.88	17.79	-13.040	1300	28.62	-24.52	4.122
300	30.89	17.71	-12.902	1400	28.35	-28.60	4.465
400	30.84	13.32	-7.278	1500	28.07	-32.66	4.759
500	30.58	8.97	-3.921	1600	27.78	-36.71	5.014
525	30.44	7.89	-3.284	1700	27.49	-40.72	5.235
565	30.34	6.18	-2.391	1728	27.41	-41.86	5.294
600	30.29	4.69	-1.708	1728	31.51	-41.86	5.294
631	30.26	3.36	-1.164	1800	31.31	-44.91	5.453
700	30.12	.42	-.131	1900	31.01	-49.12	5.650
800	29.87	-3.80	1.038	2000	30.69	-53.34	5.829
900	29.63	-7.99	1.940				

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiO(s) + CO(g) = Ni(s,l) + CO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-10.04	-10.04	∞	1000	-11.39	-11.07	2.419
100	-10.02	-10.36	22.642	1100	-11.41	-11.05	2.195
200	-10.12	-10.67	11.660	1200	-11.41	-11.00	2.003
298.15	-10.34	-10.91	7.997	1300	-11.41	-10.97	1.844
300	-10.34	-10.91	7.948	1400	-11.41	-10.94	1.708
400	-10.59	-11.06	6.043	1500	-11.42	-10.91	1.590
500	-10.92	-11.14	4.869	1600	-11.42	-10.88	1.486
525	-11.05	-11.15	4.642	1700	-11.43	-10.83	1.392
565	-11.14	-11.15	4.313	1728	-11.43	-10.83	1.370
600	-11.17	-11.15	4.061	1728	-7.33	-10.83	1.370
631	-11.17	-11.15	3.862	1800	-7.32	-10.98	1.333
700	-11.23	-11.15	3.481	1900	-7.33	-11.17	1.285
800	-11.32	-11.13	3.041	2000	-7.35	-11.38	1.244
900	-11.36	-11.09	2.693				

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_3S_2(s,l) + 2CaO(s) + 2C(s) = 3Ni(s,l) + 2CaS(s) + 2CO(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	69.2	69.2	∞	1000	54.4	-14.2	3.10
100	70.7	62.7	-137.03	1064	53.4	-18.6	3.82
200	71.8	54.2	-59.23	1064	48.7	-18.6	3.82
298.15	72.2	45.4	-33.28	1100	48.1	-20.9	4.15
300	72.3	45.3	-33.00	1200	46.6	-27.1	4.94
400	72.4	36.3	-19.83	1300	45.1	-33.2	5.58
500	72.2	27.2	-11.89	1400	43.8	-39.1	6.10
600	72.0	18.3	-6.67	1500	42.5	-45.0	6.56
631	72.0	15.5	-5.37	1600	41.3	-50.8	6.94
700	71.7	9.3	-2.90	1700	40.1	-56.5	7.26
800	70.8	.5	-.14	1728	39.8	-58.2	7.36
840	70.5	-3.0	.78	1728	52.1	-58.2	7.36
840	57.1	-3.0	.78	1800	51.4	-62.7	7.61
900	56.0	-7.3	1.77				

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_3S_2(s,l) + 2CaO(s) + 2CO(g) = 3Ni(s,l) + 2CaS(s) + 2CO_2(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	-9.9	-9.9	∞	1000	-27.2	-12.1	2.64
100	-9.8	-10.6	23.17	1064	-27.8	-11.1	2.28
200	-9.9	-11.3	12.35	1064	-32.5	-11.1	2.28
298.15	-10.2	-12.0	8.80	1100	-32.9	-10.4	2.07
300	-10.2	-12.0	8.74	1200	-34.0	-8.3	1.51
400	-10.5	-12.5	6.83	1300	-34.9	-6.1	1.03
500	-10.8	-13.0	5.68	1400	-35.8	-3.8	.59
600	-10.9	-13.4	4.88	1500	-36.5	-1.5	.22
631	-10.8	-13.5	4.68	1600	-37.2	.8	-.11
700	-11.0	-13.8	4.31	1700	-37.7	3.3	-.42
800	-11.5	-14.2	3.88	1728	-37.8	3.9	-.49
840	-11.8	-14.3	3.72	1728	-25.5	3.9	-.49
840	-25.2	-14.3	3.72	1800	-25.9	5.1	-.62
900	-25.9	-13.5	3.28				

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiS(s,l) + CaO(s) + C(s) = Ni(s,l) + CaS(s) + CO(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	30.7	30.7	∞	1000	29.5	-11.5	2.51
100	31.4	27.4	-59.88	1066.5	29.1	-14.3	2.93
200	32.0	23.2	-25.35	1066.5	22.1	-14.3	2.93
298.15	32.2	18.8	-13.78	1100	21.9	-15.4	3.06
300	32.2	18.8	-13.70	1200	21.3	-18.8	3.42
400	32.2	14.3	-7.81	1300	20.7	-22.1	3.72
500	32.1	9.8	-4.28	1400	20.2	-25.3	3.95
600	31.9	5.4	-1.97	1500	19.6	-28.6	4.17
623	31.9	4.3	-1.51	1600	19.2	-31.8	4.34
623	31.2	4.3	-1.51	1700	18.7	-34.9	4.49
631	31.2	4.0	-1.39	1728	18.6	-35.8	4.53
700	31.0	1.0	-.31	1728	22.7	-35.8	4.53
800	30.5	-3.2	.87	1800	22.4	-38.3	4.65
900	30.1	-7.4	1.80				

Phase changes: 623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiS(s,l) + CaO(s) + CO(g) = Ni(s,l) + CaS(s) + CO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-8.8	-8.8	∞	1000	-11.3	-10.4	2.27
100	-8.8	-9.2	20.11	1066.5	-11.5	-10.4	2.13
200	-8.9	-9.6	10.49	1066.5	-18.5	-10.4	2.13
298.15	-9.0	-9.9	7.26	1100	-18.7	-10.1	2.01
300	-9.0	-9.9	7.21	1200	-19.0	-9.3	1.69
400	-9.2	-10.1	5.52	1300	-19.3	-8.5	1.43
500	-9.4	-10.3	4.50	1400	-19.6	-7.7	1.20
600	-9.5	-10.5	3.82	1500	-19.8	-6.8	.99
623	-9.6	-10.5	3.68	1600	-20.0	-5.9	.81
623	-10.3	-10.5	3.68	1700	-20.2	-5.0	.64
631	-10.3	-10.5	3.64	1728	-20.3	-4.8	.61
700	-10.4	-10.5	3.28	1728	-16.2	-4.8	.61
800	-10.6	-10.5	2.87	1800	-16.2	-4.3	.52
900	-10.9	-10.5	2.55				

Phase changes: 623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_2SiO_4(s) + 2C(s) = 2Ni(s,l) + SiO_2(s) + 2CO(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
298.15	65.4	38.5	-28.22	1000	61.8	-23.5	5.14
300	65.4	38.3	-27.90	1100	60.9	-32.0	6.36
400	65.5	29.3	-16.01	1200	60.0	-40.4	7.36
500	65.2	20.3	-8.87	1300	59.1	-48.7	8.19
600	64.7	11.3	-4.12	1400	58.2	-57.0	8.90
631	64.6	8.6	-2.98	1500	57.2	-65.2	9.50
700	64.1	2.5	-.78	1600	56.1	-73.3	10.01
800	63.3	-6.3	1.72	1700	54.9	-81.3	10.45
847	63.0	-10.3	2.66	1728	54.6	-83.6	10.57
847	63.2	-10.3	2.66	1728	62.8	-83.6	10.57
900	62.7	-14.9	3.62	1800	61.8	-89.7	10.89

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
847 K, α - β transition point of SiO_2; ΔH° = 0.174 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_2SiO_4(s) + 2CO(g) = 2Ni(s,l) + SiO_2(s) + 2CO_2(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
298.15	-17.0	-18.9	13.85	1000	-19.8	-21.3	4.66
300	-17.0	-18.9	13.77	1100	-20.2	-21.5	4.27
400	-17.4	-19.5	10.65	1200	-20.6	-21.5	3.92
500	-17.8	-20.0	8.74	1300	-21.0	-21.6	3.63
600	-18.2	-20.3	7.39	1400	-21.3	-21.7	3.39
631	-18.3	-20.4	7.07	1500	-21.8	-21.7	3.16
700	-18.6	-20.7	6.46	1600	-22.3	-21.6	2.95
800	-19.1	-20.9	5.71	1700	-22.9	-21.6	2.78
847	-19.2	-21.0	5.42	1728	-23.1	-21.6	2.73
847	-19.0	-21.0	5.42	1728	-14.9	-21.6	2.73
900	-19.3	-21.1	5.12	1800	-15.5	-21.8	2.65

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
847 K, α - β transition point of SiO_2; ΔH° = 0.174 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_2SiO_4(s) + 2CaO(s) + 2C(s) = 2Ni(s,l) + Ca_2SiO_4(s) + 2CO(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	32.7	5.6	-4.10	1121	30.8	-66.4	12.95
300	32.7	5.5	-4.01	1200	30.3	-73.2	13.33
400	32.7	-3.6	1.97	1300	29.6	-81.8	13.75
500	32.2	-12.7	5.55	1400	29.0	-90.3	14.10
600	31.6	-21.6	7.87	1500	28.4	-98.8	14.40
631	31.4	-24.4	8.45	1600	27.7	-107.3	14.66
700	30.9	-30.4	9.49	1700	27.1	-115.7	14.87
800	30.0	-39.1	10.68	1712	27.0	-116.7	14.90
900	29.1	-47.7	11.58	1712	30.4	-116.7	14.90
1000	28.3	-56.2	12.28	1728	30.2	-118.1	14.94
1100	27.6	-64.6	12.83	1728	38.4	-118.1	14.94
1121	27.4	-66.4	12.95	1800	37.7	-124.6	15.13

Phase changes:
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1121 K, γ - α' transition point of Ca_2SiO_4; ΔH° = 3.44 kcal/mole.
1712 K, α' - α transition point of Ca_2SiO_4; ΔH° = 3.39 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_2SiO_4(s) + 2CaO(s) + 2CO(g) = 2Ni(s,l) + Ca_2SiO_4(s) + 2CO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-49.7	-51.8	37.97	1121	-50.1	-54.1	10.55
300	-49.7	-51.8	37.74	1200	-50.3	-54.3	9.89
400	-50.2	-52.4	28.63	1300	-50.4	-54.7	9.20
500	-50.7	-52.9	23.12	1400	-50.5	-55.0	8.59
600	-51.3	-53.3	19.41	1500	-50.6	-55.3	8.06
631	-51.4	-53.4	18.50	1600	-50.7	-55.6	7.59
700	-51.8	-53.6	16.73	1700	-50.8	-55.9	7.19
800	-52.4	-53.8	14.70	1712	-50.8	-56.0	7.15
900	-52.9	-53.9	13.09	1712	-47.4	-56.0	7.15
1000	-53.3	-54.0	11.80	1728	-47.4	-56.1	7.10
1100	-53.5	-54.1	10.75	1728	-39.2	-56.1	7.10
1121	-53.5	-54.1	10.55	1800	-39.6	-56.8	6.90

Phase changes:
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1121 K, γ - α' transition point of Ca_2SiO_4; ΔH° = 3.44 kcal/mole.
1712 K, α' - α transition point of Ca_2SiO_4; ΔH° = 3.39 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_3S_2(s,l) + 3Cl_2(g) = 3NiCl_2(s,g) + S_2(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	-136.9	-136.9	∞	1000	-147.1	-69.6	15.21
100	-137.4	-130.0	284.11	1064	-147.2	-64.7	13.29
200	-136.8	-122.9	134.30	1064	-151.9	-64.7	13.29
298.15	-136.2	-116.2	85.18	1100	-152.0	-61.7	12.26
300	-136.2	-116.0	84.51	1200	-152.0	-53.5	9.74
400	-135.5	-109.4	59.77	1229	-151.9	-51.1	9.09
500	-134.8	-103.0	45.02	1229	6.2	-51.1	9.09
600	-134.1	-96.7	35.22	1300	5.1	-54.4	9.15
700	-133.6	-90.5	28.26	1400	3.5	-59.0	9.21
800	-133.2	-84.4	23.06	1500	1.9	-63.5	9.25
840	-133.0	-82.0	21.33	1600	.4	-67.6	9.23
840	-146.4	-82.0	21.33	1700	-1.2	-72.0	9.26
900	-146.7	-77.3	18.77	1800	-2.8	-76.0	9.23

Phase changes: 840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$NiS(s,l) + Cl_2(g) = NiCl_2(s,g) + 1/2S_2(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	-35.8	-35.8	∞	1000	-35.8	-20.5	4.48
100	-35.9	-34.2	74.74	1066.5	-35.8	-19.5	4.00
200	-35.7	-32.5	35.51	1066.5	-42.8	-19.5	4.00
298.15	-35.5	-31.0	22.72	1100	-42.9	-18.8	3.74
300	-35.5	-31.0	22.58	1200	-42.9	-16.6	3.02
400	-35.4	-29.5	16.12	1229	-42.9	-15.9	2.83
500	-35.2	-28.0	12.24	1229	9.8	-15.9	2.83
600	-35.1	-26.6	9.69	1300	9.4	-17.4	2.93
623	-35.1	-26.2	9.19	1400	8.8	-19.5	3.04
623	-35.8	-26.2	9.19	1500	8.3	-21.5	3.13
700	-35.7	-25.1	7.84	1600	7.7	-23.4	3.20
800	-35.7	-23.6	6.45	1700	7.1	-25.4	3.27
900	-35.7	-22.0	5.34	1800	6.6	-27.3	3.31

Phase changes: 623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$$NiO(s) + Cl_2(g) + C(s) = NiCl_2(s,g) + CO(g)$$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-43.55	-43.55	∞	1000	-41.57	-49.56	10.831
100	-43.21	-43.25	94.523	1100	-41.46	-50.37	10.008
200	-42.54	-43.55	47.589	1200	-41.30	-51.18	9.321
298.15	-42.10	-44.16	32.370	1229	-41.24	-51.41	9.142
300	-42.09	-44.17	32.178	1229	11.46	-51.41	9.142
400	-41.85	-44.91	24.538	1300	11.18	-55.04	9.253
500	-41.83	-45.67	19.962	1400	10.76	-60.15	9.390
525	-41.89	-45.87	19.095	1500	10.31	-65.21	9.501
565	-41.90	-46.17	17.859	1600	9.83	-70.18	9.586
600	-41.87	-46.43	16.912	1700	9.32	-75.23	9.671
700	-41.80	-47.20	14.736	1800	8.79	-80.17	9.734
800	-41.73	-47.98	13.108	1900	8.24	-84.97	9.774
900	-41.65	-48.75	11.838	2000	7.67	-90.03	9.838

Phase changes: 525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$$NiO(s) + Cl_2(g) + CO(g) = NiCl_2(s,g) + CO_2(g)$$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-83.12	-83.12	∞	1000	-82.35	-48.47	10.593
100	-83.45	-79.87	174.556	1100	-82.00	-45.10	8.961
200	-83.37	-76.30	83.377	1200	-81.59	-41.76	7.606
298.15	-83.32	-72.85	53.400	1229	-81.46	-40.79	7.254
300	-83.32	-72.79	53.027	1229	-28.76	-40.79	7.254
400	-83.28	-69.29	37.858	1300	-28.85	-41.48	6.973
500	-83.32	-65.78	28.752	1400	-29.00	-42.48	6.631
525	-83.39	-64.91	27.021	1500	-29.17	-43.45	6.331
565	-83.38	-63.50	24.563	1600	-29.38	-44.35	6.058
600	-83.33	-62.27	22.682	1700	-29.60	-45.34	5.829
700	-83.15	-58.77	18.349	1800	-29.84	-46.24	5.614
800	-82.92	-55.31	15.110	1900	-30.10	-47.02	5.409
900	-82.64	-51.86	12.593	2000	-30.37	-48.07	5.253

Phase changes: 525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$NiO(s) + Cl_2(g) = NiCl_2(s,g) + 1/2O_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-16.35	-16.35	∞	1000	-14.80	-1.70	.372
100	-16.34	-14.52	31.733	1100	-14.55	-.41	.081
200	-15.94	-12.83	14.020	1200	-14.24	.87	-.158
298.15	-15.68	-11.37	8.334	1229	-14.13	1.24	-.221
300	-15.68	-11.35	8.268	1229	38.57	1.24	-.221
400	-15.53	-9.93	5.425	1300	38.40	-.91	.153
500	-15.53	-8.53	3.728	1400	38.14	-3.96	.618
525	-15.59	-8.18	3.405	1500	37.85	-6.97	1.016
565	-15.59	-7.61	2.944	1600	37.53	-9.90	1.352
600	-15.54	-7.12	2.593	1700	37.18	-12.91	1.660
700	-15.39	-5.73	1.789	1800	36.83	-15.83	1.922
800	-15.22	-4.36	1.191	1900	36.44	-18.62	2.142
900	-15.01	-3.01	.731	2000	36.05	-21.68	2.369

Phase changes: 525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$Ni_2SiO_4(s) + 2Cl_2(g) = 2NiCl_2(s,g) + SiO_2(s) + O_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-27.7	-19.8	14.51	1100	-26.5	-.2	.04
300	-27.7	-19.8	14.42	1200	-26.2	2.2	-.40
400	-27.3	-17.2	9.40	1229	-26.1	2.9	-.52
500	-27.0	-14.7	6.43	1229	79.3	2.9	-.52
600	-27.0	-12.3	4.48	1300	78.7	-1.5	.25
700	-26.9	-9.8	3.06	1400	77.8	-7.7	1.20
800	-26.9	-7.4	2.02	1500	76.8	-13.8	2.01
847	-26.8	-6.2	1.60	1600	75.6	-19.7	2.69
847	-26.6	-6.2	1.60	1700	74.3	-25.7	3.30
900	-26.6	-5.0	1.21	1800	72.8	-31.5	3.82
1000	-26.6	-2.6	.57				

Phase changes: 847 K, α - β transition point of SiO_2; ΔH° = 0.174 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$Ni_2SiO_4(s) + 2Cl_2(g) + 2C(s) = 2NiCl_2(s,g) + SiO_2(s) + 2CO(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-80.5	-85.4	62.60	1100	-80.3	-100.1	19.89
300	-80.5	-85.4	62.21	1200	-80.4	-101.9	18.56
400	-79.9	-87.2	47.64	1229	-80.3	-102.4	18.21
500	-79.6	-89.0	38.90	1229	25.1	-102.4	18.21
600	-79.6	-90.9	33.11	1300	24.2	-109.8	18.46
700	-79.8	-92.8	28.97	1400	23.0	-120.1	18.75
800	-79.9	-94.6	25.84	1500	21.7	-130.2	18.97
847	-79.9	-95.5	24.64	1600	20.2	-140.2	19.15
847	-79.7	-95.5	24.64	1700	18.6	-150.4	19.34
900	-79.9	-96.5	23.43	1800	16.8	-160.2	19.45
1000	-80.2	-98.3	21.48				

Phase changes: 847 K, α - β transition point of SiO_2; ΔH° = 0.174 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$Ni_2SiO_4(s) + 2Cl_2(g) + 2CO(g) = 2NiCl_2(s,g) + SiO_2(s) + 2CO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-163.0	-142.8	104.68	1100	-161.4	-89.6	17.80
300	-163.0	-142.7	103.96	1200	-160.9	-83.0	15.12
400	-162.8	-135.9	74.25	1229	-160.8	-81.2	14.44
500	-162.6	-129.2	56.47	1229	-55.4	-81.2	14.44
600	-162.6	-122.6	44.66	1300	-55.8	-82.6	13.89
700	-162.5	-115.9	36.19	1400	-56.5	-84.7	13.22
800	-162.3	-109.3	29.86	1500	-57.3	-86.7	12.63
847	-162.1	-106.2	27.40	1600	-58.2	-88.6	12.10
847	-161.9	-106.2	27.40	1700	-59.2	-90.6	11.65
900	-161.9	-102.7	24.94	1800	-60.5	-92.3	11.21
1000	-161.7	-96.1	21.00				

Phase changes: 847 K, α - β transition point of SiO_2; ΔH° = 0.174 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$NiFe_2O_4(s) + Cl_2(g) + C(s) = NiCl_2(s,g) + Fe_2O_3(s) + CO(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-42.61	-42.61	∞	960	-40.52	-47.82	10.887
100	-42.28	-42.22	92.272	1000	-40.54	-48.12	10.517
200	-41.59	-42.42	46.354	1100	-40.57	-48.87	9.710
298.15	-41.10	-42.94	31.476	1200	-40.53	-49.63	9.039
300	-41.10	-42.96	31.296	1229	-40.50	-49.84	8.863
400	-40.76	-43.63	23.838	1229	12.20	-49.84	8.863
500	-40.57	-44.37	19.394	1300	11.86	-53.41	8.979
600	-40.50	-45.15	16.446	1400	11.37	-58.45	9.124
700	-40.55	-45.91	14.334	1500	10.88	-63.42	9.240
800	-40.78	-46.66	12.747	1600	10.39	-68.32	9.332
880	-41.19	-47.24	11.732	1700	9.90	-73.29	9.422
900	-41.06	-47.38	11.505	1800	9.42	-78.14	9.487

Phase changes: 880 K, α - β transition point of $NiFe_2O_4$; ΔH° = 0 kcal/mole.
960 K, Curie temperature of Fe_2O_3; ΔH^δ = 0 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$NiFe_2O_4(s) + Cl_2(g) + CO(g) = NiCl_2(s,g) + Fe_2O_3(s) + CO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-82.18	-82.18	∞	960	-81.38	-48.40	11.019
100	-82.52	-78.83	172.283	1000	-81.32	-47.03	10.278
200	-82.42	-75.17	82.142	1100	-81.11	-43.60	8.663
298.15	-82.32	-71.63	52.506	1200	-80.82	-40.21	7.323
300	-82.32	-71.58	52.146	1229	-80.72	-39.22	6.974
400	-82.19	-68.01	37.159	1229	-28.02	-39.22	6.974
500	-82.06	-64.48	28.184	1300	-28.17	-39.86	6.701
600	-81.96	-60.98	22.212	1400	-28.39	-40.78	6.366
700	-81.90	-57.49	17.949	1500	-28.60	-41.66	6.070
800	-81.97	-53.99	14.749	1600	-28.81	-42.49	5.804
880	-82.22	-51.18	12.711	1700	-29.02	-43.40	5.579
900	-82.06	-50.48	12.258	1800	-29.21	-44.21	5.368

Phase changes: 880 K, α - β transition point of $NiFe_2O_4$; ΔH° = 0 kcal/mole.
960 K, Curie temperature of Fe_2O_3; ΔH^δ = 0 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$NiFe_2O_4(s) + 4Cl_2(g) + 4C(s) = NiFe_2Cl_8(g) + 4CO(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-65.4	-98.0	71.84	700	-66.6	-142.4	44.46
300	-65.3	-98.2	71.54	800	-68.1	-153.0	41.80
400	-64.8	-109.3	59.72	880	-69.7	-161.5	40.11
500	-65.0	-120.4	52.63	900	-69.9	-163.6	39.73
600	-65.6	-131.4	47.86	1000	-71.0	-173.9	38.01

Phase change: 880 K, α - β transition point of $NiFe_2O_4$; ΔH° = 0 kcal/mole.

$NiFe_2O_4(s) + 4Cl_2(g) + 4CO(g) = NiFe_2Cl_8(g) + 4CO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-230.2	-212.8	155.99	700	-232.0	-188.6	58.88
300	-230.2	-212.7	154.95	800	-232.8	-182.4	49.83
400	-230.6	-206.8	112.99	880	-233.8	-177.3	44.03
500	-231.0	-200.8	87.77	900	-233.9	-176.0	42.74
600	-231.4	-194.8	70.96	1000	-234.1	-169.6	37.07

Phase change: 880 K, α - β transition point of $NiFe_2O_4$; ΔH° = 0 kcal/mole.

$NiFe_2O_4(s) + Cl_2(g) = NiCl_2(s,g) + Fe_2O_3(s) + 1/2O_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-15.41	-15.41	∞	960	-13.80	-.80	.182
100	-15.41	-13.48	29.461	1000	-13.77	-.26	.057
200	-14.99	-11.70	12.785	1100	-13.65	1.09	-.217
298.15	-14.68	-10.15	7.440	1200	-13.47	2.42	-.441
300	-14.68	-10.13	7.380	1229	-13.39	2.81	-.500
400	-14.44	-8.66	4.732	1229	39.31	2.81	-.500
500	-14.27	-7.23	3.160	1300	39.08	.71	-.119
600	-14.17	-5.84	2.127	1400	38.75	-2.26	.353
700	-14.14	-4.45	1.389	1500	38.42	-5.18	.755
800	-14.27	-3.05	.833	1600	38.09	-8.04	1.098
880	-14.57	-1.92	.477	1700	37.77	-10.97	1.410
900	-14.43	-1.63	.396	1800	37.45	-13.80	1.676

Phase changes: 880 K, α - β transition point of $NiFe_2O_4$; ΔH° = 0 kcal/mole.
960 K, Curie temperature of Fe_2O_3; ΔH° = 0 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.

$1.056NiO(s) + FeS(s,l) = NiS(s,l) + 1.056Fe_{.947}O(s,l) + 0.056Ni(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-5.6	-5.6	∞	900	-5.9	-6.6	1.60
100	-5.5	-5.6	12.24	1000	-5.6	-6.7	1.46
200	-5.1	-5.7	6.23	1066.5	-5.4	-6.8	1.39
298.15	-5.0	-6.0	4.40	1066.5	1.6	-6.8	1.39
300	-5.0	-6.1	4.44	1100	1.7	-7.1	1.41
400	-5.2	-6.4	3.50	1200	2.0	-7.8	1.42
411	-5.2	-6.4	3.40	1300	2.3	-8.7	1.46
411	-5.8	-6.4	3.40	1400	2.6	-9.5	1.48
500	-6.3	-6.5	2.84	1470	2.7	-10.2	1.52
525	-6.5	-6.5	2.71	1470	-5.0	-10.2	1.52
565	-6.7	-6.5	2.51	1500	-5.0	-10.3	1.50
598	-6.8	-6.5	2.38	1600	-4.9	-10.6	1.45
598	-6.9	-6.5	2.38	1652	-4.9	-10.8	1.43
600	-7.0	-6.5	2.37	1652	3.0	-10.8	1.43
623	-7.0	-6.5	2.28	1700	3.1	-11.2	1.44
623	-6.3	-6.5	2.28	1728	3.2	-11.4	1.44
631	-6.3	-6.5	2.25	1728	3.4	-11.4	1.44
700	-6.2	-6.5	2.03	1800	3.6	-12.1	1.47
800	-6.1	-6.6	1.80				

Phase changes:
411 K, α - β transition point of FeS; ΔH° = 0.57 kcal/mole.
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
598 K, β - γ transition point of FeS; ΔH° = 0.12 kcal/mole.
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1470 K, melting point of FeS; ΔH° = 7.73 kcal/mole.
1652 K, melting point of $Fe_{.947}O$; ΔH° = 7.49 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$3NiO(s) + 2FeS(s,l) + 0.841Fe(s) = Ni_3S_2(s,l) + 3Fe_{.947}O(s,l)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	-25.21	-25.21	∞	1043	-12.48	-33.73	7.068
100	-25.03	-25.32	55.337	1064	-12.46	-34.20	7.025
200	-23.96	-25.91	28.313	1064	-7.76	-34.20	7.025
298.15	-23.50	-26.98	19.777	1100	-7.39	-35.11	6.976
300	-23.50	-27.00	19.669	1185	-6.64	-37.21	6.863
400	-23.86	-28.16	15.386	1185	-6.82	-37.21	6.863
411	-23.97	-28.27	15.033	1200	-6.66	-37.60	6.848
411	-25.10	-28.27	15.033	1300	-5.70	-40.25	6.767
500	-26.29	-28.82	12.597	1400	-4.86	-42.94	6.703
525	-26.80	-28.95	12.051	1470	-4.34	-44.86	6.669
565	-27.26	-29.07	11.245	1470	-19.80	-44.86	6.669
598	-27.54	-29.17	10.661	1500	-19.65	-45.37	6.610
598	-27.78	-29.17	10.661	1600	-19.13	-47.11	6.435
600	-27.78	-29.18	10.629	1652	-18.89	-48.00	6.350
700	-27.85	-29.41	9.182	1652	3.58	-48.00	6.350
800	-27.69	-29.67	8.105	1667	3.70	-48.44	6.351
840	-27.57	-29.77	7.746	1667	3.53	-48.44	6.351
840	-14.20	-29.77	7.746	1700	3.77	-49.51	6.365
900	-13.55	-30.86	7.494	1800	4.44	-52.71	6.400
1000	-12.69	-32.86	7.182				

Phase changes:

411 K, α - β transition point of FeS; ΔH° = 0.57 kcal/mole.
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
598 K, β - γ transition point of FeS; ΔH° = 0.12 kcal/mole.
840 K, α - β transition point of Ni S ; ΔH° = 13.37 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1185 K, α - γ transition point of Fe; ΔH° = 0.215 kcal/mole.
1470 K, melting point of FeS; ΔH° = 7.73 kcal/mole.
1652 K, melting point of $Fe_{.947}O$; ΔH° = 7.49 kcal/mole.
1667 K, γ - δ transition point of Fe; ΔH° = 0.200 kcal/mole.

$3NiO(s) + 2FeS(s,l) = Ni_3S_2(s,l) + Fe_2O_3(s)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	-29.13	-29.13	∞	840	-19.64	-22.99	5.981
100	-29.22	-29.09	63.576	900	-18.48	-23.24	5.643
200	-29.36	-28.90	31.580	960	-17.13	-23.62	5.377
298.15	-29.58	-28.63	20.986	1000	-16.65	-23.90	5.223
300	-29.59	-28.63	20.857	1064	-15.97	-24.41	5.014
400	-30.25	-28.24	15.430	1064	-11.27	-24.41	5.014
411	-30.38	-28.18	14.985	1100	-10.87	-24.87	4.941
411	-31.52	-28.18	14.985	1200	-9.84	-26.14	4.761
500	-32.78	-27.32	11.942	1300	-8.99	-27.54	4.630
525	-33.29	-27.05	11.261	1400	-8.34	-28.99	4.526
565	-33.72	-26.53	10.262	1470	-8.00	-30.04	4.466
598	-33.96	-26.11	9.542	1470	-23.46	-30.04	4.466
598	-34.20	-26.11	9.542	1500	-23.39	-30.18	4.397
600	-34.20	-26.08	9.500	1600	-23.18	-30.64	4.185
700	-34.02	-24.74	7.724	1700	-23.06	-31.11	3.999
800	-33.41	-23.48	6.414	1800	-23.00	-31.60	3.837
840	-33.01	-22.99	5.981				

Phase changes:

411 K, α - β transition point of FeS; ΔH° = 0.57 kcal/mole.
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
598 K, β - γ transition point of FeS; ΔH° = 0.12 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
960 K, Curie temperature of Fe_2O_3; ΔH° = 0 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1470 K, melting point of FeS; ΔH° = 7.73 kcal/mole.

$Ni_2SiO_4(s) + 2CaS(s) = 2NiS(s,l) + Ca_2SiO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-31.6	-32.1	23.53	1100	-16.2	-33.8	6.72
300	-31.6	-32.1	23.38	1121	-16.1	-34.2	6.67
400	-31.7	-32.2	17.59	1121	-12.7	-34.2	6.67
500	-31.9	-32.3	14.12	1200	-12.3	-35.7	6.50
600	-32.2	-32.3	11.77	1300	-11.8	-37.7	6.34
623	-32.3	-32.3	11.33	1400	-11.3	-39.7	6.20
623	-30.9	-32.3	11.33	1500	-10.9	-41.7	6.08
700	-31.1	-32.5	10.15	1600	-10.6	-43.8	5.98
800	-31.1	-32.7	8.93	1700	-10.3	-45.8	5.89
900	-31.0	-32.9	7.99	1712	-10.3	-46.1	5.89
1000	-30.7	-33.1	7.23	1712	-6.9	-46.1	5.89
1066.5	-30.4	-33.3	6.82	1800	-7.1	-48.1	5.84
1066.5	-16.4	-33.3	6.82				

Phase changes:
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1121 K, γ - α′ transition point of Ca_2SiO_4; ΔH° = 3.44 kcal/mole.
1712 K, α′ - α transition point of Ca_2SiO_4; ΔH° = 3.39 kcal/mole.

$Ni_2SiO_4(s) + 2FeS(s,l) = 2NiS(s,l) + Fe_2SiO_4(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-14.3	-15.9	11.66	1066.5	-17.0	-15.6	3.20
300	-14.3	-16.0	11.66	1066.5	-3.0	-15.6	3.20
400	-14.7	-16.5	9.02	1100	-2.8	-16.0	3.18
411	-14.8	-16.5	8.77	1200	-2.4	-17.2	3.13
411	-15.9	-16.5	8.77	1300	-2.1	-18.4	3.09
500	-17.0	-16.5	7.21	1400	-1.8	-19.7	3.08
598	-18.0	-16.4	5.99	1470	-1.7	-20.6	3.06
598	-18.2	-16.4	5.99	1470	-17.2	-20.6	3.06
600	-18.2	-16.4	5.97	1492	-17.2	-20.6	3.02
623	-18.3	-16.3	5.72	1492	4.8	-20.6	3.02
623	-16.9	-16.3	5.72	1500	4.9	-20.8	3.03
700	-17.2	-16.2	5.06	1600	5.5	-22.5	3.07
300	-17.4	-16.0	4.37	1700	5.9	-24.3	3.12
900	-17.4	-15.9	3.86	1800	6.1	-26.1	3.17
1000	-17.2	-15.7	3.43				

Phase changes:
411 K, α - β transition point of FeS; ΔH° = 0.57 kcal/mole.
598 K, β - γ transition point of FeS; ΔH° = 0.12 kcal/mole.
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1470 K, melting point of FeS; ΔH° = 7.73 kcal/mole.
1492 K, melting point of Fe_2SiO_4; ΔH° = 22.03 kcal/mole.

$Ni_3S_2(s,l) + 7/2O_2(g) = 3NiO(s) + 2SO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-259.2	-259.2	∞	840	-274.0	-214.1	55.70
100	-260.2	-255.4	558.18	900	-274.7	-209.8	50.95
200	-261.2	-250.1	273.30	1000	-275.6	-202.5	44.26
298.15	-261.7	-244.5	179.22	1064	-276.2	-197.8	40.63
300	-261.7	-244.4	178.05	1064	-280.9	-197.8	40.63
400	-261.7	-238.6	130.36	1100	-281.2	-195.0	38.74
500	-261.1	-232.9	101.80	1200	-282.1	-187.1	34.08
525	-260.8	-231.5	96.37	1300	-282.9	-179.2	30.13
565	-260.6	-229.3	88.70	1400	-283.6	-171.2	26.73
600	-260.5	-227.3	82.79	1500	-284.2	-163.1	23.76
700	-260.4	-221.8	69.25	1600	-284.7	-155.0	21.17
800	-260.5	-216.3	59.09	1700	-285.2	-146.9	18.89
840	-260.6	-214.1	55.70	1800	-285.6	-138.7	16.84

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.

$Ni_3S_2(s,l) + 4NiO(s) = 7Ni(s,l) + 2SO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	137.9	137.9	∞	900	119.2	54.5	-13.23
100	139.4	129.6	-283.24	1000	117.5	47.4	-10.36
200	139.9	119.5	-130.58	1064	116.4	42.8	-8.79
298.15	139.4	109.5	-80.27	1064	111.7	42.8	-8.79
300	139.4	109.3	-79.62	1100	111.1	40.5	-8.05
400	138.4	99.5	-54.36	1200	109.5	34.2	-6.23
500	137.0	89.9	-39.30	1300	108.0	28.0	-4.71
525	136.4	87.5	-36.42	1400	106.5	21.9	-3.42
565	136.0	83.9	-32.45	1500	105.1	15.9	-2.32
600	135.8	80.6	-29.36	1600	103.7	10.0	-1.37
631	135.8	77.8	-26.95	1700	102.3	4.3	-.55
700	135.3	71.4	-22.29	1728	102.0	2.5	-.32
800	134.2	62.4	-17.05	1728	130.7	2.5	-.32
840	133.7	58.8	-15.30	1800	129.8	-2.8	.34
840	120.3	58.8	-15.30				

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_3S_2(s,l) + 2O_2(g) = 3Ni(s,l) + 2SO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-89.0	-89.0	∞	1000	-107.2	-95.4	20.85
100	-88.9	-90.4	197.57	1064	-107.9	-94.7	19.45
200	-89.3	-91.7	100.21	1064	-112.6	-94.7	19.45
298.15	-89.8	-92.8	68.02	1100	-113.1	-94.0	18.68
300	-89.8	-92.8	67.60	1200	-114.2	-92.3	16.81
400	-90.2	-93.7	51.20	1300	-115.3	-90.4	15.20
500	-90.5	-94.6	41.35	1400	-116.4	-88.4	13.80
600	-90.6	-95.4	34.75	1500	-117.4	-86.4	12.59
631	-90.6	-95.6	33.11	1600	-118.3	-84.3	11.51
700	-90.8	-96.1	30.00	1700	-119.1	-82.1	10.55
800	-91.4	-96.9	26.47	1728	-119.3	-81.6	10.32
840	-91.6	-97.1	25.26	1728	-107.0	-81.6	10.32
840	-105.0	-97.1	25.26	1800	-107.6	-80.5	9.77
900	-105.9	-96.5	23.43				

Phase changes:
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiS(s,l) + 3/2O_2(g) = NiO(s) + SO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-105.1	-105.1	∞	800	-107.0	-91.7	25.05
100	-105.5	-104.1	227.51	900	-107.2	-89.8	21.81
200	-105.9	-102.5	112.01	1000	-107.4	-87.8	19.19
298.15	-106.1	-100.8	73.89	1066.5	-107.6	-86.5	17.73
300	-106.1	-100.8	73.43	1066.5	-114.6	-86.5	17.73
400	-106.2	-99.0	54.09	1100	-114.8	-85.6	17.01
500	-106.1	-97.2	42.49	1200	-115.1	-83.0	15.12
525	-106.1	-96.8	40.30	1300	-115.4	-80.3	13.50
565	-106.0	-96.1	37.17	1400	-115.6	-77.6	12.11
600	-106.0	-95.4	34.75	1500	-115.9	-74.8	10.90
623	-106.1	-95.0	33.33	1600	-116.1	-72.1	9.85
623	-106.8	-95.0	33.33	1700	-116.3	-69.3	8.91
700	-106.8	-93.6	29.22	1800	-116.4	-66.6	8.09

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.

$NiS(s,l) + 2NiO(s) = 3Ni(s,l) + SO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	65.1	65.1	∞	900	61.6	23.5	-5.71
100	65.8	60.9	-133.10	1000	61.0	19.3	-4.22
200	66.0	55.8	-60.98	1066.5	60.6	16.5	-3.38
298.15	65.8	50.9	-37.31	1066.5	53.6	16.5	-3.38
300	65.8	50.8	-37.01	1100	53.4	15.3	-3.04
400	65.2	45.9	-25.08	1200	52.7	11.9	-2.17
500	64.5	41.1	-17.96	1300	52.1	8.5	-1.43
525	64.2	40.0	-16.65	1400	51.5	5.2	-.81
565	63.9	38.1	-14.74	1500	50.9	1.9	-.28
600	63.8	36.5	-13.30	1600	50.4	-1.3	.18
623	63.8	35.5	-12.45	1700	49.8	-4.5	.58
623	63.1	35.5	-12.45	1728	49.7	-5.5	.70
631	63.1	35.1	-12.16	1728	62.0	-5.5	.70
700	62.8	32.1	-10.02	1800	61.6	-8.3	1.01
800	62.2	27.7	-7.57				

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiS(s,l) + O_2(g) = Ni(s,l) + SO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-48.4	-48.4	∞	1000	-51.3	-52.1	11.39
100	-48.4	-49.1	107.31	1066.5	-51.6	-52.2	10.70
200	-48.6	-49.7	54.31	1066.5	-58.6	-52.2	10.70
298.15	-48.8	-50.3	36.87	1100	-58.7	-52.0	10.33
300	-48.8	-50.3	36.64	1200	-59.1	-51.3	9.34
400	-49.1	-50.7	27.70	1300	-59.5	-50.7	8.52
500	-49.3	-51.1	22.34	1400	-59.9	-50.0	7.81
600	-49.4	-51.4	18.72	1500	-60.3	-49.3	7.18
623	-49.4	-51.5	18.07	1600	-60.6	-48.5	6.62
623	-50.1	-51.5	18.07	1700	-60.9	-47.7	6.13
631	-50.1	-51.5	17.84	1728	-61.0	-47.5	6.01
700	-50.3	-51.7	16.14	1728	-56.9	-47.5	6.01
800	-50.6	-51.9	14.18	1800	-57.1	-47.1	5.72
900	-50.9	-52.0	12.63				

Phase changes:
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$3NiS(s,l) + O_2(g) = Ni_3S_2(s,l) + SO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-56.2	-56.2	∞	900	-46.8	-59.5	14.45
100	-56.2	-56.9	124.35	1000	-46.7	-60.9	13.31
200	-56.4	-57.6	62.94	1064	-46.7	-61.8	12.69
298.15	-56.7	-58.0	42.52	1064	-42.0	-61.8	12.69
300	-56.7	-58.0	42.25	1066.5	-42.0	-61.9	12.68
400	-57.1	-58.4	31.91	1066.5	-63.0	-61.9	12.68
500	-57.3	-58.7	25.66	1100	-63.1	-61.9	12.30
600	-57.6	-59.0	21.49	1200	-63.2	-61.7	11.24
623	-57.7	-59.0	20.70	1300	-63.3	-61.6	10.36
623	-59.8	-59.0	20.70	1400	-63.4	-61.5	9.60
700	-60.0	-58.9	18.39	1500	-63.5	-61.4	8.95
800	-60.3	-58.8	16.06	1600	-63.5	-61.2	8.36
840	-60.5	-58.7	15.27	1700	-63.6	-61.1	7.85
840	-47.1	-58.7	15.27	1800	-63.7	-60.9	7.39

Phase changes:
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.

$7NiS(s,l) + 2NiO(s) = 3Ni_3S_2(s,l) + SO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	41.7	41.7	∞	840	72.8	5.8	-1.51
100	42.4	37.5	-81.96	900	73.8	1.0	-.24
200	42.5	32.4	-35.41	1000	74.8	-7.1	1.55
298.15	42.1	27.6	-20.23	1064	75.1	-12.5	2.57
300	42.0	27.5	-20.03	1064	89.2	-12.5	2.57
400	41.3	22.7	-12.40	1066.5	89.2	-12.7	2.60
500	40.3	18.3	-8.00	1066.5	40.2	-12.7	2.60
525	39.9	17.2	-7.16	1100	40.3	-14.4	2.86
565	39.5	15.4	-5.96	1200	40.6	-19.3	3.52
600	39.2	13.9	-5.06	1300	40.9	-24.3	4.09
623	39.1	13.0	-4.56	1400	41.2	-29.4	4.59
623	34.2	13.0	-4.56	1500	41.4	-34.4	5.01
700	33.6	10.4	-3.25	1600	41.5	-39.5	5.40
800	32.9	7.1	-1.94	1700	41.6	-44.5	5.72
840	32.7	5.8	-1.51	1800	41.7	-49.7	6.03

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.

$Ni_3S_2(s,l) + 1/2O_2(g) = NiO(s) + 2NiS(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-48.9	-48.9	∞	840	-60.0	-32.2	8.38
100	-49.3	-47.2	103.16	900	-60.3	-30.3	7.36
200	-49.5	-45.0	49.17	1000	-60.8	-26.9	5.88
298.15	-49.4	-42.8	31.37	1064	-60.9	-24.7	5.07
300	-49.4	-42.8	31.18	1064	-65.6	-24.7	5.07
400	-49.2	-40.6	22.18	1066.5	-65.6	-24.6	5.04
500	-48.8	-38.5	16.83	1066.5	-51.6	-24.6	5.04
525	-48.7	-38.0	15.82	1100	-51.7	-23.7	4.71
565	-48.5	-37.2	14.39	1200	-51.9	-21.2	3.86
600	-48.4	-36.5	13.30	1300	-52.1	-18.6	3.13
623	-48.4	-36.0	12.63	1400	-52.3	-16.1	2.51
623	-47.0	-36.0	12.63	1500	-52.4	-13.5	1.97
700	-46.8	-34.7	10.83	1600	-52.5	-10.9	1.49
800	-46.6	-32.9	8.99	1700	-52.6	-8.3	1.07
840	-46.6	-32.2	8.38	1800	-52.7	-5.6	.68

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.

$Ni_3S_2(s,l) + 9/2O_2(g) = NiO(s) + 2NiSO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-417.2	-417.2	∞	700	-419.7	-286.8	89.54
100	-420.0	-402.1	878.79	800	-418.9	-267.9	73.19
200	-421.8	-383.4	418.96	840	-418.6	-260.3	67.72
298.15	-422.5	-364.3	267.04	840	-432.0	-260.3	67.72
300	-422.5	-364.0	265.17	900	-431.9	-248.1	60.25
400	-422.3	-344.5	188.23	1000	-431.7	-227.6	49.74
500	-421.6	-325.1	142.10	1064	-431.4	-214.6	44.08
525	-421.3	-320.2	133.29	1064	-436.1	-214.6	44.08
565	-420.9	-312.6	120.92	1100	-436.0	-207.1	41.15
600	-420.6	-305.9	111.42	1200	-435.5	-186.3	33.93

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.

$Ni_3S_2(s,l) + SO_2(g) + 5O_2(g) = 3NiSO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-496.2	-496.2	∞	800	-498.1	-293.7	80.24
100	-499.9	-475.4	1038.99	840	-497.5	-283.4	73.73
200	-502.0	-450.0	491.74	840	-510.9	-283.4	73.73
298.15	-502.8	-424.2	310.95	900	-510.5	-267.2	64.89
300	-502.9	-423.7	308.67	1000	-509.7	-240.2	52.50
400	-502.6	-397.4	217.13	1064	-509.0	-223.0	45.81
500	-501.8	-371.1	162.21	1064	-513.7	-223.0	45.81
600	-500.7	-345.1	125.70	1100	-513.4	-213.1	42.34
700	-499.4	-319.3	99.69	1200	-512.3	-185.9	33.86

Phase changes: 840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.

$3NiS(s,l) = Ni_3S_2(s,l) + 1/2S_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	29.5	29.5	∞	900	39.7	11.2	-2.72
100	29.7	27.5	-60.10	1000	39.8	8.1	-1.77
200	29.7	25.3	-27.65	1064	39.7	6.0	-1.23
298.15	29.5	23.2	-17.01	1064	44.4	6.0	-1.23
300	29.5	23.2	-16.90	1066.5	44.4	5.9	-1.21
400	29.3	21.0	-11.47	1066.5	23.4	5.9	-1.21
500	29.2	19.0	-8.30	1100	23.4	5.4	-1.07
600	28.9	17.0	-6.19	1200	23.2	3.8	-.69
623	28.8	16.6	-5.82	1300	23.1	2.1	-.35
623	26.7	16.6	-5.82	1400	23.0	.5	-.08
700	26.5	15.3	-4.78	1500	22.8	-1.1	.16
800	26.2	13.7	-3.74	1600	22.7	-2.7	.37
840	26.0	13.1	-3.41	1700	22.6	-4.2	.54
840	39.4	13.1	-3.41	1800	22.4	-5.8	.70

Phase changes: 623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.

$2NiS(s,l) + Ni(s,l) = Ni_3S_2(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-7.8	-7.8	∞	1000	4.6	-8.8	1.92
100	-7.8	-7.8	17.05	1064	4.8	-9.7	1.99
200	-7.8	-7.8	8.52	1064	9.5	-9.7	1.99
298.15	-7.9	-7.8	5.72	1066.5	9.5	-9.7	1.99
300	-7.9	-7.8	5.68	1066.5	-4.5	-9.7	1.99
400	-8.0	-7.7	4.21	1100	-4.4	-9.9	1.97
500	-8.0	-7.6	3.32	1200	-4.0	-10.4	1.89
600	-8.2	-7.5	2.73	1300	-3.7	-11.0	1.85
623	-8.2	-7.5	2.63	1400	-3.4	-11.5	1.80
623	-9.6	-7.5	2.63	1500	-3.2	-12.1	1.76
631	-9.7	-7.5	2.60	1600	-2.9	-12.7	1.73
700	-9.7	-7.2	2.25	1700	-2.7	-13.3	1.71
800	-9.8	-6.9	1.88	1728	-2.7	-13.5	1.71
840	-9.8	-6.7	1.74	1728	-6.8	-13.5	1.71
840	3.6	-6.7	1.74	1800	-6.6	-13.8	1.68
900	4.1	-7.5	1.82				

Phase changes:
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiS(s,l) + 2O_2(g) = NiSO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-184.1	-184.1	∞	623	-186.7	-132.7	46.55
100	-185.3	-177.4	387.71	700	-186.5	-126.1	39.37
200	-186.2	-169.2	184.89	800	-186.1	-117.5	32.10
298.15	-186.5	-160.8	117.87	900	-185.8	-108.9	26.44
300	-186.5	-160.6	117.00	1000	-185.5	-100.4	21.94
400	-186.6	-151.9	82.99	1066.5	-185.2	-94.7	19.41
500	-186.4	-143.3	62.64	1066.5	-192.2	-94.7	19.41
600	-186.1	-134.7	49.06	1100	-192.1	-91.7	18.22
623	-186.0	-132.7	46.55	1200	-191.8	-82.5	15.03

Phase changes:
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.

$NiO(s) + 0.947Fe(s) = Ni(s,l) + Fe_{.947}O(s,l)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	-7.12	-7.12	∞	1100	-7.22	-12.50	2.484
100	-7.00	-7.18	15.692	1185	-7.34	-12.88	2.375
200	-6.57	-7.50	8.196	1185	-7.54	-12.88	2.375
298.15	-6.34	-8.02	5.879	1200	-7.53	-12.95	2.359
300	-6.34	-8.03	5.850	1300	-7.44	-13.41	2.254
400	-6.25	-8.61	4.704	1400	-7.34	-13.88	2.167
500	-6.31	-9.19	4.017	1500	-7.25	-14.35	2.091
525	-6.39	-9.34	3.888	1600	-7.16	-14.83	2.026
565	-6.40	-9.55	3.694	1652	-7.12	-15.06	1.992
600	-6.37	-9.75	3.551	1652	.37	-15.06	1.992
631	-6.33	-9.92	3.436	1667	.40	-15.19	1.991
700	-6.32	-10.32	3.222	1667	.21	-15.19	1.991
800	-6.38	-10.90	2.978	1700	.25	-15.51	1.994
900	-6.50	-11.44	2.778	1728	.28	-15.78	1.996
1000	-6.78	-11.98	2.618	1728	4.38	-15.78	1.996
1043	-7.03	-12.20	2.556	1800	4.46	-16.63	2.019

Phase changes:

525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, α - γ transition point of Fe; H° = 0.215 kcal/mole.
1652 K, melting point of $Fe_{.947}O$; ΔH° = 7.49 kcal/mole.
1667 K, γ - δ transition point of Fe; ΔH° = 0.200 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_3S_2(s,l) + 2Fe(s) = 3Ni(s,l) + 2FeS(s,l)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	3.86	3.86	∞	1043	-8.60	-2.88	.603
100	4.02	3.76	-8.217	1064	-9.21	-2.78	.571
200	4.26	3.41	-3.726	1064	-13.91	-2.78	.571
298.15	4.48	2.93	-2.148	1100	-14.28	-2.39	.475
300	4.49	2.92	-2.127	1185	-15.38	-1.43	.264
400	5.12	2.33	-1.273	1185	-15.81	-1.43	.264
411	5.24	2.25	-1.196	1200	-15.92	-1.25	.228
411	6.38	2.25	-1.196	1300	-16.61	.02	-.003
500	7.37	1.26	-.551	1400	-17.18	1.31	-.205
598	8.42	-.04	.015	1470	-17.49	2.24	-.333
598	8.66	-.04	.015	1470	-2.03	2.24	-.333
600	8.67	-.06	.022	1500	-2.10	2.33	-.339
631	8.84	-.53	.184	1600	-2.35	2.62	-.358
700	8.89	-1.56	.487	1667	-2.51	2.87	-.376
800	8.55	-3.03	.828	1667	-2.91	2.87	-.376
840	8.29	-3.60	.937	1700	-3.03	2.98	-.383
840	-5.08	-3.60	.937	1728	-3.13	3.03	-.383
900	-5.96	-3.46	.840	1728	9.17	3.03	-.383
1000	-7.64	-3.09	.675	1800	8.93	2.81	-.341

Phase changes:

411 K, α - β transition point of FeS; ΔH° = 0.57 kcal/mole.
598 K, β - γ transition point of FeS; ΔH° = 0.12 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1185 K, α - γ transition point of Fe; ΔH° = 0.215 kcal/mole.
1470 K, melting point of FeS; ΔH° = 7.73 kcal/mole.
1667 K, γ - δ transition point of Fe; ΔH° = 0.200 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiS(s,l) + Fe(s) = Ni(s,l) + FeS(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-2.0	-2.0	∞	1043	-1.9	-6.1	1.28
100	-1.9	-2.0	4.37	1066.5	-2.2	-6.2	1.27
200	-1.8	-2.2	2.40	1066.5	-9.2	-6.2	1.27
298.15	-1.7	-2.4	1.76	1100	-9.3	-6.1	1.21
300	-1.7	-2.4	1.75	1185	-9.7	-5.9	1.09
400	-1.4	-2.7	1.48	1185	-9.9	-5.9	1.09
411	-1.4	-2.7	1.44	1200	-10.0	-5.8	1.06
411	-.8	-2.7	1.44	1300	-10.2	-5.5	.92
500	-.3	-3.2	1.40	1400	-10.3	-5.1	.80
598	.1	-3.8	1.39	1470	-10.3	-4.8	.71
598	.2	-3.8	1.39	1470	-2.6	-4.8	.71
600	.2	-3.8	1.38	1500	-2.6	-4.9	.71
623	.3	-4.0	1.40	1600	-2.6	-5.0	.68
623	-.4	-4.0	1.40	1667	-2.7	-5.1	.67
631	-.4	-4.0	1.39	1667	-2.9	-5.1	.67
700	-.4	-4.4	1.37	1700	-2.9	-5.2	.67
800	-.6	-5.0	1.37	1728	-2.9	-5.2	.66
900	-1.0	-5.5	1.34	1728	1.2	-5.2	.66
1000	-1.5	-5.9	1.29	1800	1.1	-5.5	.67

Phase changes:

411 K, α - β transition point of FeS; ΔH° = 0.57 kcal/mole.
598 K, β - γ transition point of FeS; ΔH° = 0.12 kcal/mole.
623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.
1185 K, α - γ transition point of Fe; ΔH° = 0.215 kcal/mole.
1470 K, melting point of FeS; ΔH° = 7.73 kcal/mole.
1667 K, γ - δ transition point of Fe; ΔH° = 0.200 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni_2SiO_4(s) + 2Fe(s) = 2Ni(s,l) + Fe_2SiO_4(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-17.7	-20.8	15.25	1200	-22.4	-28.8	5.25
300	-17.7	-20.8	15.15	1300	-22.4	-29.4	4.94
400	-17.6	-21.9	11.97	1400	-22.4	-29.9	4.67
500	-17.6	-22.9	10.01	1492	-22.4	-30.4	4.45
600	-17.8	-24.0	8.74	1492	-.4	-30.4	4.45
631	-17.8	-24.3	8.42	1500	-.3	-30.6	4.46
700	-18.1	-25.0	7.81	1600	.2	-32.6	4.45
800	-18.6	-25.9	7.08	1667	.5	-34.0	4.46
900	-19.3	-26.8	6.51	1667	.1	-34.0	4.46
1000	-20.2	-27.6	6.03	1700	.2	-34.6	4.45
1043	-20.9	-27.9	5.85	1728	.2	-35.3	4.46
1100	-21.5	-28.3	5.62	1728	8.4	-35.3	4.46
1185	-22.0	-28.8	5.31	1800	8.4	-37.1	4.50
1185	-22.4	-28.8	5.31				

Phase changes:
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, $\alpha - \gamma$ transition point of Fe; ΔH° = 0.215 kcal/mole.
1492 K, melting point of Fe_2SiO_4; ΔH° = 22.03 kcal/mole.
1667 K, $\gamma - \delta$ transition point of Fe; ΔH° = 0.200 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiFe_2O_4(s) + Fe(s) = Ni(s,l) + Fe_3O_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-12.50	-13.95	10.226	1185	-11.67	-19.89	3.668
300	-12.50	-13.96	10.170	1185	-11.89	-19.89	3.668
400	-12.34	-14.46	7.901	1200	-11.90	-19.99	3.641
500	-12.15	-15.02	6.565	1300	-11.95	-20.66	3.473
600	-11.93	-15.61	5.686	1400	-12.02	-21.34	3.331
631	-11.80	-15.81	5.476	1500	-12.10	-22.00	3.205
700	-11.51	-16.25	5.073	1600	-12.18	-22.65	3.094
800	-10.96	-16.96	4.633	1667	-12.24	-23.08	3.026
870	-10.24	-17.52	4.401	1667	-12.44	-23.08	3.026
880	-10.13	-17.60	4.371	1700	-12.50	-23.29	2.994
900	-10.44	-17.76	4.313	1728	-12.55	-23.48	2.970
1000	-10.84	-18.55	4.054	1728	-8.45	-23.48	2.970
1043	-11.15	-18.88	3.956	1800	-8.57	-24.11	2.927
1100	-11.43	-19.30	3.835				

Phase changes:
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
870 K, Curie temperature of Fe_3O_4; ΔH° = 0 kcal/mole.
880 K, $\alpha - \beta$ transition point of $NiFe_2O_4$; ΔH° = 0 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, $\alpha - \gamma$ transition point of Fe; ΔH° = 0.215 kcal/mole.
1667 K, $\gamma - \delta$ transition point of Fe; ΔH° = 0.200 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$Ni(s) + 4CO(g) = Ni(CO)_4(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-30.5	-30.5	∞	350	-32.5	1.2	-.75
100	-32.0	-22.8	49.83	400	-32.4	6.0	-3.28
200	-32.6	-13.3	14.53	450	-32.2	10.8	-5.25
298.15	-32.6	-3.8	2.79	500	-32.0	15.5	-6.78
300	-32.6	-3.6	2.62				

$NiO(s) + SO_2(g) + 1/2O_2(g) = NiSO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-79.03	-79.03	∞	565	-80.18	-41.64	16.107
100	-79.89	-73.35	160.306	600	-80.07	-39.25	14.297
200	-80.27	-66.64	72.821	700	-79.66	-32.48	10.141
298.15	-80.39	-59.91	43.915	800	-79.19	-25.79	7.045
300	-80.39	-59.79	43.557	900	-78.62	-19.13	4.645
400	-80.32	-52.93	28.920	1000	-78.02	-12.56	2.745
500	-80.24	-46.07	20.137	1100	-77.39	-6.06	1.204
525	-80.26	-44.37	18.471	1200	-76.73	.42	-.076

Phase changes: 525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.

$NiO(s) + SO_3(g) = NiSO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-56.15	-56.15	∞	565	-56.52	-30.72	11.883
100	-56.67	-52.12	113.908	600	-56.42	-29.13	10.611
200	-56.78	-47.51	51.917	700	-56.08	-24.61	7.684
298.15	-56.75	-42.97	31.498	800	-55.68	-20.16	5.507
300	-56.75	-42.89	31.245	900	-55.20	-15.73	3.820
400	-56.63	-38.28	20.915	1000	-54.69	-11.38	2.487
500	-56.55	-33.69	14.726	1100	-54.16	-7.08	1.407
525	-56.58	-32.56	13.554	1200	-53.60	-2.81	.512

Phase changes: 525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.

$NiO(s) + Fe_2O_3(s) = NiFe_2O_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-.94	-.94	∞	880	-.48	-1.36	.338
100	-.93	-1.04	2.273	900	-.58	-1.38	.335
200	-.95	-1.13	1.235	960	-1.09	-1.42	.323
298.15	-1.00	-1.22	.894	1000	-1.03	-1.44	.315
300	-1.00	-1.21	.881	1100	-.90	-1.50	.298
400	-1.09	-1.28	.699	1200	-.77	-1.55	.282
500	-1.26	-1.30	.568	1300	-.67	-1.62	.272
525	-1.36	-1.30	.541	1400	-.61	-1.70	.265
565	-1.39	-1.29	.499	1500	-.57	-1.79	.261
600	-1.37	-1.28	.466	1600	-.56	-1.86	.254
700	-1.25	-1.29	.403	1700	-.59	-1.95	.251
800	-.95	-1.31	.358	1800	-.63	-2.03	.246

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
880 K, α - β transition point of $NiFe_2O_4$; ΔH° = 0 kcal/mole.
960 K, Curie temperature of Fe_2O_3; ΔH° = 0 kcal/mole.

$2NiO(s) + SiO_2(s) = Ni_2SiO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-3.7	-2.9	2.13	900	-3.4	-1.0	.24
300	-3.7	-2.9	2.11	1000	-3.0	-.8	.17
400	-3.8	-2.6	1.42	1100	-2.6	-.6	.12
500	-4.0	-2.3	1.01	1200	-2.2	-.5	.09
525	-4.2	-2.2	.92	1300	-1.9	-.3	.05
565	-4.2	-2.1	.81	1400	-1.5	-.2	.03
600	-4.1	-2.0	.73	1500	-1.1	-.2	.03
700	-3.8	-1.6	.50	1600	-.6	-.1	.01
800	-3.6	-1.3	.36	1700	.0	-.1	.01
847	-3.5	-1.2	.31	1800	.8	-.1	.01
847	-3.7	-1.2	.31				

Phase changes:
525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
847 K, α - β transition point of SiO_2; ΔH° = 0.174 kcal/mole.

$NiO(s) + WO_3(s) = NiWO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-10.14	-10.52	7.711	700	-10.76	-10.78	3.366
300	-10.09	-10.48	7.635	800	-10.75	-10.79	2.948
400	-10.09	-10.61	5.797	900	-10.66	-10.83	2.630
500	-10.41	-10.75	4.699	1000	-10.52	-10.86	2.373
525	-10.54	-10.76	4.479	1050	-10.40	-10.88	2.265
565	-10.66	-10.82	4.185	1050	-10.81	-10.88	2.265
600	-10.71	-10.83	3.945	1100	-10.65	-10.88	2.162

Phase changes: 525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
1050 K, α - β transition point of WO_3; ΔH° = 0.41 kcal/mole.

$Ni_2SiO_4(s) + 2CaO(s) = 2NiO(s) + Ca_2SiO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-29.0	-30.0	21.99	1121	-30.7	-32.0	6.24
300	-29.0	-30.0	21.85	1121	-27.3	-32.0	6.24
400	-29.0	-30.3	16.56	1200	-27.5	-32.3	5.88
500	-28.9	-30.6	13.38	1300	-27.6	-32.7	5.50
525	-28.8	-30.7	12.78	1400	-27.7	-33.1	5.17
565	-28.8	-30.9	11.95	1500	-27.8	-33.5	4.88
600	-29.0	-31.0	11.29	1600	-27.8	-33.9	4.63
700	-29.4	-31.3	9.77	1700	-27.9	-34.3	4.41
800	-29.8	-31.5	8.61	1712	-27.9	-34.3	4.38
900	-30.2	-31.7	7.70	1712	-24.5	-34.3	4.38
1000	-30.5	-31.9	6.97	1800	-24.9	-34.8	4.23
1100	-30.7	-32.0	6.36				

Phase changes: 525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
1121 K, γ - α' transition point of Ca_2SiO_4; ΔH° = 3.44 kcal/mole.
1712 K, α' - α transition point of Ca_2SiO_4; ΔH° = 3.39 kcal/mole.

$NiBr_2(s) + H_2(g) = Ni(s) + 2HBr(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	34.10	21.59	-15.826	631	32.65	8.26	-2.861
300	34.10	21.51	-15.670	700	32.36	5.63	-1.758
400	33.63	17.37	-9.491	800	31.91	1.84	-.503
500	33.17	13.38	-5.848	900	31.47	-1.91	.464
600	32.75	9.47	-3.449	1000	31.05	-5.60	1.224

Phase change: 631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.

$NiBr_2(g) + H_2(g) = Ni(s,l) + 2HBr(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-19.69	-19.69	∞	1100	-20.89	-12.96	2.575
100	-19.96	-19.49	42.595	1200	-20.85	-12.23	2.227
200	-20.05	-19.00	20.762	1300	-20.78	-11.50	1.933
298.15	-20.20	-18.46	13.532	1400	-20.66	-10.77	1.681
300	-20.21	-18.45	13.441	1500	-20.53	-10.08	1.469
400	-20.38	-17.84	9.747	1600	-20.37	-9.46	1.292
500	-20.54	-17.18	7.509	1700	-20.18	-8.72	1.121
600	-20.63	-16.49	6.006	1728	-20.12	-8.55	1.081
631	-20.63	-16.28	5.639	1728	-16.02	-8.55	1.081
700	-20.69	-15.78	4.927	1800	-15.86	-8.27	1.004
800	-20.79	-15.10	4.125	1900	-15.63	-7.79	.896
900	-20.87	-14.38	3.492	2000	-15.41	-7.44	.813
1000	-20.89	-13.64	2.981				

Phase changes: 631 K, Curie temperature of Ni; $\Delta H° = 0$ kcal/mole.
1728 K, melting point of Ni; $\Delta H° = 4.10$ kcal/mole.

$NiCl_2(s,g) + H_2(g) = Ni(s,l) + 2HCl(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	29.05	29.05	∞	1200	24.88	-18.03	3.284
100	29.31	24.93	-54.484	1229	24.72	-19.07	3.391
200	29.19	20.56	-22.467	1229	-27.98	-19.07	3.391
298.15	28.86	16.39	-12.014	1300	-27.94	-18.55	3.119
300	28.85	16.32	-11.889	1400	-27.85	-17.80	2.779
400	28.43	12.21	-6.671	1500	-27.73	-17.08	2.489
500	27.99	8.20	-3.584	1600	-27.58	-16.42	2.243
600	27.59	4.28	-1.559	1700	-27.40	-15.66	2.013
631	27.49	3.08	-1.067	1728	-27.35	-15.48	1.958
700	27.19	.42	-.131	1728	-23.25	-15.48	1.958
800	26.73	-3.37	.921	1800	-23.10	-15.18	1.843
900	26.27	-7.11	1.727	1900	-22.89	-14.86	1.709
1000	25.83	-10.79	2.358	2000	-22.66	-14.28	1.560
1100	25.37	-14.44	2.869				

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiF_2(s) + H_2(g) = Ni(s) + 2HF(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	27.10	27.10	∞	800	26.18	-4.74	1.295
100	27.46	23.47	-51.294	900	25.80	-8.58	2.084
200	27.71	19.36	-21.156	1000	25.40	-12.39	2.708
298.15	27.60	15.27	-11.193	1100	24.99	-16.14	3.207
300	27.60	15.19	-11.066	1200	24.57	-19.87	3.619
400	27.35	11.10	-6.065	1300	24.14	-23.54	3.957
500	27.07	7.06	-3.086	1400	23.69	-27.19	4.245
600	26.82	3.09	-1.126	1500	23.19	-30.81	4.489
631	26.76	1.86	-.644	1600	22.62	-34.40	4.699
700	26.55	-.85	.265				

Phase change: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.

$NiF_2(g) + H_2(g) = Ni(s,l) + 2HF(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	-49.6	-49.6	∞	1100	-49.6	-42.6	8.46
100	-49.7	-48.9	106.87	1200	-49.7	-41.9	7.63
200	-49.5	-48.2	52.67	1300	-49.7	-41.3	6.94
298.15	-49.4	-47.5	34.82	1400	-49.6	-40.6	6.34
300	-49.4	-47.5	34.60	1500	-49.6	-39.9	5.81
400	-49.4	-46.9	25.62	1600	-49.5	-39.3	5.37
500	-49.3	-46.3	20.24	1700	-49.3	-38.7	4.98
600	-49.3	-45.7	16.65	1728	-49.3	-38.5	4.87
631	-49.3	-45.5	15.76	1728	-45.2	-38.5	4.87
700	-49.3	-45.1	14.08	1800	-45.1	-38.2	4.64
800	-49.4	-44.4	12.13	1900	-44.9	-37.9	4.36
900	-49.5	-43.8	10.64	2000	-44.7	-37.5	4.10
1000	-49.6	-43.2	9.44				

Phase changes: 631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$NiO(s) + H_2(g) = Ni(s,l) + H_2O(g)$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	-.37	-.37	∞	1000	-3.09	-10.34	2.260
100	-.34	-1.56	3.409	1100	-3.35	-11.07	2.199
200	-.27	-2.84	3.103	1200	-3.58	-11.74	2.138
298.15	-.50	-4.06	2.976	1300	-3.80	-12.42	2.088
300	-.50	-4.08	2.972	1400	-4.01	-13.07	2.040
400	-.88	-5.22	2.852	1500	-4.22	-13.72	1.999
500	-1.40	-6.24	2.728	1600	-4.42	-14.35	1.960
525	-1.59	-6.49	2.702	1700	-4.62	-14.95	1.922
565	-1.77	-6.84	2.646	1728	-4.67	-15.14	1.915
600	-1.88	-7.16	2.608	1728	-.57	-15.14	1.915
631	-1.95	-7.43	2.573	1800	-.70	-15.74	1.911
700	-2.18	-8.02	2.504	1900	-.89	-16.56	1.905
800	-2.52	-8.84	2.415	2000	-1.08	-17.38	1.899
900	-2.81	-9.59	2.329				

Phase changes: 525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.
631 K, Curie temperature of Ni; ΔH° = 0 kcal/mole.
1728 K, melting point of Ni; ΔH° = 4.10 kcal/mole.

$$3NiS(s,l) + H_2(g) = Ni_3S_2(s,l) + H_2S(g)$$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	9.9	9.9	∞	900	18.2	.3	-.07
100	9.9	8.4	-18.36	1000	18.3	-1.7	.37
200	9.7	7.0	-7.65	1064	18.2	-3.0	.62
298.15	9.3	5.7	-4.18	1064	22.9	-3.0	.62
300	9.3	5.7	-4.15	1066.5	22.9	-3.1	.64
400	8.8	4.5	-2.46	1066.5	1.9	-3.1	.64
500	8.4	3.6	-1.57	1100	1.8	-3.3	.66
600	7.9	2.6	-.95	1200	1.6	-3.7	.67
623	7.8	2.4	-.84	1300	1.5	-4.1	.69
623	5.7	2.4	-.84	1400	1.3	-4.6	.72
700	5.3	2.1	-.66	1500	1.2	-5.0	.73
800	4.9	1.6	-.44	1600	1.1	-5.4	.74
840	4.7	1.4	-.36	1700	1.0	-5.8	.75
840	18.1	1.4	-.36	1800	.9	-6.2	.75

Phase changes: 623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
840 K, α - β transition point of Ni_3S_2; ΔH° = 13.37 kcal/mole.
1064 K, melting point of Ni_3S_2; ΔH° = 4.70 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.

$$NiSO_4(s) + 4H_2(g) = NiS(s,l) + 4H_2O(g)$$

T, K	Kcal		Log K	T, K	Kcal		Log K
	ΔH°	ΔG°			ΔH°	ΔG°	
0	-44.3	-44.3	∞	623	-47.5	-70.8	24.84
100	-44.3	-48.8	106.65	700	-48.4	-73.6	22.98
200	-44.1	-53.4	58.35	800	-49.5	-77.1	21.06
298.15	-44.7	-57.8	42.37	900	-50.5	-80.5	19.55
300	-44.7	-57.9	42.18	1000	-51.5	-83.8	18.31
400	-45.6	-62.1	33.93	1066.5	-52.1	-85.9	17.60
500	-46.7	-66.2	28.94	1066.5	-45.1	-85.9	17.60
600	-47.9	-69.9	25.46	1100	-45.4	-87.2	17.33
623	-48.2	-70.8	24.84	1200	-46.3	-90.9	16.56

Phase changes: 623 K, α - β transition point of NiS; ΔH° = 0.7 kcal/mole.
1066.5 K, melting point of NiS; ΔH° = 7.0 kcal/mole.

$NiBr_2(s) = NiBr_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	54.3	40.0	-29.32	700	53.1	21.4	-6.68
300	54.3	40.0	-29.14	800	52.7	16.9	-4.62
400	54.0	35.2	-19.23	900	52.3	12.5	-3.04
500	53.7	30.6	-13.38	1000	51.9	8.0	-1.75
600	53.4	26.0	-9.47				

$NiCl_2(s,l) = NiCl_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	56.07	56.07	∞	900	54.21	14.29	-3.470
100	56.55	51.60	-112.772	1000	53.82	9.95	-2.175
200	56.42	46.66	-50.988	1100	53.37	5.60	-1.113
298.15	56.18	41.91	-30.721	1200	52.85	1.26	-.229
300	56.18	41.85	-30.488	1229	52.70	0	0
400	55.90	37.11	-20.276	1300	52.20	-3.05	.513
500	55.59	32.41	-14.166	1304	52.17	-3.22	.540
600	55.27	27.84	-10.141	1304	33.70	-3.22	.540
700	54.93	23.26	-7.262	1400	32.94	-5.94	.927
800	54.58	18.76	-5.125				

Phase changes: 1229 K, sublimation point of $NiCl_2$; ΔH° = 52.7 kcal/mole.
1304 K, melting point of $NiCl_2$; ΔH° = 18.47 kcal/mole.

$NiCl_2(s) + 2AlCl_3(g) = NiAl_2Cl_8(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-17.2	-9.0	6.60	700	-16.2	1.6	-.50
300	-17.2	-8.9	6.48	800	-16.0	4.2	-1.15
400	-17.0	-6.2	3.39	900	-15.7	6.7	-1.63
500	-16.7	-3.5	1.53	1000	-15.5	9.2	-2.01
600	-16.5	-.9	.33				

$NiCl_2(s) + Fe_2Cl_6(g) = NiFe_2Cl_8(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	14.4	8.9	-6.52	700	13.7	1.9	-.59
300	14.4	8.9	-6.48	800	13.6	.3	-.08
400	14.2	7.1	-3.88	900	13.4	-1.4	.34
500	14.0	5.4	-2.36	1000	13.3	-3.0	.66
600	13.9	3.7	-1.35				

$NiF_2(s) = NiF_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	76.7	76.7	∞	800	75.6	39.7	-10.85
100	77.1	72.3	-158.01	900	75.3	35.2	-8.55
200	77.2	67.5	-73.76	1000	75.0	30.8	-6.73
298.15	77.0	62.8	-46.03	1100	74.6	26.4	-5.25
300	77.0	62.7	-45.68	1200	74.2	22.0	-4.01
400	76.7	58.0	-31.69	1300	73.8	17.7	-2.98
500	76.4	53.3	-23.30	1400	73.3	13.4	-2.09
600	76.1	48.8	-17.78	1500	72.8	9.1	-1.33
700	75.9	44.2	-13.80	1600	72.1	4.9	-.67

$NiO(s) = NiO(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	130.7	130.7	∞	900	129.1	89.1	-21.64
100	131.3	126.5	-276.47	1000	128.8	84.6	-18.49
200	131.5	121.6	-132.88	1100	128.5	80.2	-15.93
298.15	131.3	116.8	-85.62	1200	128.2	75.9	-13.82
300	131.3	116.7	-85.02	1300	127.8	71.5	-12.02
400	131.0	111.9	-61.14	1400	127.4	67.2	-10.49
500	130.5	107.2	-46.86	1500	127.0	62.9	-9.16
525	130.3	106.0	-44.13	1600	126.6	58.7	-8.02
565	130.2	104.2	-40.31	1700	126.1	54.4	-6.99
600	130.0	102.6	-37.37	1800	125.6	50.2	-6.10
700	129.7	98.0	-30.60	1900	125.0	46.1	-5.30
800	129.4	93.5	-25.54	2000	124.5	41.9	-4.58

Phase changes: 525 K, α - β transition point of NiO; ΔH° = 0 kcal/mole.
565 K, β - γ transition point of NiO; ΔH° = 0 kcal/mole.

CHAPTER 3.—THERMODYNAMIC DATA FOR AUXILIARY COMPOUNDS

The tables in this chapter contain enthalpy of formation, Gibbs energy of formation, and logarithm of the equilibrium constant of formation of auxiliary compounds employed in the calculation of the thermodynamic properties of the reactions given in chapter 2. The data used in the preparation of the auxiliary tables were taken from various sources. Most of the 298.15 K enthalpy-of-formation data were from the NBS tables (*117–119*). The exceptions are as follows: Fe_3O_4(s), Coughlin (*31*); FeS(s), Adami and King (*1*); SiO_2(s), Wise, Margrave, Feder, and Hubbard (*156*); and WO_3(s), Mah (*107*).

Entropy data at 298.15 K were taken mainly from the Dow Chemical Co. JANAF tables (*39–41*). The exceptions are Ca_2SiO_4(s), King (*89*); Fe_3O_4(s), Westrum and Grønvold (*155*); $Fe_{.947}O$(s), FeS(s), and Fe_2SiO_4(s), Kelley and King (*86*); and WO_3(s), King, Weller, and Christensen (*92*).

High-temperature enthalpy and entropy increments were taken from the Dow Chemical Co. JANAF tables (*39–41*), with the following exceptions: Ca_2SiO_4(s), Coughlin and O'Brien (*34*); $Fe_{.947}O$(s), Fe_2O_3(s), and Fe_3O_4(s), Coughlin, King, and Bonnickson (*33*); FeS(s,l) and Fe_2SiO_4(s,l), Kelley (*84*); S(s,l), West (*152*); and WO_3(s), King, Weller, and Christensen (*92*). Where warranted by the accuracy of the data, values were recalculated to conform to the International Practical Temperature Scale of 1968 (*38*).

$Al(s,l) + 3/2Cl_2(g) = AlCl_3(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-138.97	-138.97	∞	933.5	-142.59	-128.27	30.030
100	-139.17	-138.14	301.905	1000	-142.69	-127.25	27.810
200	-139.30	-137.06	149.772	1100	-142.83	-125.70	24.974
298.15	-139.40	-135.95	99.654	1200	-142.98	-124.14	22.609
300	-139.40	-135.92	99.018	1300	-143.12	-122.56	20.604
400	-139.47	-134.76	73.629	1400	-143.27	-120.97	18.884
500	-139.53	-133.57	58.383	1500	-143.42	-119.38	17.394
600	-139.59	-132.37	48.216	1600	-143.56	-117.77	16.087
700	-139.68	-131.16	40.950	1700	-143.71	-116.15	14.932
800	-139.80	-129.93	35.495	1800	-143.86	-114.53	13.906
900	-139.95	-128.69	31.250	1900	-144.01	-112.89	12.985
933.5	-140.01	-128.27	30.030	2000	-144.16	-111.25	12.157

Phase change: 933.5 K, melting point of Al; ΔH° = 2.58 kcal/mole.

$C(s) + 1/2O_2(g) = CO(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-27.20	-27.20	∞	1000	-26.77	-47.86	10.460
100	-26.87	-28.74	62.811	1100	-26.91	-49.96	9.926
200	-26.60	-30.72	33.569	1200	-27.06	-52.05	9.480
298.15	-26.42	-32.78	24.028	1300	-27.22	-54.13	9.100
300	-26.41	-32.82	23.909	1400	-27.38	-56.19	8.772
400	-26.32	-34.97	19.107	1500	-27.54	-58.24	8.486
500	-26.30	-37.14	16.234	1600	-27.70	-60.28	8.234
600	-26.33	-39.31	14.319	1700	-27.86	-62.32	8.012
700	-26.41	-41.47	12.948	1800	-28.03	-64.34	7.812
800	-26.51	-43.61	11.914	1900	-28.20	-66.35	7.632
900	-26.64	-45.74	11.107	2000	-28.37	-68.35	7.469

$C(s) + O_2(g) = CO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-93.96	-93.96	∞	1000	-94.32	-94.63	20.681
100	-93.98	-94.09	205.633	1100	-94.37	-94.66	18.807
200	-94.02	-94.19	102.926	1200	-94.42	-94.68	17.244
298.15	-94.05	-94.26	69.094	1300	-94.47	-94.70	15.921
300	-94.05	-94.26	68.668	1400	-94.51	-94.71	14.785
400	-94.07	-94.33	51.540	1500	-94.56	-94.73	13.802
500	-94.09	-94.40	41.262	1600	-94.60	-94.74	12.941
600	-94.12	-94.46	34.407	1700	-94.65	-94.74	12.180
700	-94.17	-94.51	29.507	1800	-94.69	-94.75	11.504
800	-94.22	-94.55	25.830	1900	-94.74	-94.75	10.899
900	-94.27	-94.59	22.970	2000	-94.79	-94.75	10.354

$Ca(s,l) + 1/2O_2(g) = CaO(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-151.79	-144.26	105.745	1112	-151.67	-124.23	24.416
300	-151.79	-144.21	105.057	1112	-153.71	-124.23	24.416
400	-151.69	-141.69	77.416	1200	-153.55	-121.90	22.201
500	-151.56	-139.21	60.849	1300	-153.36	-119.27	20.051
600	-151.43	-136.75	49.811	1400	-153.17	-116.65	18.210
700	-151.33	-134.32	41.937	1500	-152.97	-114.06	16.619
720	-151.32	-133.83	40.623	1600	-152.75	-111.47	15.226
720	-151.54	-133.83	40.623	1700	-152.53	-108.89	13.999
800	-151.45	-131.87	36.025	1800	-152.31	-106.33	12.910
900	-151.43	-129.43	31.430	1900	-152.07	-103.78	11.937
1000	-151.49	-126.98	27.751	2000	-151.83	-101.24	11.063
1100	-151.65	-124.52	24.740				

Phase changes: 720 K, α - β transition point of Ca; ΔH° = 0.22 kcal/mole.
1112 K, melting point of Ca; ΔH° = 2.04 kcal/mole.

$Ca(s,l) + 1/2S_2(g) = CaS(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-130.64	-123.60	90.601	1112	-130.60	-104.95	20.627
300	-130.64	-123.55	90.006	1112	-132.64	-104.95	20.627
400	-130.49	-121.21	66.226	1200	-132.47	-102.77	18.717
500	-130.36	-118.91	51.976	1300	-132.27	-100.30	16.862
600	-130.25	-116.63	42.482	1400	-132.05	-97.85	15.275
700	-130.19	-114.37	35.708	1500	-131.80	-95.42	13.903
720	-130.18	-113.91	34.576	1600	-131.54	-93.00	12.703
720	-130.40	-113.91	34.576	1700	-131.26	-90.59	11.646
800	-130.34	-112.08	30.619	1800	-130.96	-88.21	10.710
900	-130.33	-109.81	26.666	1900	-130.64	-85.84	9.874
1000	-130.41	-107.52	23.498	2000	-130.30	-83.49	9.123
1100	-130.57	-105.22	20.905				

Phase changes: 720 K, α - β transition point of Ca; ΔH° = 0.22 kcal/mole.
1112 K, melting point of Ca; ΔH° = 2.04 kcal/mole.

$2Ca(s,l) + Si(s,l) + 2O_2(g) = Ca_2SiO_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-554.00	-526.14	385.671	1121	-556.86	-450.12	87.755
300	-554.00	-525.96	383.161	1121	-553.42	-450.12	87.755
400	-553.95	-516.62	282.268	1200	-552.85	-442.87	80.658
500	-553.74	-507.31	221.745	1300	-552.06	-433.74	72.918
600	-553.48	-498.04	181.411	1400	-551.16	-424.66	66.292
700	-553.21	-488.84	152.623	1500	-550.17	-415.68	60.565
720	-553.15	-486.99	147.822	1600	-549.06	-406.76	55.561
720	-553.59	-486.99	147.822	1687	-548.02	-399.00	51.690
800	-553.30	-479.60	131.021	1687	-560.10	-399.00	51.690
900	-553.03	-470.42	114.234	1700	-559.93	-397.76	51.136
1000	-552.87	-461.23	100.802	1712	-559.76	-396.62	50.632
1100	-552.83	-452.07	89.818	1712	-556.37	-396.62	50.632
1112	-552.84	-450.99	88.636	1800	-555.41	-388.43	47.162
1112	-556.92	-450.99	88.636				

Phase changes: 720 K, α - β transition point of Ca; ΔH° = 0.22 kcal/mole.
1112 K, melting point of Ca; ΔH° = 2.04 kcal/mole.
1121 K, γ - α' transition point of Ca_2SiO_4; ΔH° = 3.44 kcal/mole.
1687 K, melting point of Si; ΔH° = 12.082 kcal/mole.
1712 K, α' - α transition point of Ca_2SiO_4; ΔH° = 3.39 kcal/mole.

$2Fe(s,l) + 3Cl_2(g) = Fe_2Cl_6(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-157.44	-157.44	∞	1185	-158.07	-105.36	19.432
100	-157.67	-152.57	333.441	1200	-158.06	-104.69	19.067
200	-157.07	-147.69	161.388	1300	-158.05	-100.24	16.852
298.15	-156.50	-143.22	104.983	1400	-158.08	-95.80	14.955
300	-156.49	-143.13	104.270	1500	-158.16	-91.34	13.308
400	-156.03	-138.75	75.809	1600	-158.28	-86.88	11.867
500	-155.68	-134.48	58.781	1667	-158.39	-83.89	10.998
600	-155.46	-130.26	47.447	1667	-158.79	-83.89	10.998
700	-155.36	-126.07	39.361	1700	-158.90	-82.41	10.595
800	-155.42	-121.88	33.296	1800	-159.27	-77.90	9.458
900	-155.67	-117.68	28.577	1811	-159.32	-77.41	9.342
1000	-156.27	-113.43	24.790	1811	-165.92	-77.41	9.342
1043	-156.82	-111.58	23.380	1900	-166.43	-73.04	8.402
1100	-157.27	-109.09	21.674	2000	-167.01	-68.11	7.443
1185	-157.64	-105.36	19.432				

Phase changes:
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, α - γ transition point of Fe; ΔH° = 0.215 kcal/mole.
1667 K, γ - δ transition point of Fe; ΔH° = 0.200 kcal/mole.
1811 K, melting point of Fe; ΔH° = 3.30 kcal/mole.

$0.947Fe(s) + 1/2O_2(g) = Fe_{.947}O(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-63.85	-63.85	∞	1185	-63.30	-44.81	8.264
100	-64.09	-62.18	135.894	1185	-63.50	-44.81	8.264
200	-63.87	-60.30	65.893	1200	-63.47	-44.57	8.117
298.15	-63.64	-58.59	42.948	1300	-63.27	-43.02	7.232
300	-63.64	-58.56	42.661	1400	-63.07	-41.46	6.472
400	-63.40	-56.90	31.089	1500	-62.85	-39.93	5.818
500	-63.18	-55.31	24.176	1600	-62.64	-38.41	5.247
600	-62.99	-53.74	19.575	1652	-62.54	-37.61	4.976
700	-62.85	-52.21	16.301	1652	-55.05	-37.61	4.976
800	-62.77	-50.71	13.853	1667	-55.00	-37.45	4.910
900	-62.77	-49.20	11.947	1667	-55.19	-37.45	4.910
1000	-62.93	-47.68	10.420	1700	-55.11	-37.11	4.771
1043	-63.13	-47.02	9.853	1800	-54.88	-36.06	4.378
1100	-63.26	-46.14	9.167				

Phase changes:
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, α - γ transition point of Fe; ΔH° = 0.215 kcal/mole.
1652 K, melting point of $Fe_{.947}O$; ΔH° = 7.49 kcal/mole.
1667 K, γ - δ transition point of Fe; ΔH° = 0.200 kcal/mole.

$2Fe(s) + 3/2O_2(g) = Fe_2O_3(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-195.46	-195.46	∞	1043	-193.10	-131.55	27.565
100	-196.45	-190.30	415.900	1100	-193.28	-128.19	25.469
200	-197.02	-183.88	200.935	1185	-193.23	-123.15	22.713
298.15	-197.00	-177.42	130.052	1185	-193.66	-123.15	22.713
300	-196.99	-177.30	129.163	1200	-193.59	-122.26	22.267
400	-196.60	-170.79	93.315	1300	-193.11	-116.33	19.557
500	-196.03	-164.41	71.864	1400	-192.68	-110.44	17.240
600	-195.39	-158.14	57.602	1500	-192.31	-104.58	15.237
700	-194.72	-151.98	47.450	1600	-191.98	-98.75	13.489
800	-194.02	-145.93	39.866	1667	-191.79	-94.85	12.435
900	-193.25	-139.96	33.987	1667	-192.19	-94.85	12.435
960	-192.63	-136.42	31.057	1700	-192.16	-92.92	11.946
1000	-192.76	-134.08	29.303	1800	-192.09	-87.08	10.573

Phase changes:
960 K, Curie temperature of Fe_2O_3; ΔH° = 0 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, $\alpha - \gamma$ transition point of Fe; ΔH° = 0.215 kcal/mole.
1667 K, $\gamma - \delta$ transition point of Fe; ΔH° = 0.200 kcal/mole.

$3Fe(s) + 2O_2(g) = Fe_3O_4(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-266.34	-266.34	∞	1043	-261.33	-186.71	39.123
100	-267.59	-259.52	567.180	1100	-261.64	-182.62	36.283
200	-267.95	-251.31	274.619	1185	-261.65	-176.51	32.554
298.15	-267.80	-243.16	178.241	1185	-262.29	-176.51	32.554
300	-267.79	-243.01	177.033	1200	-262.19	-175.43	31.950
400	-267.19	-234.83	128.305	1300	-261.57	-168.22	28.280
500	-266.32	-226.84	99.152	1400	-261.03	-161.07	25.144
600	-265.32	-219.03	79.782	1500	-260.58	-153.94	22.429
700	-264.01	-211.41	66.005	1600	-260.21	-146.84	20.057
800	-262.31	-204.01	55.733	1667	-260.00	-142.10	18.630
870	-260.59	-198.98	49.985	1667	-260.60	-142.10	18.630
900	-260.54	-196.85	47.802	1700	-260.60	-139.76	17.967
1000	-260.78	-189.77	41.474	1800	-260.62	-132.65	16.106

Phase changes:
870 K, Curie temperature of Fe_3O_4; ΔH° = 0 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, $\alpha - \gamma$ transition point of Fe; ΔH° = 0.215 kcal/mole.
1667 K, $\gamma - \delta$ transition point of Fe; ΔH° = 0.200 kcal/mole.

$Fe(s,l) + 1/2S_2(g) = FeS(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-39.24	-39.24	∞	1185	-37.07	-20.20	3.725
100	-39.42	-37.36	81.650	1185	-37.28	-20.20	3.725
200	-39.33	-35.31	38.585	1200	-37.25	-19.99	3.641
298.15	-39.15	-33.38	24.468	1300	-37.00	-18.56	3.120
300	-39.15	-33.34	24.288	1400	-36.72	-17.15	2.677
400	-38.74	-31.46	17.189	1470	-36.51	-16.18	2.406
411	-38.67	-31.26	16.623	1470	-28.78	-16.18	2.406
411	-38.10	-31.26	16.623	1500	-28.66	-15.92	2.320
500	-37.53	-29.83	13.039	1600	-28.29	-15.09	2.061
598	-36.97	-28.38	10.372	1667	-28.06	-14.54	1.906
598	-36.85	-28.38	10.372	1667	-28.26	-14.54	1.906
600	-36.84	-28.35	10.326	1700	-28.17	-14.27	1.835
700	-36.65	-26.95	8.414	1800	-27.93	-13.46	1.634
800	-36.55	-25.57	6.985	1811	-27.90	-13.37	1.613
900	-36.55	-24.20	5.877	1811	-31.20	-13.37	1.613
1000	-36.71	-22.82	4.987	1900	-31.07	-12.50	1.438
1043	-36.92	-22.22	4.656	2000	-30.93	-11.53	1.260
1100	-37.05	-21.41	4.254				

Phase changes:
411 K, α - β transition point of FeS; ΔH° = 0.57 kcal/mole.
598 K, β - γ transition point of FeS; ΔH° = 0.12 kcal/mole.
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, α - γ transition point of Fe; ΔH° = 0.215 kcal/mole.
1470 K, melting point of FeS; ΔH° = 7.73 kcal/mole.
1667 K, γ - δ transition point of Fe; ΔH° = 0.200 kcal/mole.
1811 K, melting point of Fe; ΔH° = 3.30 kcal/mole.

$2Fe(s) + Si(s,l) + 2O_2(g) = Fe_2SiO_4(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
298.15	-353.70	-329.60	241.603	1200	-352.56	-258.83	47.139
300	-353.70	-329.45	240.004	1300	-351.80	-251.05	42.205
400	-353.48	-321.39	175.599	1400	-350.98	-243.32	37.984
500	-353.10	-313.41	136.991	1492	-350.20	-236.29	34.612
600	-352.68	-305.51	111.282	1492	-328.17	-236.29	34.612
700	-352.29	-297.68	92.940	1500	-328.02	-235.79	34.355
800	-351.98	-289.90	79.197	1600	-326.47	-229.69	31.374
900	-351.83	-282.15	68.515	1667	-325.45	-225.64	29.582
1000	-351.96	-274.40	59.970	1667	-325.85	-225.64	29.582
1043	-352.29	-271.06	56.798	1687	-325.59	-224.44	29.076
1100	-352.42	-266.62	52.972	1687	-337.67	-224.44	29.076
1185	-352.24	-260.00	47.952	1700	-337.49	-223.57	28.742
1185	-352.67	-260.00	47.952	1800	-336.14	-216.90	26.335

Phase changes:
1043 K, Curie temperature of Fe; ΔH° = 0 kcal/mole.
1185 K, $\alpha - \gamma$ transition point of Fe; ΔH° = 0.215 kcal/mole.
1492 K, melting point of Fe_2SiO_4; ΔH° = 22.03 kcal/mole.
1667 K, $\gamma - \delta$ transition point of Fe; ΔH° = 0.200 kcal/mole.
1687 K, melting point of Si; ΔH° = 12.082 kcal/mole.

$1/2H_2(g) + 1/2Br_2(l,g) = HBr(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-6.83	-6.83	∞	900	-12.85	-14.35	3.485
100	-6.85	-8.97	19.604	1000	-12.90	-14.51	3.171
200	-7.04	-11.04	12.064	1100	-12.93	-14.67	2.915
298.15	-8.70	-12.78	9.368	1200	-12.96	-14.83	2.701
300	-8.71	-12.80	9.325	1300	-12.98	-14.98	2.518
332.6	-8.89	-13.24	8.700	1400	-12.99	-15.14	2.363
332.6	-12.42	-13.24	8.700	1500	-13.00	-15.29	2.228
400	-12.48	-13.40	7.321	1600	-13.01	-15.44	2.109
500	-12.57	-13.61	5.949	1700	-13.02	-15.59	2.004
600	-12.66	-13.81	5.030	1800	-13.03	-15.74	1.911
700	-12.73	-14.00	4.371	1900	-13.03	-15.89	1.828
800	-12.80	-14.18	3.874	2000	-13.04	-16.05	1.754

Phase change:
332.6 K, boiling point of Br_2; ΔH° = 7.066 kcal/mole.

$1/2H_2(g) + 1/2Cl_2(g) = HCl(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-22.02	-22.02	∞	1000	-22.56	-24.09	5.265
100	-22.06	-22.29	48.715	1100	-22.61	-24.24	4.816
200	-22.03	-22.53	24.620	1200	-22.65	-24.39	4.442
298.15	-22.06	-22.78	16.698	1300	-22.69	-24.53	4.124
300	-22.06	-22.78	16.595	1400	-22.72	-24.67	3.851
400	-22.13	-23.01	12.572	1500	-22.74	-24.81	3.615
500	-22.21	-23.22	10.149	1600	-22.77	-24.95	3.408
600	-22.29	-23.42	8.531	1700	-22.79	-25.08	3.224
700	-22.37	-23.60	7.368	1800	-22.81	-25.22	3.062
800	-22.44	-23.77	6.494	1900	-22.83	-25.35	2.916
900	-22.50	-23.94	5.813	2000	-22.84	-25.49	2.785

$1/2H_2(g) + 1/2F_2(g) = HF(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-64.79	-64.79	∞	1000	-65.29	-66.20	14.468
100	-64.84	-64.98	142.014	1100	-65.37	-66.29	13.171
200	-64.79	-65.13	71.171	1200	-65.45	-66.37	12.088
298.15	-64.80	-65.30	47.866	1300	-65.53	-66.44	11.170
300	-64.80	-65.30	47.571	1400	-65.61	-66.51	10.383
400	-64.84	-65.47	35.771	1500	-65.68	-66.57	9.699
500	-64.89	-65.62	28.682	1600	-65.75	-66.63	9.101
600	-64.96	-65.76	23.953	1700	-65.82	-66.68	8.572
700	-65.04	-65.89	20.572	1800	-65.88	-66.73	8.102
800	-65.12	-66.00	18.030	1900	-65.95	-66.78	7.681
900	-65.20	-66.11	16.054	2000	-66.01	-66.82	7.302

$H_2(g) + 1/2O_2(g) = H_2O(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-57.10	-57.10	∞	1000	-59.24	-46.04	10.062
100	-57.42	-56.55	123.590	1100	-59.39	-44.71	8.883
200	-57.58	-55.63	60.790	1200	-59.52	-43.37	7.899
298.15	-57.80	-54.63	40.045	1300	-59.63	-42.02	7.064
300	-57.80	-54.61	39.783	1400	-59.73	-40.66	6.347
400	-58.04	-53.52	29.242	1500	-59.82	-39.29	5.725
500	-58.28	-52.36	22.887	1600	-59.90	-37.92	5.180
600	-58.50	-51.15	18.631	1700	-59.97	-36.55	4.699
700	-58.71	-49.91	15.583	1800	-60.04	-35.17	4.270
800	-58.90	-48.64	13.288	1900	-60.10	-33.78	3.886
900	-59.08	-47.35	11.498	2000	-60.15	-32.40	3.541

$H_2(g) + 1/2S_2(g) = H_2S(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-19.56	-19.56	∞	1000	-21.51	-9.81	2.144
100	-19.87	-19.13	41.809	1100	-21.57	-8.64	1.717
200	-20.03	-18.35	20.052	1200	-21.61	-7.46	1.359
298.15	-20.27	-17.49	12.821	1300	-21.62	-6.28	1.056
300	-20.28	-17.48	12.734	1400	-21.63	-5.10	.796
400	-20.53	-16.50	9.015	1500	-21.62	-3.92	.571
500	-20.78	-15.47	6.762	1600	-21.61	-2.74	.374
600	-20.99	-14.39	5.242	1700	-21.58	-1.56	.201
700	-21.17	-13.27	4.143	1800	-21.56	-.38	.046
800	-21.32	-12.13	3.314	1900	-21.53	.79	-.091
900	-21.43	-10.98	2.666	2000	-21.49	1.97	-.215

$2S(s,l) = S_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	30.65	30.65	∞	388.36	30.18	15.49	-8.717
100	31.01	26.94	-58.877	388.36	29.36	15.49	-8.717
200	30.88	22.83	-24.947	400	29.27	15.07	-8.234
298.15	30.68	18.98	-13.913	500	28.23	11.65	-5.092
300	30.67	18.91	-13.776	600	27.36	8.41	-3.063
368.54	30.45	16.24	-9.631	700	26.62	5.32	-1.661
368.54	30.25	16.24	-9.631	717.8	26.50	4.78	-1.455

Phase changes: 368.54 K, rhombic-monoclinic transition point of S; ΔH° = 0.096 kcal/mole
388.36 K, melting point of S; ΔH° = 0.41 kcal/mole.
717.8 K, boiling point of S.

$1/2S_2(g) + O_2(g) = SO_2(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-85.66	-85.66	∞	1000	-86.47	-68.99	15.078
100	-85.91	-84.43	184.522	1100	-86.44	-67.24	13.359
200	-86.12	-82.86	90.545	1200	-86.41	-65.50	11.929
298.15	-86.28	-81.23	59.543	1300	-86.37	-63.76	10.719
300	-86.29	-81.20	59.154	1400	-86.33	-62.02	9.682
400	-86.40	-79.48	43.426	1500	-86.29	-60.29	8.784
500	-86.47	-77.74	33.980	1600	-86.25	-58.55	7.998
600	-86.50	-75.99	27.679	1700	-86.20	-56.82	7.305
700	-86.51	-74.24	23.179	1800	-86.16	-55.09	6.689
800	-86.51	-72.49	19.803	1900	-86.13	-53.37	6.139
900	-86.49	-70.74	17.178	2000	-86.09	-51.65	5.644

$1/2S_2(g) + 3/2O_2(g) = SO_3(g)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-108.53	-108.53	∞	1000	-109.80	-70.17	15.336
100	-109.12	-105.66	230.920	1100	-109.67	-66.21	13.155
200	-109.62	-101.98	111.439	1200	-109.54	-62.27	11.341
298.15	-109.92	-98.17	71.961	1300	-109.39	-58.34	9.808
300	-109.92	-98.10	71.466	1400	-109.25	-54.41	8.494
400	-110.09	-94.12	51.425	1500	-109.11	-50.50	7.358
500	-110.15	-90.12	39.391	1600	-108.96	-46.60	6.365
600	-110.15	-86.12	31.369	1700	-108.81	-42.71	5.491
700	-110.10	-82.11	25.636	1800	-108.67	-38.82	4.713
800	-110.02	-78.12	21.341	1900	-108.53	-34.94	4.019
900	-109.92	-74.14	18.004	2000	-108.40	-31.08	3.396

$Si(s,l) + O_2(g) = SiO_2(s)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-216.56	-216.56	∞	1000	-216.42	-174.59	38.157
100	-217.17	-213.17	465.883	1100	-216.23	-170.43	33.861
200	-217.55	-209.00	228.385	1200	-216.04	-166.27	30.282
298.15	-217.75	-204.75	150.086	1300	-215.84	-162.13	27.257
300	-217.75	-204.67	149.102	1400	-215.63	-158.01	24.666
400	-217.79	-200.30	109.439	1500	-215.41	-153.91	22.425
500	-217.71	-195.94	85.645	1600	-215.17	-149.82	20.464
600	-217.56	-191.60	69.790	1687	-214.96	-146.25	18.947
700	-217.33	-187.29	58.475	1687	-227.04	-146.25	18.947
800	-217.04	-183.01	49.996	1700	-227.00	-145.62	18.721
847	-216.86	-181.02	46.708	1800	-226.67	-140.84	17.100
847	-216.69	-181.02	46.708	1900	-226.32	-136.08	15.653
900	-216.60	-178.79	43.416	2000	-225.95	-131.35	14.353

Phase changes: 847 K, α - β transition point of SiO_2; ΔH° = 0.174 kcal/mole.
1687 K, melting point of Si; ΔH° = 12.082 kcal/mole.

$W(s) + 3/2O_2(g) = WO_3(s,l)$

T, K	Kcal ΔH°	Kcal ΔG°	Log K	T, K	Kcal ΔH°	Kcal ΔG°	Log K
0	-200.11	-200.11	∞	1050	-197.87	-137.04	28.524
100	-201.01	-195.03	426.238	1100	-197.64	-134.15	26.653
200	-201.44	-188.83	206.344	1200	-197.19	-128.41	23.387
298.15	-201.46	-182.63	133.871	1300	-196.71	-122.69	20.626
300	-201.46	-182.51	132.958	1400	-196.24	-117.01	18.266
400	-201.27	-176.22	96.282	1500	-195.75	-111.37	16.227
500	-200.91	-170.00	74.307	1600	-195.25	-105.76	14.446
600	-200.47	-163.86	59.686	1700	-194.74	-100.18	12.879
700	-199.99	-157.79	49.264	1745	-194.51	-97.67	12.233
800	-199.51	-151.80	41.470	1745	-176.96	-97.67	12.233
900	-199.04	-145.85	35.417	1800	-176.36	-95.20	11.559
1000	-198.55	-139.97	30.590	1900	-175.27	-90.71	10.434
1050	-198.28	-137.04	28.524	2000	-174.20	-86.31	9.432

Phase changes: 1050 K, α - β transition point of WO_3; ΔH° = 0.41 kcal/mole.
1745 K, melting point of WO_3; ΔH° = 17.55 kcal/mole.

CHAPTER 4.—ALGEBRAIC REPRESENTATION OF HIGH-TEMPERATURE DATA

The tabular values of the relative enthalpy of nickel and its compounds given in this volume can be represented by algebraic equations in the form recommended by Maier and Kelley (*108*):

$$H^\circ - H^\circ_{298.15} = aT + bT^2 + cT^{-1} + d. \tag{1}$$

The constants, a, b, c, and d, together with the temperature ranges of validity, are given in the following table. These constants may also be used in heat capacity and relative entropy equations, as follows:

$$Cp = a + 2bT - cT^{-2}, \tag{2}$$

and

$$S^\circ - S^\circ_{298.15} = a \ln \frac{T}{298.15} + 2b\,(T - 298.15) + \frac{c}{2}\left[\frac{1}{T^2} - \frac{1}{(298.15)^2}\right]. \tag{3}$$

Constants in Enthalpy Equations of Nickel Compounds

$H^\circ - H^\circ_{298} = aT + bT^2 + cT^{-1} + d$ (kcal/mole)

Substance	Range, K	a x 10^3	b x 10^6	c x 10^{-2}	d
Ni(α)	298.15-631	2.996	4.280	-.590	-1.076
(β)	631-750	11.320	-2.745	0	-3.625
(β)	750-1728	5.071	1.157	-3.136	-.715
(l)	1728-2000	9.300	0	0	-.649
Ni(g)	298.15-2000	6.196	-.136	.473	-1.994
Ni^+(g)	298.15-2000	5.625	0	.700	-1.912
Ni^{++}(g)	298.15-2000	5.890	0	.700	-1.991
$NiAl_2Cl_8$(g)	298.15-1000	59.699	1.221	5.743	-19.834
NiBr(g)	298.15-2000	9.439	.101	.759	-3.078
$NiBr_2$(s)	298.15-1000	19.212	.393	1.592	-6.297
$NiBr_2$(g)	298.15-2000	16.150	0	.930	-5.127
$Ni(CO)_4$(g)	298.15-1000	37.436	4.119	3.743	-12.783
NiCl(g)	298.15-2000	9.393	.101	.895	-3.110
$NiCl_2$(s)	298.15-1304	17.492	1.568	1.151	-5.741
(l)	1304-1400	23.900	0	0	7.124
$NiCl_2$(g)	298.15-2000	16.321	-.116	1.569	-5.382
NiD(g)	298.15-2000	7.377	.526	.542	-2.428
NiF(g)	298.15-2000	9.106	.201	1.272	-3.159
NiF_2(s)	298.15-1600	15.917	1.666	1.423	-5.371
NiF_2(g)	298.15-2000	15.370	.124	2.568	-5.455
$NiFe_2Cl_8$(g)	298.15-1000	61.047	.583	4.120	-19.635
$NiFe_2O_4$(α)	298.15-880	29.936	15.568	3.917	-11.623
(β)	880-1800	48.500	0	0	-15.458
NiH(g)	298.15-2000	6.720	.658	.113	-2.100
NiI(g)	298.15-2000	9.440	.102	.664	-3.046
Ni_2Mg(α)	298.15-467	17.635	2.098	1.185	-5.842
(β)	467-550	16.422	2.760	0	-5.166

Constants in Enthalpy Equations of Nickel Compounds - Continued

$H^\circ - H^\circ_{298} = aT + bT^2 + cT^{-1} + d$ (kcal/mole)

Substance	Range, K	a x 10^3	b x 10^6	c x 10^{-2}	d
NiO(α)	298.15-525	-6.585	20.201	-4.561	1.697
(β)	525-565	-9.014	21.000	0	1.883
(γ)	565-2000	9.540	1.478	-5.231	-1.442
NiO(g)	298.15-2000	9.685	.113	1.478	-3.393
$Ni(OH)_2$(g)	298.15-2000	18.198	1.894	4.514	-7.108
NiS(α)	298.15-623	10.458	2.653	.694	-3.587
(β)	623-1066.5	9.052	3.689	.034	-2.307
(l)	1066.5-1800	17.000	0	0	.416
Ni_3S_2(α)	298.15-840	24.380	8.015	.923	-8.291
(β)	840-1064	51.780	-3.499	-.531	-9.647
(l)	1064-1800	45.200	0	0	-1.960
$NiSO_4$(s)	298.15-1200	24.426	4.393	6.855	-11.165
$NiSe_{1.05}$(s)	298.15-1050	10.465	3.024	-.330	-3.278
$NiSe_{1.14}$(α)	298.15-503	-3.215	18.252	-4.855	.964
(β)	503-1050	11.945	2.603	0	-3.667
$NiSe_{1.25}$(α)	298.15-589	2.828	11.695	-3.367	-.753
(β)	589-995	11.097	3.820	0	-3.463
(γ)	995-1050	23.353	-2.182	0	-9.716
NiSi(s)	298.15-1265	12.804	.451	2.112	-4.566
(l)	1265-1500	19.100	0	0	-1.122
$Ni_{1.04}Si_{1.93}$(s)	298.15-1245	16.985	1.772	2.127	-5.935
Ni_2Si(α)	298.15-1490	12.890	4.352	-1.323	-3.786
(β)	1490-1560	26.200	0	0	-12.261
(l)	1560-1800	27.700	0	0	-4.003
Ni_2SiO_4(s)	298.15-1800	41.419	3.305	11.487	-16.496
Ni_4W(s)	298.15-1100	26.520	4.831	0	-8.336
$NiWO_4$(s)	298.15-1100	26.480	6.386	1.157	-8.851

CHAPTER 5.—ENTHALPY OF FORMATION AND GIBBS ENERGY OF FORMATION EQUATIONS

Enthalpies and Gibbs energies of formation can be represented analytically by means of the equations

$$\Delta Hf^\circ = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1} \quad (4)$$

and

$$\Delta Gf^\circ = \Delta H_0 - \Delta aTlnT - \Delta bT^2 + 1/2\Delta cT^{-1} + IT. \quad (5)$$

The constants Δa, Δb, and Δc given for the substances in the following two tables were derived from the a, b, and c constants of the relative enthalpy equations for each compound and its constituent elements. The constants ΔH_0 and I were obtained by substituting the values of $\Delta Hf^\circ_{298.15}$ and $\Delta Gf^\circ_{298.15}$ for each compound into equations 4 and 5, respectively. The constants thus calculated for nickel compounds are listed in the first table, and those for auxiliary compounds are listed in the second table. A separate equation is given whenever a transition occurs in either the constituent elements or in the compound formed.

Constants in Enthalpy of Formation and Gibbs Energy of Formation Equations, Nickel Compounds

$\Delta Hf° = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1}$ (kcal/mole)
$\Delta Gf° = \Delta H_0 - \Delta aTlnT - \Delta bT^2 + 1/2\Delta cT^{-1} + IT$ (kcal/mole)

Formation reaction	Range, K	ΔH_0	$\Delta ax10^3$	$\Delta bx10^6$	$\Delta cx10^{-2}$	$Ix10^3$
$Ni(\alpha) = Ni(g)$	298.15-631	101.882	3.200	-4.416	1.063	-16.981
$Ni(\beta) = Ni(g)$	631-700	104.430	-5.124	2.609	.473	-70.180
$Ni(\beta) = Ni(g)$	700-1728	101.519	1.125	-1.293	3.609	-28.136
$Ni(l) = Ni(g)$	1728-2000	101.453	-3.104	-.136	.473	-57.572
$Ni(\alpha) - e^-(g) = Ni^+(g)$	298.15-631	277.883	7.597	-4.280	1.290	9.508
$Ni(\beta) - e^-(g) = Ni^+(g)$	631-700	280.432	-.727	2.745	.700	-43.693
$Ni(\beta) - e^-(g) = Ni^+(g)$	700-1728	277.522	5.522	-1.157	3.836	-1.648
$Ni(l) - e^-(g) = Ni^+(g)$	1728-2000	277.456	1.293	0	.700	-31.084
$Ni(\alpha) - 2e^-(g) = Ni^{++}(g)$	298.15-631	696.723	12.830	-4.280	1.290	38.754
$Ni(\beta) - 2e^-(g) = Ni^{++}(g)$	631-700	699.272	4.506	2.745	.700	-14.447
$Ni(\beta) - 2e^-(g) = Ni^{++}(g)$	700-1728	696.361	10.755	-1.157	3.836	27.598
$Ni(l) - 2e^-(g) = Ni^{++}(g)$	1728-2000	696.296	6.526	0	.700	-1.838
$Ni(\alpha) + 2Al(s) + 4Cl_2(g) = NiAl_2Cl_8(g)$	298.15-631	-373.471	12.473	-7.067	4.117	169.476
$Ni(\beta) + 2Al(s) + 4Cl_2(g) = NiAl_2Cl_8(g)$	631-700	-370.922	4.149	-.042	3.527	116.276
$Ni(\beta) + 2Al(s) + 4Cl_2(g) = NiAl_2Cl_8(g)$	700-933.5	-373.832	10.398	-3.944	6.663	158.319
$Ni(\beta) + 2Al(l) + 4Cl_2(g) = NiAl_2Cl_8(g)$	933.5-1000	-376.131	3.972	-.236	5.785	120.346
$Ni(\alpha) + 1/2Br_2(l) = NiBr(g)$	298.15-332.6	44.399	-.747	-7.069	1.349	-45.837
$Ni(\alpha) + 1/2Br_2(g) = NiBr(g)$	332.6-631	39.711	1.968	-4.204	1.164	-14.939
$Ni(\beta) + 1/2Br_2(g) = NiBr(g)$	631-700	42.259	-6.356	2.821	.574	-68.139
$Ni(\beta) + 1/2Br_2(g) = NiBr(g)$	700-1728	39.349	-.107	-1.081	3.710	-26.096
$Ni(l) + 1/2Br_2(g) = NiBr(g)$	1728-2000	39.283	-4.336	.076	.574	-55.532
$Ni(\alpha) + Br_2(l) = NiBr_2(s)$	298.15-332.6	-51.920	1.836	-9.667	2.182	22.383
$Ni(\alpha) + Br_2(g) = NiBr_2(s)$	332.6-631	-61.315	7.266	-3.937	1.812	84.235
$Ni(\beta) + Br_2(g) = NiBr_2(s)$	631-700	-58.767	-1.058	3.088	1.222	31.037
$Ni(\beta) + Br_2(g) = NiBr_2(s)$	700-1000	-61.677	5.191	-.814	4.358	73.081
$Ni(\alpha) + Br_2(l) = NiBr_2(g)$	298.15-332.6	3.550	-1.226	-10.060	1.520	-46.530
$Ni(\alpha) + Br_2(g) = NiBr_2(g)$	332.6-631	-5.846	4.204	-4.330	1.150	15.324
$Ni(\beta) + Br_2(g) = NiBr_2(g)$	631-700	-3.297	-4.120	2.695	.560	-37.876
$Ni(\beta) + Br_2(g) = NiBr_2(g)$	700-1728	-6.207	2.129	-1.207	3.696	4.168
$Ni(l) + Br_2(g) = NiBr_2(g)$	1728-2000	-6.272	-2.100	-.050	.560	-25.268

Constants in Enthalpy of Formation and Gibbs Energy of Formation Equations, Nickel Compounds - Continued

$\Delta Hf^\circ = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1}$ (kcal/mole)
$\Delta Gf^\circ = \Delta H_0 - \Delta aTlnT - \Delta bT^2 + 1/2\Delta cT^{-1} + IT$ (kcal/mole)

Formation reaction	Range, K	ΔH_0	$\Delta ax10^3$	$\Delta bx10^6$	$\Delta cx10^{-2}$	$Ix10^3$
$Ni(\alpha) + 4C(s) + 2O_2(g) = Ni(CO)_4(g)$	298.15-631	-139.811	10.132	-7.585	-2.491	73.219
$Ni(\beta) + 4C(s) + 2O_2(g) = Ni(CO)_4(g)$	631-750	-137.263	1.808	-.560	-3.081	20.019
$Ni(\beta) + 4C(s) + 2O_2(g) = Ni(CO)_4(g)$	750-1000	-140.173	8.057	-4.462	.055	62.063
$Ni(\alpha) + 1/2Cl_2(g) = NiCl(g)$	298.15-631	42.405	1.972	-4.219	1.140	-14.942
$Ni(\beta) + 1/2Cl_2(g) = NiCl(g)$	631-700	44.954	-6.352	2.806	.550	-68.142
$Ni(\beta) + 1/2Cl_2(g) = NiCl(g)$	700-1728	42.044	-.103	-1.096	3.686	-26.097
$Ni(l) + 1/2Cl_2(g) = NiCl(g)$	1728-2000	41.979	-4.332	.061	.550	-55.534
$Ni(\alpha) + Cl_2(g) = NiCl_2(s)$	298.15-631	-74.768	5.646	-2.792	1.051	73.749
$Ni(\beta) + Cl_2(g) = NiCl_2(s)$	631-700	-72.219	-2.678	4.233	.461	20.548
$Ni(\beta) + Cl_2(g) = NiCl_2(s)$	700-1304	-75.130	3.571	.331	3.597	62.592
$Ni(\beta) + Cl_2(g) = NiCl_2(l)$	1304-1400	-62.262	9.979	-1.237	2.446	96.678
$Ni(\alpha) + Cl_2(g) = NiCl_2(g)$	298.15-631	-18.229	4.475	-4.476	1.469	17.259
$Ni(\beta) + Cl_2(g) = NiCl_2(g)$	631-700	-15.680	-3.849	2.549	.879	-35.940
$Ni(\beta) + Cl_2(g) = NiCl_2(g)$	700-1728	-18.591	2.400	-1.353	4.015	6.104
$Ni(l) + Cl_2(g) = NiCl_2(g)$	1728-2000	-18.656	-1.829	-.196	.879	-23.332
$Ni(\alpha) + 1/2D_2(g) = NiD(g)$	298.15-631	93.563	1.241	-4.064	1.277	-20.625
$Ni(\beta) + 1/2D_2(g) = NiD(g)$	631-700	96.112	-7.083	2.961	.687	-73.825
$Ni(\beta) + 1/2D_2(g) = NiD(g)$	700-1728	93.202	-.834	-.941	3.823	-31.781
$Ni(l) + 1/2D_2(g) = NiD(g)$	1728-2000	93.136	-5.063	.216	.687	-61.217
$Ni(\alpha) + 1/2F_2(g) = NiF(g)$	298.15-631	24.479	1.745	-4.154	1.102	-16.056
$Ni(\beta) + 1/2F_2(g) = NiF(g)$	631-700	27.028	-6.579	2.871	.512	-69.256
$Ni(\beta) + 1/2F_2(g) = NiF(g)$	700-1728	24.118	-.330	-1.031	3.648	-27.213
$Ni(l) + 1/2F_2(g) = NiF(g)$	1728-2000	24.052	-4.559	.126	.512	-56.649
$Ni(\alpha) + F_2(g) = NiF_2(s)$	298.15-631	-158.369	4.191	-2.764	.493	64.696
$Ni(\beta) + F_2(g) = NiF_2(s)$	631-700	-155.820	-4.133	4.261	-.097	11.497
$Ni(\beta) + F_2(g) = NiF_2(s)$	700-1600	-158.730	2.116	.359	3.039	53.541
$Ni(\alpha) + F_2(g) = NiF_2(g)$	298.15-631	-81.453	3.644	-4.306	1.638	13.147
$Ni(\beta) + F_2(g) = NiF_2(g)$	631-700	-78.905	-4.680	2.719	1.048	-40.053
$Ni(\beta) + F_2(g) = NiF_2(g)$	700-1728	-81.815	1.569	-1.183	4.184	1.991

Constants in Enthalpy of Formation and Gibbs Energy of Formation Equations, Nickel Compounds - Continued

$\Delta Hf° = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1}$ (kcal/mole)
$\Delta Gf° = \Delta H_0 - \Delta aTlnT - \Delta bT^2 + 1/2\Delta cT^{-1} + IT$ (kcal/mole)

Formation reaction	Range, K	ΔH_0	$\Delta a \times 10^3$	$\Delta b \times 10^6$	$\Delta c \times 10^{-2}$	$I \times 10^3$
$Ni(l) + F_2(g) = NiF_2(g)$	1728-2000	-81.381	-2.660	-.026	1.048	-27.446
$Ni(\alpha) + 2Fe(\alpha) + 4Cl_2(g) = NiFe_2Cl_8(g)$	298.15-631	-222.612	23.071	-16.157	6.470	211.862
$Ni(\beta) + 2Fe(\alpha) + 4Cl_2(g) = NiFe_2Cl_8(g)$	631-700	-220.063	14.747	-9.132	5.880	158.662
$Ni(\beta) + 2Fe(\alpha) + 4Cl_2(g) = NiFe_2Cl_8(g)$	700-1000	-222.974	20.996	-13.034	9.016	200.706
$Ni(\alpha) + 2Fe(\alpha) + 2O_2(g) = NiFe_2O_4(\alpha)$	298.15-631	-260.852	11.900	-1.552	6.387	169.858
$Ni(\beta) + 2Fe(\alpha) + 2O_2(g) = NiFe_2O_4(\alpha)$	631-700	-258.303	3.576	5.473	5.797	116.658
$Ni(\beta) + 2Fe(\alpha) + 2O_2(g) = NiFe_2O_4(\alpha)$	700-880	-261.213	9.825	1.571	8.933	158.702
$Ni(\beta) + 2Fe(\alpha) + 2O_2(g) = NiFe_2O_4(\beta)$	880-1043	-265.048	28.389	-13.997	5.016	275.476
$Ni(\beta) + 2Fe(\alpha) + 2O_2(g) = NiFe_2O_4(\beta)$	1043-1185	-217.952	-59.551	27.423	.496	-337.440
$Ni(\beta) + 2Fe(\gamma) + 2O_2(g) = NiFe_2O_4(\beta)$	1185-1667	-264.914	16.949	-3.997	.496	206.386
$Ni(\beta) + 2Fe(\delta) + 2O_2(g) = NiFe_2O_4(\beta)$	1667-1728	-266.135	19.309	-5.117	.496	222.760
$Ni(l) + 2Fe(\delta) + 2O_2(g) = NiFe_2O_4(\beta)$	1728-1800	-266.201	15.080	-3.960	-2.640	193.324
$Ni(\alpha) + 1/2H_2(g) = NiH(g)$	298.15-631	93.945	.464	-3.817	.763	-26.316
$Ni(\beta) + 1/2H_2(g) = NiH(g)$	631-700	96.494	-7.860	3.208	.173	-79.516
$Ni(\beta) + 1/2H_2(g) = NiH(g)$	700-1728	93.584	-1.611	-.694	3.309	-34.473
$Ni(l) + 1/2H_2(g) = NiH(g)$	1728-2000	93.518	-5.840	.463	.173	-66.909
$Ni(\alpha) + 1/2I_2(s) = NiI(g)$	298.15-386.8	55.417	12.494	-18.928	4.594	31.435
$Ni(\alpha) + 1/2I_2(l) = NiI(g)$	386.8-458.4	58.287	-3.196	-4.178	1.254	-62.644
$Ni(\alpha) + 1/2I_2(g) = NiI(g)$	458.4-631	50.931	1.974	-4.213	1.164	-14.912
$Ni(\beta) + 1/2I_2(g) = NiI(g)$	631-700	53.480	-6.350	2.812	.574	-68.113
$Ni(\beta) + 1/2I_2(g) = NiI(g)$	700-1728	50.570	-.101	-1.090	3.710	-26.069
$Ni(l) + 1/2I_2(g) = NiI(g)$	1728-2000	50.504	-4.330	.067	.574	-55.505
$2Ni(\alpha) + Mg(s) = Ni_2Mg(\alpha)$	298.15-467	-15.227	6.500	-7.850	2.346	41.062
$2Ni(\alpha) + Mg(s) = Ni_2Mg(\beta)$	467-550	-14.551	5.287	-7.188	1.161	32.740
$Ni(\alpha) + 1/2O_2(g) = NiO(\alpha)$	298.15-525	-53.138	-13.446	15.746	-4.631	-60.709
$Ni(\alpha) + 1/2O_2(g) = NiO(\beta)$	525-565	-52.952	-15.875	16.545	-.070	-76.686
$Ni(\alpha) + 1/2O_2(g) = NiO(\gamma)$	565-631	-56.277	2.679	-2.977	-5.301	36.562
$Ni(\beta) + 1/2O_2(g) = NiO(\gamma)$	631-700	-53.728	-5.645	4.048	-5.891	-16.638
$Ni(\beta) + 1/2O_2(g) = NiO(\gamma)$	700-1728	-56.639	.604	.146	-2.755	25.407
$Ni(l) + 1/2O_2(g) = NiO(\gamma)$	1728-2000	-56.705	-3.625	1.303	-5.891	-4.029

Constants in Enthalpy of Formation and Gibbs Energy of Formation Equations, Nickel Compounds - Continued

$\Delta Hf° = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1}$ (kcal/mole)
$\Delta Gf° = \Delta H_0 - \Delta aT\ln T - \Delta bT^2 + 1/2\Delta cT^{-1} + IT$ (kcal/mole)

Formation reaction	Range, K	ΔH_0	$\Delta ax10^3$	$\Delta bx10^6$	$\Delta cx10^{-2}$	$Ix10^3$
$Ni(\alpha) + 1/2O_2(g) = NiO(g)$	298.15-631	73.072	2.824	-4.342	1.408	-8.900
$Ni(\beta) + 1/2O_2(g) = NiO(g)$	631-700	75.621	-5.500	2.683	.818	-62.099
$Ni(\beta) + 1/2O_2(g) = NiO(g)$	700-1728	72.712	.749	-1.219	3.945	-20.057
$Ni(l) + 1/2O_2(g) = NiO(g)$	1728-2000	72.646	-3.480	-.062	.818	-49.493
$Ni(\alpha) + O_2(g) + H_2(g) = Ni(OH)_2(g)$	298.15-631	-62.315	.952	-3.126	3.904	24.461
$Ni(\beta) + O_2(g) + H_2(g) = Ni(OH)_2(g)$	631-700	-59.766	-7.372	3.899	3.314	-28.739
$Ni(\beta) + O_2(g) + H_2(g) = Ni(OH)_2(g)$	700-1728	-62.676	-1.123	-.003	6.450	13.304
$Ni(l) + O_2(g) + H_2(g) = Ni(OH)_2(g)$	1728-2000	-62.741	-5.352	1.154	3.314	-16.132
$Ni(\alpha) + S(rh) = NiS(\alpha)$	298.15-368.54	-21.805	-.708	.093	-.276	-2.732
$Ni(\alpha) + S(mon) = NiS(\alpha)$	368.54-388.36	-23.400	4.142	-5.147	1.284	27.751
$Ni(\alpha) + S(l) = NiS(\alpha)$	388.36-623	-9.251	-27.098	14.993	-19.936	-180.075
$Ni(\alpha) + S(l) = NiS(\beta)$	623-631	-7.971	-28.504	16.029	-20.596	-190.446
$Ni(\beta) + S(l) = NiS(\beta)$	631-717.8	-5.422	-36.828	23.054	-21.186	-243.646
$Ni(\alpha) + 1/2S_2(g) = NiS(\alpha)$	298.15-623	-38.423	3.032	-1.652	.674	41.435
$Ni(\alpha) + 1/2S_2(g) = NiS(\beta)$	623-631	-37.139	1.626	-.616	-.014	31.061
$Ni(\beta) + 1/2S_2(g) = NiS(\beta)$	631-700	-34.594	-6.698	6.409	-.576	-22.136
$Ni(\beta) + 1/2S_2(g) = NiS(\beta)$	700-1066.5	-37.504	-.449	2.507	2.560	19.908
$Ni(\beta) + 1/2S_2(g) = NiS(l)$	1066.5-1728	-34.781	7.499	-1.182	2.526	68.837
$Ni(l) + 1/2S_2(g) = NiS(l)$	1728-1800	-34.847	3.270	-.025	-.610	39.401
$3Ni(\alpha) + 2S(rh) = Ni_3S_2(\alpha)$	298.15-368.54	-51.551	-.948	-1.385	-.427	-2.733
$3Ni(\alpha) + 2S(mon) = Ni_3S_2(\alpha)$	368.54-388.36	-54.741	8.752	-11.865	2.693	58.235
$3Ni(\alpha) + 2S(l) = Ni_3S_2(\alpha)$	388.36-631	-26.443	-53.728	28.415	-39.747	-357.419
$3Ni(\beta) + 2S(l) = Ni_3S_2(\alpha)$	631-717.8	-18.797	-78.700	49.490	-41.517	-517.019
$3Ni(\alpha) + S_2(g) = Ni_3S_2(\alpha)$	298.15-631	-84.788	6.532	-4.875	1.473	85.601
$3Ni(\beta) + S_2(g) = Ni_3S_2(\alpha)$	631-700	-77.142	-18.440	16.200	-.297	-73.999
$3Ni(\beta) + S_2(g) = Ni_3S_2(\alpha)$	700-840	-85.873	.307	4.494	9.111	52.132
$3Ni(\beta) + S_2(g) = Ni_3S_2(\beta)$	840-1064	-87.222	27.707	-7.020	7.657	228.665
$3Ni(\beta) + S_2(g) = Ni_3S_2(l)$	1064-1728	-79.532	21.127	-3.521	8.188	179.276
$3Ni(l) + S_2(g) = Ni_3S_2(l)$	1728-1800	-79.728	8.440	-.050	-1.220	90.967
$Ni(\alpha) + S(rh) + 2O_2(g) = NiSO_4(s)$	298.15-368.54	-210.356	1.800	1.133	3.245	103.126

Constants in Enthalpy of Formation and Gibbs Energy of Formation Equations, Nickel Compounds - Continued

$\Delta Hf° = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1}$ (kcal/mole)
$\Delta Gf° = \Delta H_0 - \Delta aTlnT - \Delta bT^2 + 1/2\Delta cT^{-1} + IT$ (kcal/mole)

Formation reaction	Range, K	ΔH_0	$\Delta ax10^3$	$\Delta bx10^6$	$\Delta cx10^{-2}$	$Ix10^3$
$Ni(\alpha) + S(mon) + 2O_2(g) = NiSO_4(s)$	368.54-388.36	-211.951	6.650	-4.107	4.805	133.609
$Ni(\alpha) + S(l) + 2O_2(g) = NiSO_4(s)$	388.36-631	-197.803	-24.590	16.033	-16.415	-74.217
$Ni(\beta) + S(l) + 2O_2(g) = NiSO_4(s)$	631-717.8	-195.254	-32.914	23.058	-17.005	-127.417
$Ni(\alpha) + 1/2S_2(g) + 2O_2(g) = NiSO_4(s)$	298.15-631	-226.974	5.540	-.612	4.195	147.293
$Ni(\beta) + 1/2S_2(g) + 2O_2(g) = NiSO_4(s)$	631-750	-224.425	-2.784	6.413	3.605	94.093
$Ni(\beta) + 1/2S_2(g) + 2O_2(g) = NiSO_4(s)$	750-1200	-227.335	3.465	2.511	6.741	136.136
$Ni(\alpha) + 1.05Se(s) = NiSe_{1.05}(s)$	298.15-494.3	-18.225	1.734	-2.499	.091	9.987
$Ni(\alpha) + 1.05Se(l) = NiSe_{1.05}(s)$	494.3-631	-20.442	1.076	-2.130	4.571	9.657
$Ni(\beta) + 1.05Se(l) = NiSe_{1.05}(s)$	631-700	-17.893	-7.248	4.895	3.981	-43.543
$Ni(\beta) + 1.05Se(l) = NiSe_{1.05}(s)$	700-1050	-20.803	-.999	.993	7.117	-1.500
$Ni(\alpha) + 1.14Se(s) = NiSe_{1.14}(\alpha)$	298.15-494.3	-14.921	-12.438	12.622	-4.449	-78.026
$Ni(\alpha) + 1.14Se(l) = NiSe_{1.14}(\alpha)$	494.3-503	-17.328	-13.152	13.024	.416	-78.382
$Ni(\alpha) + 1.14Se(l) = NiSe_{1.14}(\beta)$	503-631	-21.960	2.008	-2.625	5.271	16.299
$Ni(\beta) + 1.14Se(l) = NiSe_{1.14}(\beta)$	631-700	-19.411	-6.316	4.400	4.681	-36.901
$Ni(\beta) + 1.14Se(l) = NiSe_{1.14}(\beta)$	700-1050	-22.321	-.067	.498	7.817	5.142
$Ni(\alpha) + 1.25Se(s) = NiSe_{1.25}(\alpha)$	298.15-494.3	-17.243	-6.996	5.935	-2.978	-44.312
$Ni(\alpha) + 1.25Se(l) = NiSe_{1.25}(\alpha)$	494.3-589	-19.882	-7.779	6.375	2.356	-44.705
$Ni(\alpha) + 1.25Se(l) = NiSe_{1.25}(\beta)$	589-631	-22.592	.490	-1.500	5.723	7.515
$Ni(\beta) + 1.25Se(l) = NiSe_{1.25}(\beta)$	631-700	-20.043	-7.834	5.525	5.133	-45.685
$Ni(\beta) + 1.25Se(l) = NiSe_{1.25}(\beta)$	700-995	-22.953	-1.585	1.623	8.269	-3.641
$Ni(\beta) + 1.25Se(l) = NiSe_{1.25}(\gamma)$	995-1050	-29.204	10.670	-4.379	8.269	81.263
$Ni(\alpha) + Si(s) = NiSi(s)$	298.15-631	-22.012	4.098	-4.169	1.672	26.341
$Ni(\beta) + Si(s) = NiSi(s)$	631-700	-19.463	-4.226	2.856	1.082	-26.859
$Ni(\beta) + Si(s) = NiSi(s)$	700-1265	-22.373	2.023	-1.046	4.218	15.185
$Ni(\beta) + Si(s) = NiSi(l)$	1265-1500	-18.948	8.319	-1.497	2.106	56.944
$1.04Ni(\alpha) + 1.93Si(s) = Ni_{1.04}Si_{1.93}(s)$	298.15-631	-22.206	2.849	-3.335	.753	18.006
$1.04Ni(\beta) + 1.93Si(s) = Ni_{1.04}Si_{1.93}(s)$	631-700	-19.555	-5.808	3.971	.139	-37.322
$1.04Ni(\beta) + 1.93Si(s) = Ni_{1.04}Si_{1.93}(s)$	700-1245	-22.582	.691	-.087	3.400	6.404
$2Ni(\alpha) + Si(s) = Ni_2Si(\alpha)$	298.15-631	-33.156	1.188	-4.548	-1.173	5.065

Constants in Enthalpy of Formation and Gibbs Energy of Formation Equations, Nickel Compounds - Continued

$\Delta Hf° = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1}$ (kcal/mole)
$\Delta Gf° = \Delta H_0 - \Delta aTlnT - \Delta bT^2 + 1/2\Delta cT^{-1} + IT$ (kcal/mole)

Formation reaction	Range, K	ΔH_0	$\Delta ax10^3$	$\Delta bx10^6$	$\Delta cx10^{-2}$	$Ix10^3$
$2Ni(\beta) + Si(s) = Ni_2Si(\alpha)$	631-700	-28.058	-15.460	9.502	-2.353	-101.335
$2Ni(\beta) + Si(s) = Ni_2Si(\alpha)$	700-1490	-33.878	-2.962	1.698	3.919	-17.248
$2Ni(\beta) + Si(s) = Ni_2Si(\beta)$	1490-1560	-42.347	10.348	-2.654	5.242	79.172
$2Ni(\beta) + Si(s) = Ni_2Si(l)$	1560-1687	-34.087	11.848	-2.654	5.242	84.906
$2Ni(\beta) + Si(l) = Ni_2Si(l)$	1687-1728	-46.540	11.458	-2.314	6.272	89.945
$2Ni(l) + Si(l) = Ni_2Si(l)$	1728-1800	-46.671	3.000	0	0	31.072
$2Ni(\alpha) + Si(s) + 2O_2(g) = Ni_2SiO_4(s)$	298.15-631	-342.709	14.257	-6.295	8.997	187.983
$2Ni(\beta) + Si(s) + 2O_2(g) = Ni_2SiO_4(s)$	631-700	-337.611	-2.391	7.755	7.817	81.583
$2Ni(\beta) + Si(s) + 2O_2(g) = Ni_2SiO_4(s)$	700-1687	-343.432	10.107	-.049	14.089	165.671
$2Ni(\beta) + Si(l) + 2O_2(g) = Ni_2SiO_4(s)$	1687-1728	-355.885	9.717	.291	15.119	170.710
$2Ni(l) + Si(l) + 2O_2(g) = Ni_2SiO_4(s)$	1728-1800	-356.016	1.259	2.605	8.847	111.837
$4Ni(\alpha) + W(s) = Ni_4W(s)$	298.15-631	-9.649	8.596	-12.579	2.100	51.612
$4Ni(\beta) + W(s) = Ni_4W(s)$	631-700	.546	-24.700	15.521	-.260	-161.188
$4Ni(\beta) + W(s) = Ni_4W(s)$	700-1100	-11.095	.296	-.087	12.284	6.988
$Ni(\alpha) + W(s) + 2O_2(g) = NiWO_4(s)$	298.15-631	-269.234	2.084	1.116	-1.153	98.422
$Ni(\beta) + W(s) + 2O_2(g) = NiWO_4(s)$	631-700	-266.685	-6.240	8.141	-1.743	45.221
$Ni(\beta) + W(s) + 2O_2(g) = NiWO_4(s)$	700-1100	-269.595	.009	4.239	1.393	87.265

Constants in Enthalpy of Formation and Gibbs Energy of Formation Equations, Auxiliary Compounds

$\Delta Hf° = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1}$ (kcal/mole)
$\Delta Gf° = \Delta H_0 - \Delta aTlnT - \Delta bT^2 + 1/2\Delta cT^{-1} + IT$ (kcal/mole)

Formation reaction	Range, K	ΔH_0	$\Delta ax10^3$	$\Delta bx10^6$	$\Delta cx10^{-2}$	$Ix10^3$
$Al(s) + 3/2Cl_2(g) = AlCl_3(g)$	298.15-933.5	-140.218	1.783	-1.844	1.343	23.182
$Al(l) + 3/2Cl_2(g) = AlCl_3(g)$	933.5-2000	-141.412	-1.392	0	1.071	4.485
$C(s) + 1/2O_2(g) = CO(g)$	298.15-2000	-25.395	-.669	-.430	-2.334	-27.402
$C(s) + O_2(g) = CO_2(g)$	298.15-2000	-93.591	-.562	-.040	-.860	-4.979
$Ca(\alpha) + 1/2O_2(g) = CaO(s)$	298.15-720	-153.516	4.284	-2.223	1.927	53.720
$Ca(\beta) + 1/2O_2(g) = CaO(s)$	720-1112	-155.289	8.252	-4.604	1.426	80.623
$Ca(l) + 1/2O_2(g) = CaO(s)$	1112-2000	-155.505	1.115	.347	1.317	36.269
$Ca(\alpha) + 1/2S_2(g) = CaS(s)$	298.15-720	-131.516	2.986	-1.679	.403	42.850
$Ca(\beta) + 1/2S_2(g) = CaS(s)$	720-1112	-133.290	6.954	-4.060	-.098	69.754
$Ca(l) + 1/2S_2(g) = CaS(s)$	1112-2000	-133.506	-.183	.891	-.207	25.400
$2Ca(\alpha) + Si(s) + 2O_2(g) = Ca_2SiO_4(\gamma)$	298.15-720	-555.639	3.061	-.085	2.188	115.141
$2Ca(\beta) + Si(s) + 2O_2(g) = Ca_2SiO_4(\gamma)$	720-1112	-559.185	10.997	-4.847	1.186	168.946
$2Ca(l) + Si(s) + 2O_2(g) = Ca_2SiO_4(\gamma)$	1112-1121	-559.617	-3.277	5.055	.968	80.237
$2Ca(l) + Si(s) + 2O_2(g) = Ca_2SiO_4(\alpha')$	1121-1687	-555.819	-3.517	4.746	4.356	74.683
$2Ca(l) + Si(l) + 2O_2(g) = Ca_2SiO_4(\alpha')$	1687-1712	-568.272	-3.907	5.086	5.386	79.722
$2Ca(l) + Si(l) + 2O_2(g) = Ca_2SiO_4(\alpha)$	1712-1800	-576.994	13.348	-.700	-2.640	203.518
$2Fe(\alpha) + 3Cl_2(g) = Fe_2Cl_6(g)$	298.15-1043	-162.074	17.489	-12.346	4.344	156.774
$2Fe(\alpha) + 3Cl_2(g) = Fe_2Cl_6(g)$	1043-1185	-114.947	-70.481	29.074	-.176	-456.380
$2Fe(\gamma) + 3Cl_2(g) = Fe_2Cl_6(g)$	1185-1667	-161.944	6.049	-2.346	-.176	87.688
$2Fe(\delta) + 3Cl_2(g) = Fe_2Cl_6(g)$	1667-1811	-163.166	8.409	-3.466	-.176	104.062
$2Fe(l) + 3Cl_2(g) = Fe_2Cl_6(g)$	1811-2000	-156.212	-4.931	-.206	-1.760	6.079
$0.947Fe(\alpha) + 1/2O_2(g) = Fe_{.947}O(s)$	298.15-1043	-66.392	8.157	-5.005	2.280	69.868
$0.947Fe(\alpha) + 1/2O_2(g) = Fe_{.947}O(s)$	1043-1185	-44.091	-33.483	14.607	.140	-220.352
$0.947Fe(\gamma) + 1/2O_2(g) = Fe_{.947}O(s)$	1185-1652	-66.329	2.740	-.270	.140	37.153
$0.947Fe(\gamma) + 1/2O_2(g) = Fe_{.947}O(l)$	1652-1667	-63.499	7.107	-1.188	-.660	66.296
$0.947Fe(\delta) + 1/2O_2(g) = Fe_{.947}O(l)$	1667-1800	-64.075	8.224	-1.719	-.660	74.043
$2Fe(\alpha) + 3/2O_2(g) = Fe_2O_3(\alpha)$	298.15-960	-202.101	11.435	-2.555	5.720	143.936
$2Fe(\alpha) + 3/2O_2(g) = Fe_2O_3(\beta)$	960-1043	-203.425	22.865	-12.665	2.540	214.271

Constants in Enthalpy of Formation and Gibbs Energy of Formation Equations, Auxiliary Compounds - Continued

$\Delta Hf° = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1}$ (kcal/mole)
$\Delta Gf° = \Delta H_0 - \Delta aTlnT - \Delta bT^2 + 1/2\Delta cT^{-1} + IT$ (kcal/mole)

Formation reaction	Range, K	ΔH_0	$\Delta a \times 10^3$	$\Delta b \times 10^6$	$\Delta c \times 10^{-2}$	$I \times 10^3$
$2Fe(\alpha) + 3/2O_2(g) = Fe_2O_3(\beta)$	1043-1185	-156.329	-65.075	28.755	-1.980	-398.645
$2Fe(\gamma) + 3/2O_2(g) = Fe_2O_3(\beta)$	1185-1667	-203.290	11.425	-2.665	-1.980	145.181
$2Fe(\delta) + 3/2O_2(g) = Fe_2O_3(\beta)$	1667-1800	-204.512	13.785	-3.785	-1.980	161.555
$3Fe(\alpha) + 2O_2(g) = Fe_3O_4(\alpha)$	298.15-870	-269.199	.188	10.725	1.162	90.948
$3Fe(\alpha) + 2O_2(g) = Fe_3O_4(\beta)$	870-1043	-276.338	34.130	-19.309	4.140	302.564
$3Fe(\alpha) + 2O_2(g) = Fe_3O_4(\beta)$	1043-1185	-205.694	-97.780	42.821	-2.640	-616.810
$3Fe(\gamma) + 2O_2(g) = Fe_3O_4(\beta)$	1185-1667	-276.137	16.970	-4.309	-2.640	198.929
$3Fe(\delta) + 2O_2(g) = Fe_3O_4(\beta)$	1667-1800	-277.970	20.510	-5.989	-2.640	223.491
$Fe(\alpha) + 1/2S_2(g) = FeS(\alpha)$	298.15-411	-36.723	-13.746	24.286	-1.452	-59.034
$Fe(\alpha) + 1/2S_2(g) = FeS(\beta)$	411-598	-42.836	13.160	-6.095	1.650	104.371
$Fe(\alpha) + 1/2S_2(g) = FeS(\gamma)$	598-1043	-36.680	4.465	-3.762	-8.342	41.276
$Fe(\alpha) + 1/2S_2(g) = FeS(\gamma)$	1043-1185	-13.132	-39.505	16.948	-10.602	-265.182
$Fe(\gamma) + 1/2S_2(g) = FeS(\gamma)$	1185-1470	-36.613	-1.255	1.238	-10.602	6.731
$Fe(\gamma) + 1/2S_2(g) = FeS(l)$	1470-1667	-36.694	7.024	-1.095	-.610	63.504
$Fe(\delta) + 1/2S_2(g) = FeS(l)$	1667-1811	-37.304	8.204	-1.655	-.610	71.691
$Fe(l) + 1/2S_2(g) = FeS(l)$	1811-2000	-33.870	1.534	-.025	-.610	22.711
$2Fe(\alpha) + Si(s) + 2O_2(g) = Fe_2SiO_4(s)$	298.15-1043	-360.271	15.990	-8.660	7.672	187.094
$2Fe(\alpha) + Si(s) + 2O_2(g) = Fe_2SiO_4(s)$	1043-1185	-313.175	-71.950	32.760	3.152	-425.822
$2Fe(\gamma) + Si(s) + 2O_2(g) = Fe_2SiO_4(s)$	1185-1492	-360.136	4.550	1.340	3.152	118.004
$2Fe(\gamma) + Si(s) + 2O_2(g) = Fe_2SiO_4(l)$	1492-1667	-358.486	25.259	-3.180	-3.670	261.646
$2Fe(\delta) + Si(s) + 2O_2(g) = Fe_2SiO_4(l)$	1667-1687	-359.707	27.619	-4.300	-3.670	278.020
$2Fe(\delta) + Si(l) + 2O_2(g) = Fe_2SiO_4(l)$	1687-1800	-372.160	27.229	-3.960	-2.640	283.059
$1/2H_2(g) + 1/2Br_2(l) = HBr(g)$	298.15-332.6	-7.246	-4.040	-2.465	-.090	-42.246
$1/2H_2(g) + 1/2Br_2(g) = HBr(g)$	332.6-2000	-11.943	-1.325	.400	-.275	-11.322
$1/2H_2(g) + 1/2Cl_2(g) = HCl(g)$	298.15-2000	-21.478	-1.415	.385	-.585	-11.975
$1/2H_2(g) + 1/2F_2(g) = HF(g)$	298.15-2000	-64.119	-1.225	.150	-.980	-10.347
$H_2(g) + 1/2O_2(g) = H_2O(g)$	298.15-2000	-56.557	-3.525	.898	-.800	-12.918
$H_2(g) + 1/2S_2(g) = H_2S(g)$	298.15-2000	-19.289	-3.420	1.195	-.200	-12.995

Constants in Enthalpy of Formation and Gibbs Energy of Formation Equations, Auxiliary Compounds - Continued

$\Delta Hf° = \Delta H_0 + \Delta aT + \Delta bT^2 + \Delta cT^{-1}$ (kcal/mole)
$\Delta Gf° = \Delta H_0 - \Delta aTlnT - \Delta bT^2 + 1/2\Delta cT^{-1} + IT$ (kcal/mole)

Formation reaction	Range, K	ΔH_0	$\Delta ax10^3$	$\Delta bx10^6$	$\Delta cx10^{-2}$	$Ix10^3$
:S(rh) = S_2(g)	298.15-368.54	33.237	-7.480	3.490	-1.900	-88.334
:S(mon) = S_2(g)	368.54-388.36	30.047	2.220	-6.990	1.220	-27.368
:S(l) = S_2(g)	388.36-717.8	58.345	-60.260	33.290	-41.220	-443.020
./2S_2(g) + O_2(g) = SO_2(g)	298.15-2000	-85.931	-1.213	.626	-.139	9.132
./2S_2(g) + 3/2O_2(g) = SO_3(g)	298.15-2000	-110.054	-.851	.918	.914	34.778
:i(s) + O_2(g) = SiO_2(α)	298.15-847	-217.257	-2.833	3.872	.022	26.942
:i(s) + O_2(g) = SiO_2(β)	847-1687	-217.317	.626	.514	-2.407	47.657
:i(l) + O_2(g) = SiO_2(β)	1687-2000	-229.770	.236	.854	-1.377	52.696
/(s) + 3/2O_2(g) = WO_3(α)	298.15-1050	-203.122	3.303	1.082	1.732	86.898
/(s) + 3/2O_2(g) = WO_3(β)	1050-1745	-207.394	7.455	-.469	23.071	117.254
/(s) + 3/2O_2(g) = WO_3(l)	1745-2000	-198.664	14.028	-.863	-2.227	161.044

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