

Appendix C | Thermodynamic Quantities for Substances and Ions at 25°C

Substance or Ion	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol·K)	Substance or Ion	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol·K)
$e^-(g)$	0	0	20.87	CaO(s)	-635.1	-603.5	38.21
Aluminum				Ca(OH) ₂ (s)	-986.1	-898.4	83.39
Al(s)	0	0	28.28	Ca ₃ (PO ₄) ₂ (s)	-4120.8	-3884.8	236.0
Al ³⁺ (aq)	-531	-485	-321.7	CaSO ₄ (s)	-1434.1	-1321.9	106.7
AlCl ₃ (s)	-705.6	-630.0	109.3	Carbon			
Al ₂ O ₃ (s)	-1675.7	-1582.3	50.95	C(g)	716.7	671.3	158.0
Barium				C(s, diamond)	1.897	2.900	2.377
Ba(g)	179.1	147.0	170.1	C(s, graphite)	0	0	5.740
Ba(s)	0	0	62.48	CCl ₄ (g)	-95.98	-53.65	309.7
Ba ²⁺ (aq)	-537.6	-560.7	9.6	CCl ₄ (l)	-135.4	-65.27	216.4
BaCO ₃ (s)	-1216.3	-1137.6	112.1	CF ₄ (g)	-933.2	-888.5	261.3
BaCl ₂ (s)	-858.6	-810.3	123.7	CN ⁻ (aq)	151	166	118
Ba(NO ₃) ₂ (aq)	-952.4	-783.4	302.5	CO(g)	-110.5	-137.2	197.5
Ba(OH) ₂ (s)	-946.3	-859.3	107.1	CO ₂ (g)	-393.5	-394.4	213.7
Ba(OH) ₂ ·8H ₂ O(s)	-3342.2	-2793	427	CO ₃ ²⁻ (aq)	-677.1	-527.9	-56.9
BaSO ₄ (s)	-1473.2	-1362.3	132.2	CS ₂ (g)	116.9	66.85	237.9
Beryllium				CS ₂ (l)	89.70	65.27	151.3
Be(s)	0	0	9.440	COCl ₂ (g)	-220.1	-205.9	283.9
BeO(s)	-608.4	-579.1	13.77	HCN(aq)	150.6	172.4	94.1
Be(OH) ₂ (s)	-905.8	-817.9	50.21	HCN(g)	135.1	124.7	201.7
Boron				HCN(l)	108.9	124.9	112.8
B(s)	0	0	5.834	HCO ₃ ⁻ (aq)	-692.0	-586.8	91.2
BCl ₃ (l)	-427.2	-387.4	206	<i>Hydrocarbons</i>			
BF ₃ (g)	-1135.6	-1119.0	254.2	CH ₄ (g)	-74.87	-50.80	186.1
B ₂ O ₃ (s)	-1271.9	-1192.8	53.95	C ₂ H ₂ (g)	226.7	209.2	200.9
Bromine				C ₂ H ₄ (g)	52.47	68.39	219.2
Br(g)	111.9	82.40	174.9	C ₂ H ₆ (g)	-84.68	-32.89	229.5
Br ⁻ (aq)	-121.5	-104.0	82.4	C ₃ H ₈ (g)	-104.7	-23.6	270.2
Br ⁻ (g)	-219.0	-238.8	163.4	C ₄ H ₁₀ (g)	-125.6	-17.2	310.1
Br ₂ (g)	30.91	3.159	245.3	C ₆ H ₆ (g)	82.6	129.7	269.2
Br ₂ (l)	0	0	152.2	C ₆ H ₆ (l)	49.0	124.4	173.4
HBr(g)	-36.44	-53.50	198.6	<i>Alcohols</i>			
Calcium				CH ₃ OH(g)	-200.7	-162.0	239.7
Ca(g)	177.8	144.1	154.8	CH ₃ OH(l)	-238.7	-166.4	126.8
Ca(s)	0	0	41.59	C ₂ H ₅ OH(g)	-235.1	-168.6	282.6
Ca ⁺ (g)	773.8	732.1	160.5	C ₂ H ₅ OH(l)	-277.7	-174.9	160.7
Ca ²⁺ (aq)	-542.8	-553.5	-53.1	<i>Aldehydes</i>			
Ca ²⁺ (g)	1925.9	—	—	HCHO(g)	-117	-113	219.0
CaCO ₃ (s, calcite)	-1206.9	-1128.8	92.9	CH ₃ CHO(g)	-166.1	-133.4	246.4
CaCl ₂ (s)	-795.8	-748.1	104.6	CH ₃ CHO(l)	-191.8	-128.3	160.4
CaF ₂ (s)	-1225.9	-1173.5	68.57	<i>Carboxylic acids and ions</i>			
				HCOOH(aq)	-425.6	-351.0	92
				HCOOH(l)	-424.7	-361.4	129

Substance or Ion	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol·K)	Substance or Ion	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol·K)
$\text{Li}^+(aq)$	-278.5	-293.3	13.4	$\text{NH}_4\text{Cl}(s)$	-314.6	-203.1	94.86
$\text{Li}^+(g)$	685.7	648.5	132.9	$\text{NH}_4\text{NO}_3(s)$	-365.6	-184.0	151.1
$\text{LiBr}(s)$	-350.9	-341.6	74.06	$\text{NO}(g)$	90.29	86.60	210.6
$\text{LiCl}(s)$	-408.3	-384.0	59.30	$\text{NO}_2(g)$	33.10	51.24	239.9
$\text{LiF}(s)$	-616.9	-588.7	35.66	$\text{NO}_3^-(aq)$	-207.4	-111.3	146.4
$\text{LiI}(s)$	-270.1	-269.7	85.77	$\text{N}_2\text{O}(g)$	82.05	104.2	219.9
Magnesium				$\text{N}_2\text{O}_4(g)$	9.079	97.72	304.3
$\text{Mg}(g)$	147.1	112.6	148.5	$\text{N}_2\text{O}_4(l)$	-19.56	97.52	209.2
$\text{Mg}(s)$	0	0	32.67	$\text{NOCl}(g)$	51.71	66.08	261.6
$\text{Mg}^+(g)$	891.0	848.6	154.3	$\text{HNO}_3(aq)$	-207.4	-111.3	146.4
$\text{Mg}^{2+}(aq)$	-466.9	-454.8	-138.1	$\text{HNO}_3(g)$	-134.3	-73.99	266.3
$\text{Mg}^{2+}(g)$	2351	—	—	$\text{HNO}_3(l)$	-174.1	-80.79	155.6
$\text{MgCO}_3(s)$	-1111.7	-1028.1	65.85	Oxygen			
$\text{MgCl}_2(s)$	-641.6	-592.1	89.63	$\text{O}(g)$	249.2	231.8	160.9
$\text{Mg}_3\text{N}_2(s)$	-461.1	-400.9	87.86	$\text{O}_2(g)$	0	0	205.0
$\text{MgO}(s)$	-601.2	-568.9	26.92	$\text{O}_3(g)$	142.7	163.2	238.8
$\text{Mg(OH)}_2(s)$	-924.7	-833.7	63.24	$\text{OH}^-(aq)$	-230.0	-157.3	-10.75
Manganese				Phosphorus			
$\text{Mn}(g)$	283.3	241.0	173.6	$\text{P}(g)$	316.4	280.0	163.1
$\text{Mn}(s)$	0	0	32.01	$\text{P}(s, \text{red})$	-17.46	-12.03	22.85
$\text{MnO}(s)$	-385.2	-362.9	59.71	$\text{P}(s, \text{white})$	0	0	41.08
$\text{MnO}_2(s)$	-520.0	-465.2	53.05	$\text{P}_2(g)$	143.7	103.1	218.0
$\text{MnO}_4^-(aq)$	-541.4	-447.3	191.2	$\text{P}_4(g)$	58.91	24.45	279.9
Mercury				$\text{PCl}_3(g)$	-288.7	-269.6	311.6
$\text{Hg}(g)$	61.38	31.91	174.9	$\text{PCl}_5(g)$	-360.2	-290.3	364.2
$\text{Hg}(l)$	0	0	76.03	$\text{PF}_3(g)$	-1594.4	-1520.7	300.7
$\text{Hg}^{2+}(aq)$	171.1	164.4	-32.2	$\text{PH}_3(g)$	5.439	7.175	210.1
$\text{Hg}_2^{2+}(aq)$	172.3	153.6	84.5	$\text{P}_4\text{O}_{10}(s)$	-3009.9	-2723.3	228.8
$\text{HgCl}_2(s)$	-230.1	-184.0	144.5	$\text{PO}_4^{3-}(aq)$	-1277.4	-1018.8	-222
$\text{Hg}_2\text{Cl}_2(s)$	-265.2	-210.8	192.4	$\text{POCl}_3(g)$	-559.8	-514.3	325.3
$\text{HgO}(s)$	-90.79	-58.49	70.27	$\text{POCl}_3(l)$	-597.1	-520.9	222.5
Nickel				$\text{P}_4\text{S}_3(s)$	-224.6	-206.9	200.8
$\text{Ni}(g)$	430.1	384.7	182.1	$\text{HPO}_4^{2-}(aq)$	-1281	-1082	-36
$\text{Ni}(s)$	0	0	29.87	$\text{H}_2\text{PO}_4^-(aq)$	-1285	-1135	89.1
$\text{Ni}^{2+}(aq)$	-54.0	-45.6	-128.9	$\text{H}_3\text{PO}_4(aq)$	-1288.3	-1142.6	158.2
$\text{NiCl}_2(s)$	-304.9	-258.8	98.16	Potassium			
$\text{NiO}(s)$	-239.7	-211.7	37.99	$\text{K}(g)$	89.00	60.51	160.2
Nitrogen				$\text{K}(s)$	0	0	64.67
$\text{N}(g)$	472.7	455.6	153.2	$\text{K}^+(aq)$	-252.4	-283.3	102.5
$\text{N}_2(g)$	0	0	191.6	$\text{K}^+(g)$	514.0	481.0	154.5
$\text{NH}_3(aq)$	-80.29	-26.57	111.3	$\text{KBr}(s)$	-393.8	-380.4	95.94
$\text{NH}_3(g)$	-45.90	-16.40	192.7	$\text{KCl}(s)$	-436.7	-408.8	82.55
$\text{NH}_4^+(aq)$	-132.5	-79.37	113.4	$\text{KF}(s)$	-568.6	-538.9	66.55
$\text{N}_2\text{H}_4(g)$	95.35	159.2	238.6	$\text{KI}(s)$	-327.9	-323.0	106.4
$\text{N}_2\text{H}_4(l)$	50.63	149.4	121.4	$\text{KClO}_3(s)$	-397.7	-296.3	143.1

Substance or Ion	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol·K)	Substance or Ion	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol·K)
$K_2CO_3(s)$	-1150.2	-1064.5	155.5	$NaHCO_3(s)$	-950.8	-851.0	101.7
$KNO_3(s)$	-494.6	-394.9	133.1	$NaI(s)$	-287.9	-284.6	98.50
$K_2O(s)$	-363.2	-322.1	94.14	$NaNO_3(s)$	-467.9	-367.1	116.5
$KO_2(s)$	-284.5	-240.6	122.5	$NaOH(s)$	-425.9	-379.7	64.44
$K_2O_2(s)$	-495.8	-429.8	113.0	Strontium			
$KOH(s)$	-424.7	-378.9	78.91	$Sr(g)$	164.0	131.6	164.5
Rubidium				$Sr(s)$	0	0	55.69
$Rb(g)$	80.90	53.11	170.0	$Sr^+(g)$	719.7	679.3	170.3
$Rb(s)$	0	0	76.78	$Sr^{2+}(aq)$	-545.8	-559.4	-32.6
$RbBr(s)$	-394.6	-381.8	110.0	$Sr^{2+}(g)$	1790.6	—	—
$RbCl(s)$	-435.5	-407.8	95.90	$SrCO_3(s)$	-1220.1	-1140.1	97.1
$RbF(s)$	-549.4	—	75.3	$SrCl_2(s)$	-828.9	-781.2	114.9
$RbI(s)$	-333.8	-328.9	118.4	$SrO(s)$	-592.0	-561.4	55.52
Silicon				$SrSO_4(s)$	-1453.1	-1341.0	117
$Si(g)$	450.0	405.6	167.9	Sulfur			
$Si(s)$	0	0	18.82	$S(g)$	277.0	236.5	167.7
$SiC(s)$	-65.3	-62.8	16.61	$S(s, monoclinic)$	0.360	0.070	33.03
$SiCl_4(l)$	-687.0	-619.9	239.7	$S(s, rhombic)$	0	0	32.06
$SiF_4(g)$	-1614.9	-1572.7	282.7	$S^{2-}(aq)$	41.8	83.7	22
$SiO_2(s, quartz)$	-910.9	-856.4	41.46	$S_2(g)$	128.6	79.7	228.1
Silver				$S_8(g)$	100.4	48.61	430.2
$Ag(g)$	284.6	245.7	172.9	$SO_2(g)$	-296.8	-300.1	248.1
$Ag(s)$	0	0	42.55	$SO_3(g)$	-395.8	-371.0	256.7
$Ag^+(aq)$	105.6	77.12	72.68	$SO_4^{2-}(aq)$	-909.3	-744.6	20.1
$AgBr(s)$	-100.4	-96.90	107.1	$HS^-(aq)$	-17.7	12.6	61.1
$AgCl(s)$	-127.1	-109.8	96.2	$H_2S(aq)$	-39	-27.4	122
$AgF(s)$	-204.6	—	83.7	$H_2S(g)$	-20.50	-33.33	205.6
$AgI(s)$	-61.84	-66.19	115.5	$HSO_4^-(aq)$	-887.3	-756.0	131.8
$Ag_2O(s)$	-31.05	-11.21	121.3	$H_2SO_4(l)$	-814.0	-689.9	156.9
$Ag_2S(s)$	-32.59	-40.67	144.0	Tin			
$AgNO_3(s)$	-124.4	-33.47	140.9	$Sn(s, gray)$	-2.09	0.13	44.14
Sodium				$Sn(s, white)$	0	0	51.55
$Na(g)$	107.3	76.86	153.6	$SnCl_4(l)$	-511.3	-440.2	258.6
$Na(s)$	0	0	51.46	$SnO_2(s)$	-580.7	-519.7	52.3
$Na^+(aq)$	-240.1	-261.9	59.1	Zinc			
$Na^+(g)$	609.3	574.4	147.8	$Zn(g)$	130.4	94.89	160.9
$NaBr(s)$	-361.4	-349.3	86.82	$Zn(s)$	0	0	41.72
$Na_2CO_3(s)$	-1130.8	-1048.0	138.8	$Zn^{2+}(aq)$	-153.9	-147.0	-112.1
$NaCl(s)$	-411.1	-384.0	72.12	$ZnCl_2(s)$	-415.1	-369.4	111.5
$NaF(s)$	-575.4	-545.1	51.21	$ZnO(s)$	-348.3	-318.3	43.64
				$ZnS(s, sphalerite)$	-206.0	-201.3	-57.7