


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

| Substance | ΔH_f° (kJ/mol) | ΔG_f° (kJ/mol) | S° (J/mol-K) | Substance | ΔH_f° (kJ/mol) | ΔG_f° (kJ/mol) | S° (J/mol-K) |
|-----------------------------|--------------------------------|--------------------------------|------------------------|-------------------|--------------------------------|--------------------------------|------------------------|
| Aluminum | | | | $C_2H_4(g)$ | 52.30 | 68.11 | 219.4 |
| Al(s) | 0 | 0 | 28.32 | $C_2H_6(g)$ | -84.68 | -32.89 | 229.5 |
| $AlCl_3(s)$ | -705.6 | -630.0 | 109.3 | $C_3H_8(g)$ | -103.85 | -23.47 | 269.9 |
| $Al_2O_3(s)$ | -1669.8 | -1576.5 | 51.00 | $C_4H_{10}(g)$ | -124.73 | -15.71 | 310.0 |
| Barium | | | | $C_4H_{10}(l)$ | -147.6 | -15.0 | 231.0 |
| Ba(s) | 0 | 0 | 63.2 | $C_6H_6(g)$ | 82.9 | 129.7 | 269.2 |
| $BaCO_3(s)$ | -1216.3 | -1137.6 | 112.1 | $C_6H_6(l)$ | 49.0 | 124.5 | 172.8 |
| $BaO(s)$ | -553.5 | -525.1 | 70.42 | $CH_3OH(g)$ | -201.2 | -161.9 | 237.6 |
| Beryllium | | | | $CH_3OH(l)$ | -238.6 | -166.23 | 126.8 |
| Be(s) | 0 | 0 | 9.44 | $C_2H_5OH(g)$ | -235.1 | -168.5 | 282.7 |
| $BeO(s)$ | -608.4 | -579.1 | 13.77 | $C_2H_5OH(l)$ | -277.7 | -174.76 | 160.7 |
| $Be(OH)_2(s)$ | -905.8 | -817.9 | 50.21 | $C_6H_{12}O_6(s)$ | -1273.02 | -910.4 | 212.1 |
| Bromine | | | | $CO(g)$ | -110.5 | -137.2 | 197.9 |
| Br(g) | 111.8 | 82.38 | 174.9 | $CO_2(g)$ | -393.5 | -394.4 | 213.6 |
| $Br^-(aq)$ | -120.9 | -102.8 | 80.71 | $CH_3COOH(l)$ | -487.0 | -392.4 | 159.8 |
| $Br_2(g)$ | 30.71 | 3.14 | 245.3 | Cesium | | | |
| $Br_2(l)$ | 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 |
| Calcium | | | | $Cs(s)$ | 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 | Chlorine | | | |
| $CaCO_3(s, \text{calcite})$ | -1207.1 | -1128.76 | 92.88 | $Cl(g)$ | 121.7 | 105.7 | 165.2 |
| $CaCl_2(s)$ | -795.8 | -748.1 | 104.6 | $Cl(aq)$ | -167.2 | -131.2 | 56.5 |
| $CaF_2(s)$ | -1219.6 | -1167.3 | 68.87 | $Cl_2(g)$ | 0 | 0 | 222.96 |
| $CaO(s)$ | -635.5 | -604.17 | 39.75 | $HCl(aq)$ | -167.2 | -131.2 | 56.5 |
| $Ca(OH)_2(s)$ | -986.2 | -898.5 | 83.4 | $HCl(g)$ | -92.30 | -95.27 | 186.69 |
| $CaSO_4(s)$ | -1434.0 | -1321.8 | 106.7 | Chromium | | | |
| Carbon | | | | $Cr(g)$ | 397.5 | 352.6 | 174.2 |
| $C(g)$ | 718.4 | 672.9 | 158.0 | $Cr(s)$ | 0 | 0 | 23.6 |
| $C(s, \text{diamond})$ | 1.88 | 2.84 | 2.43 | $Cr_2O_3(s)$ | -1139.7 | -1058.1 | 81.2 |
| $C(s, \text{graphite})$ | 0 | 0 | 5.69 | Cobalt | | | |
| $CCl_4(g)$ | -106.7 | -64.0 | 309.4 | $Co(g)$ | 439 | 393 | 179 |
| $CCl_4(l)$ | -139.3 | -68.6 | 214.4 | $Co(s)$ | 0 | 0 | 28.4 |
| $CF_4(g)$ | -679.9 | -635.1 | 262.3 | Copper | | | |
| $CH_4(g)$ | -74.8 | -50.8 | 186.3 | $Cu(g)$ | 338.4 | 298.6 | 166.3 |
| $C_2H_2(g)$ | 226.77 | 209.2 | 200.8 | $Cu(s)$ | 0 | 0 | 33.30 |

| Substance | ΔH_f° (kJ/mol) | ΔG_f° (kJ/mol) | S° (J/mol·K) | Open with  | Substance | ΔH_f° (kJ/mol) | ΔG_f° (kJ/mol) | S° (J/mol·K) |
|--|--------------------------------|--------------------------------|------------------------|---|-------------------------------------|--------------------------------|--------------------------------|------------------------|
| CuCl ₂ (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) ₂ (s) | -924.7 | -833.7 | 63.24 |
| Cu ₂ O(s) | -170.7 | -147.9 | 92.36 | | | | | |
| Fluorine | | | | | Manganese | | | |
| F(g) | 80.0 | 61.9 | 158.7 | | Mn(g) | 280.7 | 238.5 | 173.6 |
| F(aq) | -332.6 | -278.8 | -13.8 | | Mn(s) | 0 | 0 | 32.0 |
| F ₂ (g) | 0 | 0 | 202.7 | | MnO(s) | -385.2 | -362.9 | 59.7 |
| HF(g) | -268.61 | -270.70 | 173.51 | | MnO ₂ (s) | -519.6 | -464.8 | 53.14 |
| | | | | | MnO ₄ ⁻ (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 ⁺ (aq) | 0 | 0 | 0 | | Hg(l) | 0 | 0 | 77.40 |
| H ⁺ (g) | 1536.2 | 1517.0 | 108.9 | | HgCl ₂ (s) | -230.1 | -184.0 | 144.5 |
| H ₂ (g) | 0 | 0 | 130.58 | | Hg ₂ Cl ₂ (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 ⁻ (aq) | -55.19 | -51.57 | 111.3 | | Ni(s) | 0 | 0 | 29.9 |
| I ₂ (g) | 62.25 | 19.37 | 260.57 | | NiCl ₂ (s) | -305.3 | -259.0 | 97.65 |
| I ₂ (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 ₂ (g) | 0 | 0 | 191.50 |
| Fe(s) | 0 | 0 | 27.15 | | NH ₃ (aq) | -80.29 | -26.50 | 111.3 |
| Fe ²⁺ (aq) | -87.86 | -84.93 | 113.4 | | NH ₃ (g) | -46.19 | -16.66 | 192.5 |
| Fe ³⁺ (aq) | -47.69 | -10.54 | 293.3 | | NH ₄ ⁺ (aq) | -132.5 | -79.31 | 113.4 |
| FeCl ₂ (s) | -341.8 | -302.3 | 117.9 | | N ₂ H ₄ (g) | 95.40 | 159.4 | 238.5 |
| FeCl ₃ (s) | -400 | -334 | 142.3 | | NH ₄ CN(s) | 0.0 | — | — |
| FeO(s) | -271.9 | -255.2 | 60.75 | | NH ₄ Cl(s) | -314.4 | -203.0 | 94.6 |
| Fe ₂ O ₃ (s) | -822.16 | -740.98 | 89.96 | | NH ₄ NO ₃ (s) | -365.6 | -184.0 | 151 |
| Fe ₃ O ₄ (s) | -1117.1 | -1014.2 | 146.4 | | NO(g) | 90.37 | 86.71 | 210.62 |
| FeS ₂ (s) | -171.5 | -160.1 | 52.92 | | NO ₂ (g) | 33.84 | 51.84 | 240.45 |
| Lead | | | | | N ₂ O(g) | 81.6 | 103.59 | 220.0 |
| Pb(s) | 0 | 0 | 68.85 | | N ₂ O ₄ (g) | 9.66 | 98.28 | 304.3 |
| PbBr ₂ (s) | -277.4 | -260.7 | 161 | | NOCl(g) | 52.6 | 66.3 | 264 |
| PbCO ₃ (s) | -699.1 | -625.5 | 131.0 | | HNO ₃ (aq) | -206.6 | -110.5 | 146 |
| Pb(NO ₃) ₂ (aq) | -421.3 | -246.9 | 303.3 | | HNO ₃ (g) | -134.3 | -73.94 | 266.4 |
| Pb(NO ₃) ₂ (s) | -451.9 | — | — | | Oxygen | | | |
| PbO(s) | -217.3 | -187.9 | 68.70 | | O(g) | 247.5 | 230.1 | 161.0 |
| Lithium | | | | | O ₂ (g) | 0 | 0 | 205.0 |
| Li(g) | 159.3 | 126.6 | 138.8 | | O ₃ (g) | 142.3 | 163.4 | 237.6 |
| Li(s) | 0 | 0 | 29.09 | | OH ⁻ (aq) | -230.0 | -157.3 | -10.7 |
| Li ⁺ (aq) | -278.5 | -273.4 | 12.2 | | H ₂ O(g) | -241.82 | -228.57 | 188.83 |
| Li ⁺ (g) | 685.7 | 648.5 | 133.0 | | H ₂ O(l) | -285.83 | -237.13 | 69.91 |
| LiCl(s) | -408.3 | -384.0 | 59.30 | | H ₂ O ₂ (g) | -136.10 | -105.48 | 232.9 |
| Magnesium | | | | | H ₂ O ₂ (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 ₂ (s) | -641.6 | -592.1 | 89.6 | | P ₂ (g) | 144.3 | 103.7 | 218.1 |

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