

Selected Thermodynamic Values*

Table 20 • Selected Thermodynamic Values*

Species	ΔH_f° (298.15 K) kJ/mol	S° (298.15 K) J/K · mol	ΔG_f° (298.15 K) kJ/mol
<i>Aluminum</i>			
Al(s)	0	28.3	0
AlCl ₃ (s)	-705.63	109.29	-630.0
Al ₂ O ₃ (s)	-1675.7	50.92	-1582.3
<i>Barium</i>			
BaCl ₂ (s)	-858.6	123.68	-810.4
BaCO ₃ (s)	-1213	112.1	-1134.41
BaO(s)	-548.1	72.05	-520.38
BaSO ₄ (s)	-1473.2	132.2	-1362.2
<i>Boron</i>			
BCl ₃ (g)	-402.96	290.17	-387.95
<i>Beryllium</i>			
Be(s)	0	9.5	0
Be(OH) ₂ (s)	-902.5	51.9	-815.0
<i>Bromine</i>			
Br(g)	111.884	175.022	82.396
Br ₂ (l)	0	152.2	0
Br ₂ (g)	30.91	245.42	3.12
BrF ₃ (g)	-255.60	292.53	-229.43
HBr(g)	-36.29	198.70	-53.45
<i>Calcium</i>			
Ca(s)	0	41.59	0
Ca(g)	178.2	158.884	144.3
Ca ²⁺ (g)	1925.90	—	—
CaC ₂ (s)	-59.8	70.	-64.93
CaCO ₃ (s, calcite)	-1207.6	91.7	-1129.16

(continues)

Species	ΔH_f° (298.15 K) kJ/mol	S° (298.15 K) J/K · mol	ΔG_f° (298.15 K) kJ/mol
CaCl ₂ (s)	-795.8	104.6	-748.1
CaF ₂ (s)	-1219.6	68.87	-1167.3
CaH ₂ (s)	-186.2	42	-147.2
CaO(s)	-635.09	38.2	-603.42
CaS(s)	-482.4	56.5	-477.4
Ca(OH) ₂ (s)	-986.09	83.39	-898.43
Ca(OH) ₂ (aq)	-1002.82	-74.5	-868.07
CaSO ₄ (s)	-1434.52	106.5	-1322.02
<i>Carbon</i>			
C(s, graphite)	0	5.6	0
C(s, diamond)	1.8	2.377	2.900
C(g)	716.67	158.1	671.2
CCl ₄ (l)	-128.4	214.39	-57.63
CCl ₄ (g)	-95.98	309.65	-53.61
CHCl ₃ (l)	-134.47	201.7	-73.66
CHCl ₃ (g)	-103.18	295.61	-70.4
CH ₄ (g, methane)	-74.87	186.26	-50.8
C ₂ H ₂ (g, ethyne)	226.73	200.94	209.20
C ₂ H ₄ (g, ethene)	52.47	219.36	68.35
C ₂ H ₆ (g, ethane)	-83.85	229.2	-31.89
C ₃ H ₈ (g, propane)	-104.7	270.3	-24.4
C ₆ H ₆ (l, benzene)	48.95	173.26	124.21
CH ₃ OH(l, methanol)	-238.4	127.19	-166.14
CH ₃ OH(g, methanol)	-201	126.8	-161.96
C ₂ H ₅ OH(l, ethanol)	-277.0	160.7	-174.7
C ₂ H ₅ OH(g, ethanol)	-235.3	282.70	-168.49
CO(g)	-110.525	197.674	-137.168
CO ₂ (g)	-393.509	213.74	-394.359
CS ₂ (l)	89.41	151	65.2
CS ₂ (g)	116.7	237.8	66.61
COCl ₂ (g)	-218.8	283.53	-204.6
<i>Cesium</i>			
Cs(s)	0	85.23	0
Cs ⁺ (g)	457.964	—	—
CsCl(s)	-443.04	101.17	-414.53
<i>Chlorine</i>			
Cl(g)	121.3	165.19	105.3
Cl ⁻ (g)	-233.13	—	—
Cl ₂ (g)	0	223.08	0
HCl(g)	-92.31	186.2	-95.09
HCl(aq)	-167.159	56.5	-131.26

Species	ΔH_f° (298.15 K) kJ/mol	S° (298.15 K) J/K · mol	ΔG_f° (298.15 K) kJ/mol	Species	ΔH_f° (298.15 K) kJ/mol	S° (298.15 K) J/K · mol	ΔG_f° (298.15 K) kJ/mol
Chromium				PbO(s, yellow)			
Cr(s)	0	23.62	0	PbO ₂ (s)	-219	66.5	-196
Cr ₂ O ₃ (s)	-1134.7	80.65	-1052.95	PbS(s)	-277.4	68.6	-217.39
CrCl ₃ (s)	-556.5	123.0	-486.1	Lithium	-100.4	91.2	-98.7
Copper				Li(s)	0		
Cu(s)	0	33.17	0	Li ⁺ (g)	685.783	29.12	0
CuO(s)	-156.06	42.59	-128.3	LiOH(s)	-484.93	—	—
CuCl ₂ (s)	-220.1	108.07	-175.7	LiOH(aq)	-508.48	42.81	-438.96
CuSO ₄ (s)	-769.98	109.05	-660.75	LiCl(s)	-408.701	2.80	-450.58
Fluorine				Magnesium		59.33	-384.37
F ₂ (g)	0	202.8	0	Mg(s)	0	32.67	0
F(g)	78.99	158.754	61.91	MgCl ₂ (s)	-641.62	89.62	-592.09
F ⁻ (g)	-255.39	—	—	MgCO ₃ (s)	-1111.69	65.84	-1028.2
F ⁻ (aq)	-332.63	-13.8	-278.79	MgO(s)	-601.24	26.85	-568.93
HF(g)	-271.1	173.779	-273.2	Mg(OH) ₂ (s)	-924.54	63.18	-833.51
HF(aq)	-332.63	88.7	-278.79	MgS(s)	-346.0	50.33	-341.8
Hydrogen				Mercury			
H ₂ (g)	0	130.7	0	Hg(l)	0	76.02	0
H(g)	217.965	114.713	203.247	HgCl ₂ (s)	-224.3	146.0	-178.6
H ⁺ (g)	1536.202	—	—	HgO(s, red)	-90.83	70.29	-58.539
H ₂ O(l)	-285.83	69.95	-237.15	HgS(s, red)	-58.2	82.4	-50.6
H ₂ O(g)	-241.83	188.84	-228.59	Nickel			
H ₂ O ₂ (l)	-187.78	109.6	-120.35	Ni(s)	0	29.87	0
Iodine				NiO(s)	-239.7	37.99	-211.7
I ₂ (s)	0	116.135	0	NiCl ₂ (s)	-305.332	97.65	-259.032
I ₂ (g)	62.438	260.69	19.327	Nitrogen			
I(g)	106.838	180.791	70.250	N ₂ (g)	0	191.56	0
I ⁻ (g)	-197	—	—	N(g)	472.704	153.298	455.563
ICl(g)	17.51	247.56	-5.73	NH ₃ (g)	-45.90	192.77	-16.37
Iron				N ₂ H ₄ (l)	50.63	121.52	149.45
Fe(s)	0	27.78	0	NH ₄ Cl(s)	-314.55	94.85	-203.08
FeO(s)	-272	—	—	NH ₄ Cl(aq)	-299.66	169.9	-210.57
Fe ₂ O ₃ (s, hematite)	-824.2	87.40	-742.2	NH ₄ NO ₃ (s)	-365.56	151.08	-183.84
Fe ₃ O ₄ (s, magnetite)	-1118.4	146.4	-1015.4	NH ₄ NO ₃ (aq)	-339.87	259.8	-190.57
FeCl ₂ (s)	-341.79	117.95	-302.30	NO(g)	90.29	210.76	86.58
FeCl ₃ (s)	-399.49	142.3	-344.00	NO ₂ (g)	33.1	240.04	51.23
FeS ₂ (s, pyrite)	-178.2	52.93	-166.9	N ₂ O(g)	82.05	219.85	104.20
Fe(CO) ₅ (l)	-774.0	338.1	-705.3	N ₂ O ₄ (g)	9.08	304.38	97.73
Lead				NOCl(g)	51.71	261.8	66.08
Pb(s)	0	64.81	0	HNO ₃ (l)	-174.10	155.60	-80.71
PbCl ₂ (s)	-359.41	136.0	-314.10	HNO ₃ (g)	-135.06	266.38	-74.72

Species	ΔH_f° (298.15 K) kJ/mol	S° (298.15 K) J/K · mol	ΔG_f° (298.15 K) kJ/mol
HN₃(aq)	-207.36	146.4	-111.25
Oxygen			
O ₂ (g)	0	205.07	0
O(g)	249.170	161.055	231.731
O ₃ (g)	142.67	238.92	163.2
Phosphorus			
P ₄ (s, white)	0	41.1	0
P ₄ (s, red)	-17.6	22.80	-12.1
P(g)	314.64	163.193	278.25
PH ₃ (g)	22.89	210.24	30.91
PCl ₃ (g)	-287.0	311.78	-267.8
P ₄ O ₁₀ (s)	-2984.0	228.86	-2697.7
H ₃ PO ₄ (ℓ)	-1279.0	110.5	-1119.1
Potassium			
K(s)	0	64.63	0
KCl(s)	-436.68	82.56	-408.77
KClO ₃ (s)	-397.73	143.1	-296.25
KI(s)	-327.90	106.32	-324.892
KOH(s)	-424.72	78.9	-378.92
KOH(aq)	-482.37	91.6	-440.50
Silicon			
Si(s)	0	18.82	0
SiBr ₄ (ℓ)	-457.3	277.8	-443.9
SiC(s)	-65.3	16.61	-62.8
SiCl ₄ (g)	-662.75	330.86	-622.76
SiH ₄ (g)	34.31	204.65	56.84
SiF ₄ (g)	-1614.94	282.49	-1572.65
SiO ₂ (s, quartz)	-910.86	41.46	-856.97
Silver			
Ag(s)	0	42.55	0
Ag ₂ O(s)	-31.1	121.3	-11.32
AgCl(s)	-127.01	96.25	-109.76
AgNO ₃ (s)	-124.39	140.92	-33.41
Sodium			
Na(s)	0	51.21	0
Na(g)	107.3	153.765	76.83
Na ⁺ (g)	609.358	—	—
NaBr(s)	-361.02	86.82	-348.983
NaCl(s)	-411.12	72.11	-384.04
NaCl(g)	-181.42	229.79	-201.33
NaCl(aq)	-407.27	115.5	-393.133
Species	ΔH_f° (298.15 K) kJ/mol	S° (298.15 K) J/K · mol	ΔG_f° (298.15 K) kJ/mol
NaOH(s)	-425.93	64.46	-379.75
NaOH(aq)	-469.15	48.1	-418.09
Na ₂ CO ₃ (s)	-1130.77	134.79	-1048.08
Sulfur			
S(s, rhombic)	0	32.1	0
S(g)	278.98	167.83	236.51
S ₂ Cl ₂ (g)	-18.4	331.5	-31.8
SF ₆ (g)	-1209	291.82	-1105.3
H ₂ S(g)	-20.63	205.79	-33.56
SO ₂ (g)	-296.84	248.21	-300.13
SO ₃ (g)	-395.77	256.77	-371.04
SOCl ₂ (g)	-212.5	309.77	-198.3
H ₂ SO ₄ (ℓ)	-814	156.9	-689.96
H ₂ SO ₄ (aq)	-909.27	20.1	-744.53
Tin			
Sn(s, white)	0	51.08	0
Sn(s, gray)	-2.09	44.14	0.13
SnCl ₄ (ℓ)	-511.3	258.6	-440.15
SnCl ₄ (g)	-471.5	365.8	-432.31
SnO ₂ (s)	-577.63	49.04	-515.88
Titanium			
Ti(s)	0	30.72	0
TiCl ₄ (ℓ)	-804.2	252.34	-737.2
TiCl ₄ (g)	-763.16	354.84	-726.7
TiO ₂ (s)	-939.7	49.92	-884.5
Zinc			
Zn(s)	0	41.63	0
ZnCl ₂ (s)	-415.05	111.46	-369.398
ZnO(s)	-348.28	43.64	-318.30
ZnS(s, sphalerite)	-205.98	57.7	-201.29