

THERMODYNAMIC VALUES FOR SUBSTANCES AT 298.15 K (25°C)

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol-K)
Aluminum			
Al _(s)	0	0	28.3
AlCl _{3(s)}	-705.6	-630.0	109.3
Al ₂ O _{3(s)}	-1669.8	-1576.5	51.0
Barium			
Ba _(s)	0	0	63.2
BaCO _{3(s)}	-1216.3	-1137.6	112.1
BaO _(s)	-553.5	-525.1	70.4
Beryllium			
Be _(s)	0	0	9.44
BeO _(s)	-608.4	-579.1	13.8
Be(OH) _{2(s)}	-905.8	-817.9	50.2
Bromine			
Br _(g)	111.8	82.4	174.9
Br ⁻ _(aq)	-120.9	-102.8	80.7
Br _{2(g)}	30.7	3.14	245.3
Br _{2(l)}	0	0	152.3
HBr _(g)	-36.2	-53.2	198.5
Calcium			
Ca _(g)	179.3	145.5	154.8
Ca _(s)	0	0	41.4
CaCO _{3(s, calcite)}	-1207.1	1128.8	92.9
CaCl _{2(s)}	-795.8	-748.1	104.6
CaF _{2(s)}	-1219.6	-1167.3	68.9
CaO _(s)	-635.5	-604.2	39.8
Ca(OH) _{2(s)}	-986.2	-898.5	83.4
CaSO _{4(s)}	-1434.0	-1321.8	106.7
Carbon			
C _(g)	718.4	672.9	158.0

$C_{(s, \text{diamond})}$	1.88	2.84	2.43
$C_{(s, \text{graphite})}$	0	0	5.69
$CCl_{4(g)}$	-106.7	-64.0	309.4
$CCl_{4(l)}$	-139.3	-68.6	214.4
$CF_{4(g)}$	-679.9	-635.1	262.3
$CH_{4(g)}$	-74.8	-50.8	186.3
$C_2H_2(g)$	226.7	209.2	200.8
$C_2H_4(g)$	52.3	68.1	219.4
$C_2H_6(g)$	-84.7	-32.9	229.5
$C_3H_8(g)$	-103.9	-23.5	269.9
$C_4H_{10(g)}$	-124.7	-15.7	310.0
$C_4H_{10(l)}$	-147.6	-15.0	231.0
$C_6H_6(g)$	82.9	129.7	269.2
$C_6H_6(l)$	49.0	124.5	172.8
$CH_3OH(g)$	-201.2	-161.9	237.6
$CH_3OH(l)$	-238.6	-166.2	126.8
$C_2H_5OH(g)$	-235.1	-168.5	282.7
$C_2H_5OH(l)$	-277.7	-174.8	160.7
$C_6H_{12}O_6(s)$	-1273.0	-910.4	212.1
$CO(g)$	-110.5	-137.2	197.9
$CO_2(g)$	-393.5	-394.4	213.6
$HC_2H_3O_2(l)$	-487.0	-392.4	159.8
Cesium			
$Cs(g)$	76.5	49.5	175.6
$Cs(l)$	2.09	0.03	92.1
$Cs(s)$	0	0	85.2
$CsCl(s)$	-442.8	-414.4	101.2
Chlorine			
$Cl(g)$	121.7	105.7	165.2
$Cl_{(aq)}$	-167.2	-131.2	56.5
$Cl_{2(g)}$	0	0	223.0
$HCl_{(aq)}$	-167.2	-131.2	56.5
$HCl(g)$	-92.3	-95.3	186.7

Chromium			
$\text{Cr}_{(g)}$	397.5	352.6	174.2
$\text{Cr}_{(s)}$	0	0	23.6
$\text{Cr}_2\text{O}_{3(s)}$	-1139.7	-1058.1	81.2
Cobalt			
$\text{Co}_{(g)}$	439	393	179
$\text{Co}_{(s)}$	0	0	28.4
Copper			
$\text{Cu}_{(g)}$	338.4	298.6	166.3
$\text{Cu}_{(s)}$	0	0	33.3
$\text{CuCl}_{2(s)}$	-205.9	-161.7	108.1
$\text{CuO}_{(s)}$	-156.1	-128.3	42.6
$\text{Cu}_2\text{O}_{(s)}$	-170.7	-147.9	92.4
Fluorine			
$\text{F}_{(g)}$	80.0	61.9	158.7
$\text{F}_{(aq)}^-$	-332.6	-278.8	-13.8
$\text{F}_{2(g)}$	0	0	202.7
$\text{HF}_{(g)}$	-268.6	-270.7	173.5
Hydrogen			
$\text{H}_{(g)}$	217.9	203.3	114.6
$\text{H}_{(aq)}^+$	0	0	0
$\text{H}_{(g)}^+$	1536.2	1517.0	108.9
$\text{H}_{2(g)}$	0	0	130.6
Iodine			
$\text{I}_{(g)}$	106.6	70.2	180.7
$\text{I}_{(aq)}^-$	-55.2	-51.6	111.3
$\text{I}_{2(g)}$	62.3	19.4	260.6
$\text{I}_{2(s)}$	0	0	116.7
$\text{HI}_{(g)}$	25.9	1.30	206.3
Iron			
$\text{Fe}_{(g)}$	415.5	369.8	180.5
$\text{Fe}_{(s)}$	0	0	27.2
$\text{Fe}_{(aq)}^{2+}$	-87.9	-84.9	113.4

$\text{Fe}^{3+}_{(\text{aq})}$	-47.7	-10.5	293.3
$\text{FeCl}_{2(\text{s})}$	-341.8	-302.3	117.9
$\text{FeCl}_{3(\text{s})}$	-400	-334	142.3
$\text{FeO}_{(\text{s})}$	-271.9	-255.2	60.8
$\text{Fe}_2\text{O}_{3(\text{s})}$	-822.2	-741.0	90.0
$\text{Fe}_3\text{O}_{4(\text{s})}$	-1117.1	-1014.2	146.4
$\text{FeS}_{2(\text{s})}$	-171.5	-160.1	52.9

Lead

$\text{Pb}_{(\text{s})}$	0	0	68.9
$\text{PbBr}_{2(\text{s})}$	-277.4	-260.7	161
$\text{PbCO}_{3(\text{s})}$	-699.1	-625.5	131.0
$\text{Pb}(\text{NO}_3)_{2(\text{aq})}$	-421.3	-246.9	303.3
$\text{Pb}(\text{NO}_3)_{2(\text{s})}$	-451.9	—	—
$\text{PbO}_{(\text{s})}$	-217.3	-187.9	68.7

Lithium

$\text{Li}_{(\text{g})}$	159.3	126.6	138.8
$\text{Li}_{(\text{s})}$	0	0	29.1
$\text{Li}^{+}_{(\text{aq})}$	-278.5	-273.4	12.2
$\text{Li}^{+}_{(\text{g})}$	685.7	648.5	133.0
$\text{LiCl}_{(\text{s})}$	-408.3	-384.0	59.3

Magnesium

$\text{Mg}_{(\text{g})}$	147.1	112.5	148.6
$\text{Mg}_{(\text{s})}$	0	0	32.5
$\text{MgCl}_{2(\text{s})}$	-641.6	-592.1	89.6
$\text{MgO}_{(\text{s})}$	-601.8	-569.6	26.8
$\text{Mg}(\text{OH})_{2(\text{s})}$	-924.7	-833.7	63.2

Manganese

$\text{Mn}_{(\text{g})}$	280.7	238.5	173.6
$\text{Mn}_{(\text{s})}$	0	0	32.0
$\text{MnO}_{(\text{s})}$	-385.2	-362.9	59.7
$\text{MnO}_{2(\text{s})}$	-519.6	-464.8	53.1
$\text{MnO}_4^{-}_{(\text{aq})}$	-541.4	-447.2	191.2

Mercury

$\text{Hg}_{(\text{g})}$	60.8	31.8	174.9
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Hg(l)	0	0	77.4
HgCl _{2(s)}	-230.1	-184.0	144.5
Hg ₂ Cl _{2(s)}	-264.9	-210.5	192.5
Nickel			
Ni(g)	429.7	384.5	182.1
Ni(s)	0	0	29.9
NiCl _{2(s)}	-305.3	-259.0	97.65
NiO(s)	-239.7	-211.7	38.0
Nitrogen			
N(g)	472.7	455.5	153.3
N _{2(g)}	0	0	191.5
NH _{3(aq)}	-80.3	-26.5	111.3
NH _{3(g)}	-46.2	-16.7	192.5
NH ₄ ⁺ (aq)	-132.5	-79.3	113.4
N ₂ H _{4(g)}	95.4	159.4	238.5
NH ₄ CN(s)	0.0	—	—
NH ₄ Cl(s)	-314.4	-203.0	94.6
NH ₄ NO _{3(s)}	-365.6	-184.0	151
NO(g)	90.4	86.7	210.6
NO _{2(g)}	33.8	51.8	240.5
N ₂ O(g)	81.6	103.6	220.0
N ₂ O _{4(g)}	9.66	98.3	304.3
NOCl(g)	52.6	66.3	264
HNO _{3(aq)}	-206.6	-110.5	146
HNO _{3(g)}	-134.3	-73.9	266.4
Oxygen			
O(g)	247.5	230.1	161.0
O _{2(g)}	0	0	205.0
O _{3(g)}	142.3	163.4	237.6
OH ⁻ (aq)	-230.0	-157.3	-10.7
H ₂ O(g)	-241.8	-228.6	188.8
H ₂ O(l)	-285.8	-237.1	69.9
H ₂ O _{2(g)}	-136.1	-105.5	232.9
H ₂ O _{2(l)}	-187.8	-120.4	109.6

Phosphorus

$P_{(g)}$	316.4	280.0	163.2
$P_{2(g)}$	144.3	103.7	218.1
$P_{4(g)}$	58.9	24.4	280
$P_{4(s, \text{red})}$	-17.5	-12.0	22.9
$P_{4(s, \text{white})}$	0	0	41.1
$PCl_{3(g)}$	-288.1	-269.6	311.7
$PCl_{3(l)}$	-319.6	-272.4	217
$PF_{5(g)}$	-1594.4	-1520.7	300.8
$PH_{3(g)}$	5.4	13.4	210.2
$P_4O_{6(s)}$	-1640.1	—	—
$P_4O_{10(s)}$	-2940.1	-2675.2	228.9
$POCl_{3(g)}$	542.2	-502.5	325
$POCl_{3(l)}$	-597.0	-520.9	222
$H_3PO_{4(aq)}$	-1288.3	-1142.6	158.2

Potassium

$K_{(g)}$	90.0	61.17	160.2
$K_{(s)}$	0	0	64.7
$KCl_{(s)}$	-435.9	-408.3	82.7
$KClO_{3(s)}$	-391.2	-289.9	143.0
$KClO_{3(aq)}$	-349.5	-284.9	265.7
$K_2CO_{3(s)}$	-1150.2	-1064.6	155.4
$KNO_{3(s)}$	-492.7	-393.1	288.1
$K_2O_{(s)}$	-363.2	-322.1	94.1
$KO_{2(s)}$	-284.5	-240.6	122.5
$K_2O_{2(s)}$	-495.8	-429.8	113.0
$KOH_{(s)}$	-424.7	-378.9	78.91
$KOH_{(aq)}$	-482.4	-440.5	91.6

Rubidium

$Rb_{(g)}$	85.8	55.8	170.0
$Rb_{(s)}$	0	0	76.8
$RbCl_{(s)}$	-430.5	-412.0	92
$RbClO_{3(s)}$	-392.4	-292.0	152

Scandium			
$\text{Sc}_{(g)}$	377.8	336.1	174.7
$\text{Sc}_{(s)}$	0	0	34.6
Selenium			
$\text{H}_2\text{Se}_{(g)}$	29.7	15.9	219.0
Silicon			
$\text{Si}_{(g)}$	368.2	323.9	167.8
$\text{Si}_{(s)}$	0	0	18.7
$\text{SiC}_{(s)}$	-73.2	-70.9	16.6
$\text{SiCl}_{4(l)}$	-640.1	-572.8	239.3
$\text{SiO}_{2(s, \text{quartz})}$	-910.9	-856.5	41.8
Silver			
$\text{Ag}_{(s)}$	0	0	42.6
$\text{Ag}^+_{(aq)}$	105.9	77.11	73.9
$\text{AgCl}_{(s)}$	-127.0	-109.7	96.1
$\text{Ag}_2\text{O}_{(s)}$	-31.1	-11.2	121.3
$\text{AgNO}_{3(s)}$	-124.4	-33.4	140.9
Sodium			
$\text{Na}_{(g)}$	107.7	77.3	153.7
$\text{Na}_{(s)}$	0	0	51.5
$\text{Na}^+_{(aq)}$	-240.1	-261.9	59.0
$\text{Na}^+_{(g)}$	609.3	574.3	148.0
$\text{NaBr}_{(aq)}$	-360.6	-364.7	141.0
$\text{NaBr}_{(s)}$	-361.4	-349.3	86.8
$\text{Na}_2\text{CO}_{3(s)}$	-1130.9	-1047.7	136.0
$\text{NaCl}_{(aq)}$	-407.1	-393.0	115.5
$\text{NaCl}_{(g)}$	-181.4	-201.3	229.8
$\text{NaCl}_{(s)}$	-410.9	-384.0	72.3
$\text{NaHCO}_{3(s)}$	-947.7	-851.8	102.1
$\text{NaNO}_{3(aq)}$	-446.2	-372.4	207
$\text{NaNO}_{3(s)}$	-467.9	-367.0	116.5
$\text{NaOH}_{(aq)}$	-469.6	-419.2	49.8

NaOH _(s)	-425.6	-379.5	64.5
Strontium			
SrO _(s)	-592.0	-561.9	54.9
Sr _(g)	164.4	110.0	164.6
Sulfur			
S _(s, rhombic)	0	0	31.88
S _{8(g)}	102.3	49.7	430.9
SO _{2(g)}	-296.9	-300.4	248.5
SO _{3(g)}	-395.2	-370.4	256.2
SO _{4²⁻(aq)}	-909.3	-744.5	20.1
SOCl _{2(l)}	-245.6	—	—
H ₂ S _(g)	-20.2	-33.0	205.6
H ₂ SO _{4(aq)}	-909.3	-744.5	20.1
H ₂ SO _{4(l)}	-814.0	-689.9	156.1
Titanium			
Ti _(g)	468	422	180.3
Ti _(s)	0	0	30.76
TiCl _{4(g)}	-763.2	-726.8	354.9
TiCl _{4(l)}	-804.2	-728.1	221.9
TiO _{2(s)}	-944.7	-889.4	50.29
Vanadium			
V _(g)	514.2	453.1	182.2
V _(s)	0	0	28.9
Zinc			
Zn _(g)	130.7	95.2	160.9
Zn _(s)	0	0	41.63
ZnCl _{2(s)}	-415.1	-369.4	111.5
ZnO _(s)	-348.0	-318.2	43.9