

# THERMODYNAMIC QUANTITIES FOR SELECTED SUBSTANCES AT 298.15 K (25 °C)

Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)	Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)
<b>Aluminum</b>				C <sub>2</sub> H <sub>4</sub> (g)	52.30	68.11	219.4
Al(s)	0	0	28.32	C <sub>2</sub> H <sub>6</sub> (g)	-84.68	-32.89	229.5
AlCl <sub>3</sub> (s)	-705.6	-630.0	109.3	C <sub>3</sub> H <sub>8</sub> (g)	-103.85	-23.47	269.9
Al <sub>2</sub> O <sub>3</sub> (s)	-1669.8	-1576.5	51.00	C <sub>4</sub> H <sub>10</sub> (g)	-124.73	-15.71	310.0
<b>Barium</b>				C <sub>4</sub> H <sub>10</sub> (l)	-147.6	-15.0	231.0
Ba(s)	0	0	63.2	C <sub>6</sub> H <sub>6</sub> (g)	82.9	129.7	269.2
BaCO <sub>3</sub> (s)	-1216.3	-1137.6	112.1	C <sub>6</sub> H <sub>6</sub> (l)	49.0	124.5	172.8
BaO(s)	-553.5	-525.1	70.42	CH <sub>3</sub> OH(g)	-201.2	-161.9	237.6
<b>Beryllium</b>				CH <sub>3</sub> OH(l)	-238.6	-166.23	126.8
Be(s)	0	0	9.44	C <sub>2</sub> H <sub>5</sub> OH(g)	-235.1	-168.5	282.7
BeO(s)	-608.4	-579.1	13.77	C <sub>2</sub> H <sub>5</sub> OH(l)	-277.7	-174.76	160.7
Be(OH) <sub>2</sub> (s)	-905.8	-817.9	50.21	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> (s)	-1273.02	-910.4	212.1
<b>Bromine</b>				CO(g)	-110.5	-137.2	197.9
Br(g)	111.8	82.38	174.9	CO <sub>2</sub> (g)	-393.5	-394.4	213.6
Br <sup>-</sup> (aq)	-120.9	-102.8	80.71	CH <sub>3</sub> COOH(l)	-487.0	-392.4	159.8
Br <sub>2</sub> (g)	30.71	3.14	245.3	<b>Cesium</b>			
Br <sub>2</sub> (l)	0	0	152.3	Cs(g)	76.50	49.53	175.6
HBr(g)	-36.23	-53.22	198.49	Cs(l)	2.09	0.03	92.07
<b>Calcium</b>				Cs(s)	0	0	85.15
Ca(g)	179.3	145.5	154.8	CsCl(s)	-442.8	-414.4	101.2
Ca(s)	0	0	41.4	<b>Chlorine</b>			
CaCO <sub>3</sub> (s, calcite)	-1207.1	-1128.76	92.88	Cl(g)	121.7	105.7	165.2
CaCl <sub>2</sub> (s)	-795.8	-748.1	104.6	Cl(aq)	-167.2	-131.2	56.5
CaF <sub>2</sub> (s)	-1219.6	-1167.3	68.87	Cl <sub>2</sub> (g)	0	0	222.96
CaO(s)	-635.5	-604.17	39.75	HCl(aq)	-167.2	-131.2	56.5
Ca(OH) <sub>2</sub> (s)	-986.2	-898.5	83.4	HCl(g)	-92.30	-95.27	186.69
CaSO <sub>4</sub> (s)	-1434.0	-1321.8	106.7	<b>Chromium</b>			
<b>Carbon</b>				Cr(g)	397.5	352.6	174.2
C(g)	718.4	672.9	158.0	Cr(s)	0	0	23.6
C(s, diamond)	1.88	2.84	2.43	Cr <sub>2</sub> O <sub>3</sub> (s)	-1139.7	-1058.1	81.2
C(s, graphite)	0	0	5.69	<b>Cobalt</b>			
CCl <sub>4</sub> (g)	-106.7	-64.0	309.4	Co(g)	439	393	179
CCl <sub>4</sub> (l)	-139.3	-68.6	214.4	Co(s)	0	0	28.4
CF <sub>4</sub> (g)	-679.9	-635.1	262.3	<b>Copper</b>			
CH <sub>4</sub> (g)	-74.8	-50.8	186.3	Cu(g)	338.4	298.6	166.3
C <sub>2</sub> H <sub>2</sub> (g)	226.77	209.2	200.8	Cu(s)	0	0	33.30

Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)	Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)
CuCl <sub>2</sub> (s)	-205.9	-161.7	108.1	MgO(s)	-601.8	-569.6	26.8
CuO(s)	-156.1	-128.3	42.59	Mg(OH) <sub>2</sub> (s)	-924.7	-833.7	63.24
Cu <sub>2</sub> O(s)	-170.7	-147.9	92.36	Manganese			
Fluorine				Mn(g)	280.7	238.5	173.6
F(g)	80.0	61.9	158.7	Mn(s)	0	0	32.0
F(aq)	-332.6	-278.8	-13.8	MnO(s)	-385.2	-362.9	59.7
F <sub>2</sub> (g)	0	0	202.7	MnO <sub>2</sub> (s)	-519.6	-464.8	53.14
HF(g)	-268.61	-270.70	173.51	MnO <sub>4</sub> <sup>-</sup> (aq)	-541.4	-447.2	191.2
Hydrogen				Mercury			
H(g)	217.94	203.26	114.60	Hg(g)	60.83	31.76	174.89
H <sup>+</sup> (aq)	0	0	0	Hg(l)	0	0	77.40
H <sup>+</sup> (g)	1536.2	1517.0	108.9	HgCl <sub>2</sub> (s)	-230.1	-184.0	144.5
H <sub>2</sub> (g)	0	0	130.58	Hg <sub>2</sub> Cl <sub>2</sub> (s)	-264.9	-210.5	192.5
Iodine				Nickel			
I(g)	106.60	70.16	180.66	Ni(g)	429.7	384.5	182.1
I <sup>-</sup> (aq)	-55.19	-51.57	111.3	Ni(s)	0	0	29.9
I <sub>2</sub> (g)	62.25	19.37	260.57	NiCl <sub>2</sub> (s)	-305.3	-259.0	97.65
I <sub>2</sub> (s)	0	0	116.73	NiO(s)	-239.7	-211.7	37.99
HI(g)	25.94	1.30	206.3	Nitrogen			
Iron				N(g)	472.7	455.5	153.3
Fe(g)	415.5	369.8	180.5	N <sub>2</sub> (g)	0	0	191.50
Fe(s)	0	0	27.15	NH <sub>3</sub> (aq)	-80.29	-26.50	111.3
Fe <sup>2+</sup> (aq)	-87.86	-84.93	113.4	NH <sub>3</sub> (g)	-46.19	-16.66	192.5
Fe <sup>3+</sup> (aq)	-47.69	-10.54	293.3	NH <sub>4</sub> <sup>+</sup> (aq)	-132.5	-79.31	113.4
FeCl <sub>2</sub> (s)	-341.8	-302.3	117.9	N <sub>2</sub> H <sub>4</sub> (g)	95.40	159.4	238.5
FeCl <sub>3</sub> (s)	-400	-334	142.3	NH <sub>4</sub> CN(s)	0.0	—	—
FeO(s)	-271.9	-255.2	60.75	NH <sub>4</sub> Cl(s)	-314.4	-203.0	94.6
Fe <sub>2</sub> O <sub>3</sub> (s)	-822.16	-740.98	89.96	NH <sub>4</sub> NO <sub>3</sub> (s)	-365.6	-184.0	151
Fe <sub>3</sub> O <sub>4</sub> (s)	-1117.1	-1014.2	146.4	NO(g)	90.37	86.71	210.62
FeS <sub>2</sub> (s)	-171.5	-160.1	52.92	NO <sub>2</sub> (g)	33.84	51.84	240.45
Lead				N <sub>2</sub> O(g)	81.6	103.59	220.0
Pb(s)	0	0	68.85	N <sub>2</sub> O <sub>4</sub> (g)	9.66	98.28	304.3
PbBr <sub>2</sub> (s)	-277.4	-260.7	161	NOCl(g)	52.6	66.3	264
PbCO <sub>3</sub> (s)	-699.1	-625.5	131.0	HNO <sub>3</sub> (aq)	-206.6	-110.5	146
Pb(NO <sub>3</sub> ) <sub>2</sub> (aq)	-421.3	-246.9	303.3	HNO <sub>3</sub> (g)	-134.3	-73.94	266.4
Pb(NO <sub>3</sub> ) <sub>2</sub> (s)	-451.9	—	—	Oxygen			
PbO(s)	-217.3	-187.9	68.70	O(g)	247.5	230.1	161.0
Lithium				O <sub>2</sub> (g)	0	0	205.0
Li(g)	159.3	126.6	138.8	O <sub>3</sub> (g)	142.3	163.4	237.6
Li(s)	0	0	29.09	OH <sup>-</sup> (aq)	-230.0	-157.3	-10.7
Li <sup>+</sup> (aq)	-278.5	-273.4	12.2	H <sub>2</sub> O(g)	-241.82	-228.57	188.83
Li <sup>+</sup> (g)	685.7	648.5	133.0	H <sub>2</sub> O(l)	-285.83	-237.13	69.91
LiCl(s)	-408.3	-384.0	59.30	H <sub>2</sub> O <sub>2</sub> (g)	-136.10	-105.48	232.9
Magnesium				H <sub>2</sub> O <sub>2</sub> (l)	-187.8	-120.4	109.6
Mg(g)	147.1	112.5	148.6	Phosphorus			
Mg(s)	0	0	32.51	P(g)	316.4	280.0	163.2
MgCl <sub>2</sub> (s)	-641.6	-592.1	89.6	P <sub>2</sub> (g)	144.3	103.7	218.1

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P <sub>4</sub> (g)	58.9	24.4	280	AgNO <sub>3</sub> (s)	-124.4	-33.41	140.9
P <sub>4</sub> (s, red)	-17.46	-12.03	22.85	Sodium			
P <sub>4</sub> (s, white)	0	0	41.08	Na(g)	107.7	77.3	153.7
PCl <sub>3</sub> (g)	-288.07	-269.6	311.7	Na(s)	0	0	51.45
PCl <sub>3</sub> (l)	-319.6	-272.4	217	Na <sup>+</sup> (aq)	-240.1	-261.9	59.0
PF <sub>5</sub> (g)	-1594.4	-1520.7	300.8	Na <sup>+</sup> (g)	609.3	574.3	148.0
PH <sub>3</sub> (g)	5.4	13.4	210.2	NaBr(aq)	-360.6	-364.7	141.00
P <sub>4</sub> O <sub>6</sub> (s)	-1640.1	—	—	NaBr(s)	-361.4	-349.3	86.82
P <sub>4</sub> O <sub>10</sub> (s)	-2940.1	-2675.2	228.9	Na <sub>2</sub> CO <sub>3</sub> (s)	-1130.9	-1047.7	136.0
POCl <sub>3</sub> (g)	-542.2	-502.5	325	NaCl(aq)	-407.1	-393.0	115.5
POCl <sub>3</sub> (l)	-597.0	-520.9	222	NaCl(g)	-181.4	-201.3	229.8
H <sub>3</sub> PO <sub>4</sub> (aq)	-1288.3	-1142.6	158.2	NaCl(s)	-410.9	-384.0	72.33
Potassium				NaHCO <sub>3</sub> (s)	-947.7	-851.8	102.1
K(g)	89.99	61.17	160.2	NaNO <sub>3</sub> (aq)	-446.2	-372.4	207
K(s)	0	0	64.67	NaNO <sub>3</sub> (s)	-467.9	-367.0	116.5
KCl(s)	-435.9	-408.3	82.7	NaOH(aq)	-469.6	-419.2	49.8
KClO <sub>3</sub> (s)	-391.2	-289.9	143.0	NaOH(s)	-425.6	-379.5	64.46
KClO <sub>3</sub> (aq)	-349.5	-284.9	265.7	Na <sub>2</sub> SO <sub>4</sub> (s)	-1387.1	-1270.2	149.6
K <sub>2</sub> CO <sub>3</sub> (s)	-1150.18	-1064.58	155.44	Strontium			
KNO <sub>3</sub> (s)	-492.70	-393.13	132.9	SrO(s)	-592.0	-561.9	54.9
K <sub>2</sub> O(s)	-363.2	-322.1	94.14	Sr(g)	164.4	110.0	164.6
KO <sub>2</sub> (s)	-284.5	-240.6	122.5	Sulfur			
K <sub>2</sub> O <sub>2</sub> (s)	-495.8	-429.8	113.0	S(s, rhombic)	0	0	31.88
KOH(s)	-424.7	-378.9	78.91	S <sub>8</sub> (g)	102.3	49.7	430.9
KOH(aq)	-482.4	-440.5	91.6	SO <sub>2</sub> (g)	-296.9	-300.4	248.5
Rubidium				SO <sub>3</sub> (g)	-395.2	-370.4	256.2
Rb(g)	85.8	55.8	170.0	SO <sub>4</sub> <sup>2-</sup> (aq)	-909.3	-744.5	20.1
Rb(s)	0	0	76.78	SOCl <sub>2</sub> (l)	-245.6	—	—
RbCl(s)	-430.5	-412.0	92	H <sub>2</sub> S(g)	-20.17	-33.01	205.6
RbClO <sub>3</sub> (s)	-392.4	-292.0	152	H <sub>2</sub> SO <sub>4</sub> (aq)	-909.3	-744.5	20.1
Scandium				H <sub>2</sub> SO <sub>4</sub> (l)	-814.0	-689.9	156.1
Sc(g)	377.8	336.1	174.7	Titanium			
Sc(s)	0	0	34.6	Ti(g)	468	422	180.3
Selenium				Ti(s)	0	0	30.76
H <sub>2</sub> Se(g)	29.7	15.9	219.0	TiCl <sub>4</sub> (g)	-763.2	-726.8	354.9
Silicon				TiCl <sub>4</sub> (l)	-804.2	-728.1	221.9
Si(g)	368.2	323.9	167.8	TiO <sub>2</sub> (s)	-944.7	-889.4	50.29
Si(s)	0	0	18.7	Vanadium			
SiC(s)	-73.22	-70.85	16.61	V(g)	514.2	453.1	182.2
SiCl <sub>4</sub> (l)	-640.1	-572.8	239.3	V(s)	0	0	28.9
SiO <sub>2</sub> (s, quartz)	-910.9	-856.5	41.84	Zinc			
Silver				Zn(g)	130.7	95.2	160.9
Ag(s)	0	0	42.55	Zn(s)	0	0	41.63
Ag <sup>+</sup> (aq)	105.90	77.11	73.93	ZnCl <sub>2</sub> (s)	-415.1	-369.4	111.5
AgCl(s)	-127.0	-109.70	96.11	ZnO(s)	-348.0	-318.2	43.9
Ag <sub>2</sub> O(s)	-31.05	-11.20	121.3				