# THERMOCHEMICAL DATA OF SOLUTES

Standard thermochemical data for some solutes, either pure at 298 K and 100 kPa, or in infinitely dilute aqueous solution at 298 K, 100 kPa and extrapolated to 1 mol/L, including in the latter case the standard electrochemical data for the reduction reaction.

| Solute (state) | Reaction of formation | $h_f^{\ominus}$ kJ/mol | $g_f^{\ominus}$ kJ/mol | $s^{\ominus}$ J/(mol·K) | $\varepsilon^{\ominus}$ V | $d\varepsilon^{\ominus}/dT$ mV/K |
|---|---|---|---|---|---|---|
| $Al^{3+}(aq)$ | $Al(s)=Al^{3+}(aq)+3e^-$ | -531 | -485 | –322 | -1.676 | |
| C(s,gra.) | C(s,graphite)=C(s,graphite) | 0 | 0 | 5.74 | | |
| $C_{12}H_{22}O_{11}(aq)$ | $C_{12}H_{22}O_{11}(s)=C_{12}H_{22}O_{11}(aq)$ | | -13.5 | | | |
| $C_{12}H_{22}O_{11}(s)$ | $12C(s)+11H_2(g)+\frac{11}{2}O_2(g)=C_{12}H_{22}O_{11}(s)$ | -2222 | -1545 | 360 | | |
| $Ca(OH)_2(s)$ | $Ca(s)+O_2(g)+H_2(g)=Ca(OH)_2(s)$ | -986 | -899 | 83 | | |
| $Ca^{2+}(aq)$ | $Ca(s)=Ca^{2+}(aq)+2e^-$ | -543 | -553 | –56 | -2.866 | -0.175 |
| $CaC_2(s)$ | $Ca(s)+2C(s)=CaC_2(s)$ | -63 | -68 | 70 | | |
| $CaCl_2(s)$ | $Ca(s)+Cl_2(g)=CaCl_2(s)$ | -796 | -748 | 105 | | |
| $CaCO_3(s)$ | $Ca(s)+C(s)+(3/2)O_2(g)=CaCO_3(s$ | -1207 | -1129 | 93 | | |
| CaO(s) | $Ca(s)+(1/2)O_2(g)=CaO(s)$ | -635 | -604 | 40 | | |
| $Cl^-(aq)$ | $(1/2)Cl_2(g)+e^-=Cl^-(aq)$ | -167 | -131 | 56 | 1.360 | -1.250 |
| $CO_2(aq)$ | $C(s)+O_2(g)=CO_2(aq)$ | -414 | -386 | 118 | | |
| $CO_2(g)$ | $C(s)+O_2(g)=CO_2(g)$ | -394 | -394 | 214 | | |
| $Cu^{2+}(aq)$ | $Cu(s)=Cu^{2+}(aq)+2e^-$ | 64.8 | 65.5 | –99.6 | 0.337 | |
| $F^-(aq)$ | $(1/2)F_2(g)+e^-=F^-(aq)$ | –333 | –279 | –13.8 | 2.89 | |
| $Fe^{2+}(aq)$ | $Fe(s)=Fe^{2+}(aq)+2e^-$ | -89 | -79 | –138 | -0.440 | |
| $H^+(aq)$ | $(1/2)H_2(g)=H^+(aq)+e^-$ | 0 | 0 | 0 | 0 | 0 |
| $H^+(g)$ | $(1/2)H_2(g)=H^+(g)+e^-$ | 1536 | 1517 | 109 | | |
| $H_2(aq)$ | $H_2(g)=H_2(aq)$ | -4.2 | 17.6 | 58 | | |
| $H_2(g)$ | $H_2(g)=H_2(g)$ | 0 | 0 | 131 | | |
| $H_2O(l)$ | $H_2(g)+(1/2)O_2(g)=H_2O(l)$ | -286 | -237 | 70 | | |
| $H_2O_2(aq)$ | $H_2(g)+O_2(g)=H_2O_2(aq)$ | -191 | -134 | 144 | | |
| $H_2O_2(l)$ | $H_2(g)+O_2(g)=H_2O_2(l)$ | -188 | -120 | 110 | | |
| HCl(g) | $(1/2)H_2(g)+(1/2)Cl_2(g)=HCl(g)$ | -92 | -95 | 187 | | |
| $K^+(aq)$ | $K(s)=K^+(aq)+e^-$ | -252 | -283 | 101 | -2.925 | -1.080 |
| $Li^+(aq)$ | $Li(s)=Li^+(aq)+e^-$ | -278 | -293 | 13.4 | -3.045 | |
| $Mg^{2+}(aq)$ | $Mg(s)=Mg^{2+}(aq)+2e^-$ | -467 | -455 | –138 | -2.363 | |
| $N_2(aq)$ | $N_2(g)=N_2(aq)$ | | | | | |
| $N_2(g)$ | $N_2(g)=N_2(g)$ | 0 | 0 | 191.5 | | |
| Na(s) | Na(s)=Na(s) | 0 | 0 | 51 | | |
| $Na^+(aq)$ | $Na(s)=Na^+(aq)+e^-$ | -240 | -262 | 58 | -2.714 | -0.772 |
| NaCl(s) | $Na(s)+(1/2)Cl_2(g)=NaCl(s)$ | -411 | -384 | 72 | | |
| $NH_3(aq)$ | $(1/2)N_2(g)+(3/2)H_2(g)=NH_3(aq)$ | -80.3 | -26.5 | 111 | | |
| $NH_3(g)$ | $(1/2)N_2(g)+(3/2)H_2(g)=NH_3(g)$ | -46 | -17 | 192 | | |
| $NH_4^+(aq)$ | $(1/2)N_2(g)+2H_2(g)=NH_4^+(aq)+e^-$ | -133 | -79 | 113 | | |
| $NH_4Cl(s)$ | $(1/2)N_2(g)+2H_2(g)+(1/2)Cl_2(g)=NH_4Cl(s)$ | -314 | -203 | 95 | | |
| $NH_4NO_3(s)$ | $N_2(g)+2H_2(g)+(3/2)O_2(g)=NH_4NO_3(s)$ | -366 | -184 | 151 | | |
| $O_2(aq)$ | $O_2(g)=O_2(aq)$ | -11.7 | 16.4 | 111 | | |
| $O_2(g)$ | $O_2(g)=O_2(g)$ | 0 | 0 | 205 | | |
| $O_3(aq)$ | $(3/2)O_2(g)=O_3(aq)$ | -12.1 | 16.3 | 111 | | |
| $O_3(g)$ | $(3/2)O_2(g)=O_3(g)$ | 142.4 | 162.9 | 230.8 | 2.07 | |
| $OH^-(aq)$ | $(1/2)O_2(g)+(1/2)H_2(g)+e^-=OH^-(aq)$ | -230 | -157 | –10.8 | 2.8 | |

| | | | | | |
|---|---|---|---|---|---|
| $Pb^{2+}(aq)$ | $Pb(s)=Pb^{2+}(aq)+2e^-$ | -1.7 | -24.4 | 10.5 | -0.130 |
| $Zn^{2+}(aq)$ | $Zn(s)=Zn^{2+}(aq)+2e^-$ | -154 | -147 | –112 | -0.763 |

Many other properties can be found in Solution properties for some special solutions: salt-water, sugar-water, alcohol-water, hydrogen peroxide-water, ammonia-water and carbon dioxide-water.

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