This is “Appendix A: Standard Thermodynamic Quantities for Chemical Substances at 25°C”, appendix 1 from the book Principles of General Chemistry (index.html) (v. 1.0M).

Chapter 25

Appendix A: Standard Thermodynamic Quantities for Chemical Substances at 25°C

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
Aluminum:			
Al(s)	0.0	0.0	28.3
Al(g)	330.0	289.4	164.6
$AlCl_3$(s)	−704.2	−628.8	109.3
Al_2O_3(s)	−1675.7	−1582.3	50.9
Barium:			
Ba(s)	0.0	0.0	62.5
Ba(g)	180.0	146.0	170.2
BaO(s)	−548.0	−520.3	72.1
$BaCO_3$(s)	−1213.0	−1134.4	112.1
$BaSO_4$(s)	−1473.2	−1362.2	132.2
Beryllium:			
Be(s)	0.0	0.0	9.5
Be(g)	324.0	286.6	136.3
$Be(OH)_2$(s)	−902.5	−815.0	45.5
BeO(s)	−609.4	−580.1	13.8
Bismuth:			
Bi(s)	0.0	0.0	56.7
Bi(g)	207.1	168.2	187.0
Bromine:			
Br(g)	111.9	82.4	175.0
Br_2(l)	0.0	0.0	152.2
Br^-(aq)	−121.6	−104.0	82.4

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
$Br_2(g)$	30.9	3.1	245.5
HBr(g)	−36.3	−53.4	198.7
HBr(aq)	−121.6	−104.0	82.4
Cadmium:			
Cd(s)	0.0	0.0	51.8
Cd(g)	111.8	—	167.7
$CdCl_2(s)$	−391.5	−343.9	115.3
CdS(s)	−161.9	−156.5	64.9
Calcium:			
Ca(s)	0.0	0.0	41.6
Ca(g)	177.8	144.0	154.9
$CaCl_2(s)$	−795.4	−748.8	108.4
$CaF_2(s)$	−1228.0	−1175.6	68.5
$Ca(OH)_2(s)$	−985.2	−897.5	83.4
CaO(s)	−634.9	−603.3	38.1
$CaSO_4(s)$	−1434.5	−1322.0	106.5
$CaCO_3$(s, calcite)	−1207.6	−1129.1	91.7
$CaCO_3$(s, aragonite)	−1207.8	−1128.2	88.0
Carbon:			
C(s, graphite)	0.0	0.0	5.7
C(s, diamond)	1.9	2.9	2.4
C(s, fullerene—C_{60})	2327.0	2302.0	426.0
C(s, fullerene—C_{70})	2555.0	2537.0	464.0
C(g)	716.7	671.3	158.1
C(g, fullerene—C_{60})	2502.0	2442.0	544.0
C(g, fullerene—C_{70})	2755.0	2692.0	614.0
$CBr_4(s)$	29.4	47.7	212.5
$CBr_4(g)$	83.9	67.0	358.1
$CCl_2F_2(g)$	−477.4	−439.4	300.8

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
$CCl_2O(g)$	−219.1	−204.9	283.5
$CCl_4(l)$	−128.2	−62.6	216.2
$CCl_4(g)$	−95.7	−53.6	309.9
$CF_4(g)$	−933.6	−888.3	261.6
$CHCl_3(l)$	−134.1	−73.7	201.7
$CHCl_3(g)$	−102.7	6.0	295.7
$CH_2Cl_2(l)$	−124.2	—	177.8
$CH_2Cl_2(g)$	−95.4	−68.9	270.2
$CH_3Cl(g)$	−81.9	−58.5	234.6
$CH_4(g)$	−74.6	−50.5	186.3
$CH_3COOH(l)$	−484.3	−389.9	159.8
$CH_3OH(l)$	−239.2	−166.6	126.8
$CH_3OH(g)$	−201.0	−162.3	239.9
$CH_3NH_2(l)$	−47.3	35.7	150.2
$CH_3NH_2(g)$	−22.5	32.7	242.9
$CH_3CN(l)$	40.6	86.5	149.6
$CH_3CN(g)$	74.0	91.9	243.4
$CO(g)$	−110.5	−137.2	197.7
$CO_2(g)$	−393.5	−394.4	213.8
$CS_2(l)$	89.0	64.6	151.3
$CS_2(g)$	116.7	67.1	237.8
$C_2H_2(g)$	227.4	209.9	200.9
$C_2H_4(g)$	52.4	68.4	219.3
$C_2H_6(g)$	−84.0	−32.0	229.2
$C_3H_8(g)$	−103.8	−23.4	270.3
$C_3H_6O_3(s)$ (lactic acid)	−694.1	−522.9	142.3
$C_6H_6(l)$	49.1	124.5	173.4
$C_6H_6(g)$	82.9	129.7	269.2

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
$C_6H_{12}O_6$(s) (glucose)	−1273.3	−910.4	212.1
C_2H_5OH(l)	−277.6	−174.8	160.7
C_2H_5OH(g)	−234.8	−167.9	281.6
$(CH_3)_2O$(l)	−203.3	—	—
$(CH_3)_2O$(g)	−184.1	−112.6	266.4
$CH_3CO_2^-$(aq)	−486.0	−369.3	86.6
n-$C_{12}H_{26}$(l) (dodecane)	−350.9	28.1	490.6
Cesium:			
Cs(s)	0.0	0.0	85.2
Cs(g)	76.5	49.6	175.6
CsCl(s)	−443.0	−414.5	101.2
Chlorine:			
Cl(g)	121.3	105.3	165.2
Cl_2(g)	0.0	0.0	223.1
Cl^-(aq)	−167.2	−131.2	56.5
HCl(g)	−92.3	−95.3	186.9
HCl(aq)	−167.2	−131.2	56.5
ClF_3(g)	−163.2	−123.0	281.6
Chromium:			
Cr(s)	0.0	0.0	23.8
Cr(g)	396.6	351.8	174.5
$CrCl_3$(s)	−556.5	−486.1	123.0
CrO_3(g)	−292.9	—	266.2
Cr_2O_3(s)	−1139.7	−1058.1	81.2
Cobalt:			
Co(s)	0.0	0.0	30.0
Co(g)	424.7	380.3	179.5
$CoCl_2$(s)	−312.5	−269.8	109.2
Copper:			

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
Cu(s)	0.0	0.0	33.2
Cu(g)	337.4	297.7	166.4
CuCl(s)	−137.2	−119.9	86.2
$CuCl_2$(s)	−220.1	−175.7	108.1
CuO(s)	−157.3	−129.7	42.6
Cu_2O(s)	−168.6	−146.0	93.1
CuS(s)	−53.1	−53.6	66.5
Cu_2S(s)	−79.5	−86.2	120.9
CuCN(s)	96.2	111.3	84.5
Fluorine:			
F(g)	79.4	62.3	158.8
F^-(aq)	−332.6	−278.8	−13.8
F_2(g)	0.0	0.0	202.8
HF(g)	−273.3	−275.4	173.8
HF(aq)	−332.6	−278.8	−13.8
Hydrogen:			
H(g)	218.0	203.3	114.7
H_2(g)	0.0	0.0	130.7
H^+(aq)	0.0	0.0	0.0
Iodine:			
I(g)	106.8	70.2	180.8
I^-(aq)	−55.2	−51.6	111.3
I_2(s)	0.0	0.0	116.1
I_2(g)	62.4	19.3	260.7
HI(g)	26.5	1.7	206.6
HI(aq)	−55.2	−51.6	111.3
Iron:			
Fe(s)	0.0	0.0	27.3
Fe(g)	416.3	370.7	180.5

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
$Fe^{2+}(aq)$	−89.1	−78.9	−137.7
$Fe^{3+}(aq)$	−48.5	−4.7	−315.9
$FeCl_2(s)$	−341.8	−302.3	118.0
$FeCl_3(s)$	−399.5	−334.0	142.3
$FeO(s)$	−272.0	−251.4	60.7
$Fe_2O_3(s)$	−824.2	−742.2	87.4
$Fe_3O_4(s)$	−1118.4	−1015.4	146.4
$FeS_2(s)$	−178.2	−166.9	52.9
$FeCO_3(s)$	−740.6	−666.7	92.9
Lead:			
Pb(s)	0.0	0.0	64.8
Pb(g)	195.2	162.2	175.4
PbO(s, red or litharge)	−219.0	−188.9	66.5
PbO(s, yellow or massicot)	−217.3	−187.9	68.7
$PbO_2(s)$	−277.4	−217.3	68.6
$PbCl_2(s)$	−359.4	−314.1	136.0
PbS(s)	−100.4	−98.7	91.2
$PbSO_4(s)$	−920.0	−813.0	148.5
$PbCO_3(s)$	−699.1	−625.5	131.0
$Pb(NO_3)_2(s)$	−451.9	—	—
$Pb(NO_3)_2(aq)$	−416.3	−246.9	303.3
Lithium:			
Li(s)	0.0	0.0	29.1
Li(g)	159.3	126.6	138.8
$Li^+(aq)$	−278.5	−293.3	13.4
LiCl(s)	−408.6	−384.4	59.3
$Li_2O(s)$	−597.9	−561.2	37.6
Magnesium:			
Mg(s)	0.0	0.0	32.7

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
Mg(g)	147.1	112.5	148.6
$MgCl_2$(s)	−641.3	−591.8	89.6
MgO(s)	−601.6	−569.3	27.0
$Mg(OH)_2$(s)	−924.5	−833.5	63.2
$MgSO_4$(s)	−1284.9	−1170.6	91.6
MgS(s)	−346.0	−341.8	50.3
Manganese:			
Mn(s)	0.0	0.0	32.0
Mn(g)	280.7	238.5	173.7
$MnCl_2$(s)	−481.3	−440.5	118.2
MnO(s)	−385.2	−362.9	59.7
MnO_2(s)	−520.0	−465.1	53.1
$KMnO_4$(s)	−837.2	−737.6	171.7
MnO_4^-(aq)	−541.4	−447.2	191.2
Mercury:			
Hg(l)	0.0	0.0	75.9
Hg(g)	61.4	31.8	175.0
$HgCl_2$(s)	−224.3	−178.6	146.0
Hg_2Cl_2(s)	−265.4	−210.7	191.6
HgO(s)	−90.8	−58.5	70.3
HgS(s, red)	−58.2	−50.6	82.4
Hg_2(g)	108.8	68.2	288.1
Molybdenum:			
Mo(s)	0.0	0.0	28.7
Mo(g)	658.1	612.5	182.0
MoO_2(s)	−588.9	−533.0	46.3
MoO_3(s)	−745.1	−668.0	77.7
Nickel:			
Ni(s)	0.0	0.0	29.9

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
Ni(g)	429.7	384.5	182.2
$NiCl_2$(s)	−305.3	−259.0	97.7
$Ni(OH)_2$(s)	−529.7	−447.2	88.0
Nitrogen:			
N(g)	472.7	455.5	153.3
N_2(g)	0.0	0.0	191.6
NH_3(g)	−45.9	−16.4	192.8
NH_4^+(aq)	−132.5	−79.3	113.4
N_2H_4(l)	50.6	149.3	121.2
N_2H_4(g)	95.4	159.4	238.5
NH_4Cl(s)	−314.4	−202.9	94.6
NH_4OH(l)	−361.2	−254.0	165.6
NH_4NO_3(s)	−365.6	−183.9	151.1
$(NH_4)_2SO_4$(s)	−1180.9	−901.7	220.1
NO(g)	91.3	87.6	210.8
NO_2(g)	33.2	51.3	240.1
N_2O(g)	81.6	103.7	220.0
N_2O_4(l)	−19.5	97.5	209.2
N_2O_4(g)	11.1	99.8	304.4
HNO_2(g)	−79.5	−46.0	254.1
HNO_3(l)	−174.1	−80.7	155.6
HNO_3(g)	−133.9	−73.5	266.9
HNO_3(aq)	−207.4	−111.3	146.4
NF_3(g)	−132.1	−90.6	260.8
HCN(l)	108.9	125.0	112.8
HCN(g)	135.1	124.7	201.8
Osmium:			
Os(s)	0.0	0.0	32.6

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
Os(g)	791.0	745.0	192.6
OsO_4(s)	−394.1	−304.9	143.9
OsO_4(g)	−337.2	−292.8	293.8
Oxygen:			
O(g)	249.2	231.7	161.1
O_2(g)	0.0	0.0	205.2
O_3(g)	142.7	163.2	238.9
OH^-(aq)	−230.0	−157.2	−10.8
H_2O(l)	−285.8	−237.1	70.0
H_2O(g)	−241.8	−228.6	188.8
H_2O_2(l)	−187.8	−120.4	109.6
H_2O_2(g)	−136.3	−105.6	232.7
Phosphorus:			
P(s, white)	0.0	0.0	41.1
P(s, red) −17.6	−17.6	−12.5	22.8
P(s, black)	−39.3	—	—
P(g, white)	316.5	280.1	163.2
P_2(g)	144.0	103.5	218.1
P_4(g)	58.9	24.4	280.0
PCl_3(l)	−319.7	−272.3	217.1
PCl_3(g)	−287.0	−267.8	311.8
$POCl_3$(l)	−597.1	−520.8	222.5
$POCl_3$(g)	−558.5	−512.9	325.5
PCl_5(g)	−374.9	−305.0	364.6
PH_3(g)	5.4	13.5	210.2
H_3PO_4(s)	−1284.4	−1124.3	110.5
H_3PO_4(l)	−1271.7	−1123.6	150.8
Potassium:			

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
K(s)	0.0	0.0	64.7
K(g)	89.0	60.5	160.3
KBr(s)	−393.8	−380.7	95.9
KCl(s)	−436.5	−408.5	82.6
$KClO_3$(s)	−397.7	−296.3	143.1
K_2O(s)	−361.5	−322.1	94.1
K_2O_2(s)	−494.1	−425.1	102.1
KNO_2(s)	−369.8	−306.6	152.1
KNO_3(s)	−494.6	−394.9	133.1
KSCN(s)	−200.2	−178.3	124.3
K_2CO_3(s)	−1151.0	−1063.5	155.5
K_2SO_4(s)	−1437.8	−1321.4	175.6
Rubidium:			
Rb(s)	0.0	0.0	76.8
Rb(g)	80.9	53.1	170.1
RbCl(s)	−435.4	−407.8	95.9
Selenium:			
Se(s, gray)	0.0	0.0	42.4
Se(g, gray)	227.1	187.0	176.7
H_2Se(g)	29.7	15.9	219.0
Silicon:			
Si(s)	0.0	0.0	18.8
Si(g)	450.0	405.5	168.0
$SiCl_4$(l)	−687.0	−619.8	239.7
$SiCl_4$(g)	−657.0	−617.0	330.7
SiH_4(g)	34.3	56.9	204.6
SiC(s, cubic)	−65.3	−62.8	16.6
SiC(s, hexagonal)	−62.8	−60.2	16.5
Silver:			

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
Ag(s)	0.0	0.0	42.6
Ag(g)	284.9	246.0	173.0
Ag^+(aq)	105.6	77.1	72.7
AgBr(s)	−100.4	−96.9	107.1
AgCl(s)	−127.0	−109.8	96.3
$AgNO_3$(s)	−124.4	−33.4	140.9
Ag_2O(s)	−31.1	−11.2	121.3
Ag_2S(s)	−32.6	−40.7	144.0
Sodium:			
Na(s)	0.0	0.0	51.3
Na(g)	107.5	77.0	153.7
Na^+(aq)	−240.1	−261.9	59.0
NaF(s)	−576.6	−546.3	51.1
NaF(aq)	−572.8	−540.7	45.2
NaCl(s)	−411.2	−384.1	72.1
NaCl(aq)	−407.3	−393.1	115.5
NaBr(s)	−361.1	−349.0	86.8
NaBr(g)	−143.1	−177.1	241.2
NaBr(aq)	−361.7	−365.8	141.4
NaO_2(s)	−260.2	−218.4	115.9
Na_2O(s)	−414.2	−375.5	75.1
Na_2O_2(s)	−510.9	−447.7	95.0
NaCN(s)	−87.5	−76.4	115.6
$NaNO_3$(aq)	−447.5	−373.2	205.4
$NaNO_3$(s)	−467.9	−367.0	116.5
NaN_3(s)	21.7	93.8	96.9
Na_2CO_3(s)	−1130.7	−1044.4	135.0
Na_2SO_4(s)	−1387.1	−1270.2	149.6
Sulfur:			

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
S(s, rhombic)	0.0	0.0	32.1
S(g, rhombic)	277.2	236.7	167.8
$SO_2(g)$	−296.8	−300.1	248.2
$SO_3(g)$	−395.7	−371.1	256.8
$SO_4^{2-}(aq)$	−909.3	−744.5	20.1
$SOCl_2(g)$	−212.5	−198.3	309.8
$H_2S(g)$	−20.6	−33.4	205.8
$H_2SO_4(aq)$	−909.3	−744.5	20.1
Tin:			
Sn(s, white)	0.0	0.0	51.2
Sn(s, gray)	−2.1	0.1	44.1
Sn(g, white)	301.2	266.2	168.5
$SnCl_4(l)$	−511.3	−440.1	258.6
$SnCl_4(g)$	−471.5	−432.2	365.8
$SnO_2(s)$	−557.6	−515.8	49.0
Titanium:			
Ti(s)	0.0	0.0	30.7
Ti(g)	473.0	428.4	180.3
$TiCl_2(s)$	−513.8	−464.4	87.4
$TiCl_3(s)$	−720.9	−653.5	139.7
$TiCl_4(l)$	−804.2	−737.2	252.3
$TiCl_4(g)$	−763.2	−726.3	353.2
$TiO_2(s)$	−944.0	−888.8	50.6
Uranium:			
U(s)	0.0	0.0	50.2
U(g)	533.0	488.4	199.8
$UO_2(s)$	−1085.0	−1031.8	77.0
$UO_2(g)$	−465.7	−471.5	274.6

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol K)
$UF_4(s)$	−1914.2	−1823.3	151.7
$UF_4(g)$	−1598.7	−1572.7	368.0
$UF_6(s)$	−2197.0	−2068.5	227.6
$UF_6(g)$	−2147.4	−2063.7	377.9
Vanadium:			
V(s)	0.0	0.0	28.9
V(g)	514.2	754.4	182.3
$VCl_3(s)$	−580.7	−511.2	131.0
$VCl_4(l)$	−569.4	−503.7	255.0
$VCl_4(g)$	−525.5	−492.0	362.4
$V_2O_5(s)$	−1550.6	−1419.5	131.0
Zinc:			
Zn(s)	0.0	0.0	41.6
Zn(g)	130.4	94.8	161.0
$ZnCl_2(s)$	−415.1	−369.4	111.5
$Zn(NO_3)_2(s)$	−483.7	—	—
ZnS(s, sphalerite)	−206.0	−201.3	57.7
$ZnSO_4(s)$	−982.8	−871.5	110.5
Zirconium:			
Zr(s)	0.0	0.0	39.0
Zr(g)	608.8	566.5	181.4
$ZrCl_2(s)$	−502.0	−386	110
$ZrCl_4(s)$	−980.5	−889.9	181.6

Source of data: *CRC Handbook of Chemistry and Physics*, 84th Edition (2004).