Table 2.1 The Standard Free Energies of Formation of Selected Compounds from Compiled Thermochemical Data

Notations: < > solid, { } liquid, ( ) gas, d decomposition, m melting, b boiling.

	$\Delta G^\circ = \Delta H^\circ - \Delta S^\circ T$			
	$-\Delta H^\circ$ kJ mol^{-1}	$-\Delta S^\circ$ J mol^{-1}K^{-1}	ΔG° ±kJ	Temp.Range °C
<Al> = {Al}	−10.8	11.5	0.2	660m
2{Al} + 3/2(O_2) = <Al_2O_3>	1683.2	325.6	8	660–1700
{Al} + 1/2(N_2) = <AlN>	328.3	115.5	4	660–1700
<C> + 2(H_2) = (CH_4)	91.0	110.7	2	25–2000
<C> + 1/2(O_2) = (CO)	114.4	−85.8	2	25–2000
<C> + (O_2) = (CO_2)	395.3	−0.5	2	25–2000
<Ca> = {Ca}	−8.5	7.7	0.5	842m
{Ca} = (Ca)	153.6	87.4	0.5	842–1500b
{Ca} + 1/2(O_2) = <CaO>	900.3	275.1	6	842–1500b
{Ca} + 1/2(S_2) = <CaS>	548.1	103.8	4	842–1500b
<CaO> + <Al_2O_3> = <$CaAl_2O_4$>	19.1	− 17.2	8	25–1605m
<CaO> + (CO_2) = <$CaCO_3$>	161.3	137.2	4	25–880d
2<CaO> + <SiO_2> = <Ca_2SiO_4>	118.8	− 11.3	10	25–1700
<CaO> + <SiO_2> = <$CaSiO_3$>	92.5	2.5	12	25–1540m
<Cr> = {Cr}	−16.9	7.9	–	1857m
2<Cr> + 3/2(O_2) = <Cr_2O_3>	1110.3	247.3	2	900–1650
<Fe> = {Fe}	−13.8	7.6	1	1537m
0.947<Fe> + 1/2(O_2) = <$Fe_{0.947}O$>	263.7	64.3	4	25–1371m
{Fe} + 1/2(O_2) = {FeO}	225.5	41.3	4	1537–1700
3<Fe> + 2(O_2) = <Fe_3O_4>	1102.2	307.4	4	25–1597m
2<Fe> + 3/2(O_2) = <Fe_2O_3)	814.1	250.7	4	25–1500
<Fe> + 1/2(S_2) = <FeS>	154.9	56.9	4	25–988m
{Fe} + 1/2(O_2) + <Cr_2O_3>=<$FeCr_2O_4$>	330.5	80.3	2	1537–1700
2<FeO> + <SiO_2> = <Fe_2SiO_4>	36.2	21.1	4	25–1220m
(H_2) + 1/2(O_2) = (H_2O)	247.3	55.9	1	25–2000
(H_2) + 1/2(S_2) = (H_2S)	91.6	50.6	1	25–2000
3/2(H_2) + 1/2(N_2) = (NH_3)	53.7	32.8	0.5	25–2000
{K} = (K)	−84.5	82.0	0.5	63–759b
(K) + <C> + 1/2(N_2) = {KCN}	171.5	93.5	16	622–1132b
{KCN} = 1/2$(KCN)_2$	109.2	76.7	4	622–1132b
<Mg> = {Mg}	−9.0	9.7	0.5	649m
{Mg} = (Mg)	129.6	95.1	2	649–1090b
(Mg) + 1/2(O_2) = <MgO>	759.4	202.6	10	1090–2000
(Mg) + 1/2(S_2) = <MgS>	539.7	193.0	8	1090–2000
2<MgO> + <SiO_2> = <Mg_2SiO_4>	67.2	4.3	8	25–1898m
<MgO> + <SiO_2> = <$MgSiO_3$>	41.1	6.1	8	25–1577m
<MgO> + (CO_2) = $MgCO_3$)	116.3	173.4	8	25–402d
<Mn> = {Mn}	−14.6	9.6	1	1244m
<Mn> + 1/2(O_2) = <MnO>	391.9	78.3	4	25–1244m
{Mn} + 1/2(O_2) = <MnO>	406.5	87.9	4	1244–1700
{Mn} + 1/2(O2) = {MnO}**	352.2	61.5	4	1500–1700
** supercooled liquid below the melting point 1785°C				
<Mn> + 1/2(S_2) = <MnS>	277.9	64.0	4	25–1244m
{Mn} + 1/2(S_2) = <MnS>	292.5	73.6	4	1244–1530m
{Mn} + 1/2(S_2) = {MnS}	265.0	66.1	4	1530–1700
<MnO> + <SiO_2) = <$MnSiO_3$)	28.0	2.8	12	25–1291m
<Mo> = {Mo}	−27.8	9.6	6	2620m
<Mo> + (O_2) = <MoO_2>	578.2	166.5	12	25–2000
<Mo> + 3/2(O_2) = (MoO_3)	359.8	59.4	20	25–2000

Table 2.1 *(continued)*

	$\Delta G^\circ = \Delta H^\circ - \Delta S^\circ T$			
	$-\Delta H^\circ$ kJ mol^{-1}	$-\Delta S^\circ$ J mol^{-1}K^{-1}	ΔG° ±kJ	Temp.Range °C
$\frac{1}{2}(N_2) + \frac{3}{2}(H_2) = (NH_3)$	53.7	116.5	0.5	25–2000
$\frac{1}{2}(N_2) + \frac{1}{2}(O_2) + (NO)$	–90.4	–12.7	0.5	25–2000
$\frac{1}{2}(N_2) + (O_2) + (NO_2)$	–32.3	63.3	1	25–2000
{Na} = (Na)	–101.3	87.9	1	98–883b
(Na) + <C> + $\frac{1}{2}(N_2)$ = {NaCN}	152.3	83.7	16	833–1530b
2(Na) + $\frac{1}{2}(O_2)$ = {Na_2O}	518.8	234.7	12	1132–1950d
<Nb> = {Nb}	–26.9	9.8	–	2477m
2<Nb> + $\frac{1}{2}(N_2)$ = <Nb_2N>	251.0	83.3	16	25–2400m
<Nb> + $\frac{1}{2}(N_2)$ = <NbN>	230.1	77.8	16	25–2050m
2<Nb> + $\frac{5}{2}(N_2)$ = <Nb_2O_5>	1888.2	419.7	12	25–1512m
<Ni> = {Ni}	–17.5	10.1	2	1453m
<Ni> + $\frac{1}{2}(O_2)$ = <NiO>	235.6	86.1	2	25–1984m
<Ni> + $\frac{1}{2}(S_2)$ = <NiS>	146.4	72.0	6	25–600
3<Ni> + (S_2) = <Ni_3S_2>	331.5	163.2	8	25–790m
$\frac{1}{2}(S_2) + (O_2) = (SO_2)$	361.7	72.7	0.5	25–1700
<Si> = {Si}	–49.3	30.0	2	1412m
{Si} + $\frac{1}{2}(O_2)$ = (SiO)	154.7	–52.5	12	1412–1700
<Si> + (O_2) = <SiO_2>	902.3	172.9	12	400–1412m
{Si} + (O_2) – <SiO_2>	952.5	202.8	12	1412–1723m
<Ti> = {Ti}	–18.6	9.6	–	1660m
<Ti> + $\frac{1}{2}(N_2)$ = <TiN>	336.3	93.3	6	25–1660m
<Ti> + (O_2) = <TiO_2>	941.0	177.6	2	25–1660m
<V> + {V}	–22.8	10.4	–	1920m
<V> + $\frac{1}{2}(N_2)$ = <VN>	214.6	82.4	16	25–2346d
2<V> + $\frac{3}{2}(O_2)$ = <V_2O_3>	1202.9	237.5	8	25–2070m
{Zn} = (Zn)	–118.1	100.2	1	420–907b
(Zn) + $\frac{1}{2}(O_2)$ = <ZnO>	460.2	198.3	10	907–1700
{Zn} + $\frac{1}{2}(S_2)$ = <ZnS>	277.8	107.9	10	420–907b
(Zn) + $\frac{1}{2}(S_2)$ = (ZnS)	–5.0	30.5	10	1182–1700
<Zr> = {Zr}	–20.9	9.8	–	1850m
<Zr> + $\frac{1}{2}(N_2)$ = <ZnN>	363.6	92.0	16	25–1850m
<Zr> + (O_2) – <ZrO_2>	1092.0	183.7	16	25–1850m
<Zr> + (S_2) = <ZrS_2>	698.7	178.2	20	25–1550m
<ZrO_2> + <SiO_2> = <$ZrSiO_4$>	26.8	12.6	20	25–1707m

* References to the compiled thermochemical data used in deriving ΔH° and ΔS° values are given in Ref. 27 cited in Section 2.2.2.4