



## 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	$h_f^\oplus$ kJ/mol	$g_f^\oplus$ kJ/mol	$s^\oplus$ J/(mol·K)	$\epsilon^\oplus$ V	$d\epsilon^\oplus/dT$ mV/K
Al <sup>3+</sup> (aq)	Al(s)=Al <sup>3+</sup> (aq)+3e <sup>-</sup>	-531	-485	-322	-1.676	
C(s,gra.)	C(s,graphite)=C(s,graphite)	0	0	5.74		
C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> (aq)	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> (s)=C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> (aq)		-13.5			
C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> (s)	12C(s)+11H <sub>2</sub> (g)+ $\frac{11}{2}$ O <sub>2</sub> (g)=C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> (s)	-2222	-1545	360		
Ca(OH) <sub>2</sub> (s)	Ca(s)+O <sub>2</sub> (g)+H <sub>2</sub> (g)=Ca(OH) <sub>2</sub> (s)	-986	-899	83		
Ca <sup>2+</sup> (aq)	Ca(s)=Ca <sup>2+</sup> (aq)+2e <sup>-</sup>	-543	-553	-56	-2.866	-0.175
CaC <sub>2</sub> (s)	Ca(s)+2C(s)=CaC <sub>2</sub> (s)	-63	-68	70		
CaCl <sub>2</sub> (s)	Ca(s)+Cl <sub>2</sub> (g)=CaCl <sub>2</sub> (s)	-796	-748	105		
CaCO <sub>3</sub> (s)	Ca(s)+C(s)+(3/2)O <sub>2</sub> (g)=CaCO <sub>3</sub> (s)	-1207	-1129	93		
CaO(s)	Ca(s)+(1/2)O <sub>2</sub> (g)=CaO(s)	-635	-604	40		
Cl <sup>-</sup> (aq)	(1/2)Cl <sub>2</sub> (g)+e <sup>-</sup> =Cl <sup>-</sup> (aq)	-167	-131	56	1.360	-1.250
CO <sub>2</sub> (aq)	C(s)+O <sub>2</sub> (g)=CO <sub>2</sub> (aq)	-414	-386	118		
CO <sub>2</sub> (g)	C(s)+O <sub>2</sub> (g)=CO <sub>2</sub> (g)	-394	-394	214		
Cu <sup>2+</sup> (aq)	Cu(s)=Cu <sup>2+</sup> (aq)+2e <sup>-</sup>	64.8	65.5	-99.6	0.337	
F <sup>-</sup> (aq)	(1/2)F <sub>2</sub> (g)+e <sup>-</sup> =F <sup>-</sup> (aq)	-333	-279	-13.8	2.89	
Fe <sup>2+</sup> (aq)	Fe(s)=Fe <sup>2+</sup> (aq)+2e <sup>-</sup>	-89	-79	-138	-0.440	
H <sup>+</sup> (aq)	(1/2)H <sub>2</sub> (g)=H <sup>+</sup> (aq)+e <sup>-</sup>	0	0	0	0	0
H <sup>+</sup> (g)	(1/2)H <sub>2</sub> (g)=H <sup>+</sup> (g)+e <sup>-</sup>	1536	1517	109		
H <sub>2</sub> (aq)	H <sub>2</sub> (g)=H <sub>2</sub> (aq)	-4.2	17.6	58		
H <sub>2</sub> (g)	H <sub>2</sub> (g)=H <sub>2</sub> (g)	0	0	131		
H <sub>2</sub> O(l)	H <sub>2</sub> (g)+(1/2)O <sub>2</sub> (g)=H <sub>2</sub> O(l)	-286	-237	70		
H <sub>2</sub> O <sub>2</sub> (aq)	H <sub>2</sub> (g)+O <sub>2</sub> (g)=H <sub>2</sub> O <sub>2</sub> (aq)	-191	-134	144		
H <sub>2</sub> O <sub>2</sub> (l)	H <sub>2</sub> (g)+O <sub>2</sub> (g)=H <sub>2</sub> O <sub>2</sub> (l)	-188	-120	110		
HCl(g)	(1/2)H <sub>2</sub> (g)+(1/2)Cl <sub>2</sub> (g)=HCl(g)	-92	-95	187		
K <sup>+</sup> (aq)	K(s)=K <sup>+</sup> (aq)+e <sup>-</sup>	-252	-283	101	-2.925	-1.080
Li <sup>+</sup> (aq)	Li(s)=Li <sup>+</sup> (aq)+e <sup>-</sup>	-278	-293	13.4	-3.045	
Mg <sup>2+</sup> (aq)	Mg(s)=Mg <sup>2+</sup> (aq)+2e <sup>-</sup>	-467	-455	-138	-2.363	
N <sub>2</sub> (aq)	N <sub>2</sub> (g)=N <sub>2</sub> (aq)					
N <sub>2</sub> (g)	N <sub>2</sub> (g)=N <sub>2</sub> (g)	0	0	191.5		
Na(s)	Na(s)=Na(s)	0	0	51		
Na <sup>+</sup> (aq)	Na(s)=Na <sup>+</sup> (aq)+e <sup>-</sup>	-240	-262	58	-2.714	-0.772
NaCl(s)	Na(s)+(1/2)Cl <sub>2</sub> (g)=NaCl(s)	-411	-384	72		
NH <sub>3</sub> (aq)	(1/2)N <sub>2</sub> (g)+(3/2)H <sub>2</sub> (g)=NH <sub>3</sub> (aq)	-80.3	-26.5	111		
NH <sub>3</sub> (g)	(1/2)N <sub>2</sub> (g)+(3/2)H <sub>2</sub> (g)=NH <sub>3</sub> (g)	-46	-17	192		
NH <sub>4</sub> <sup>+</sup> (aq)	(1/2)N <sub>2</sub> (g)+2H <sub>2</sub> (g)=NH <sub>4</sub> <sup>+</sup> (aq)+e <sup>-</sup>	-133	-79	113		
NH <sub>4</sub> Cl(s)	(1/2)N <sub>2</sub> (g)+2H <sub>2</sub> (g)+(1/2)Cl <sub>2</sub> (g)=NH <sub>4</sub> Cl(s)	-314	-203	95		
NH <sub>4</sub> NO <sub>3</sub> (s)	N <sub>2</sub> (g)+2H <sub>2</sub> (g)+(3/2)O <sub>2</sub> (g)=NH <sub>4</sub> NO <sub>3</sub> (s)	-366	-184	151		
O <sub>2</sub> (aq)	O <sub>2</sub> (g)=O <sub>2</sub> (aq)	-11.7	16.4	111		
O <sub>2</sub> (g)	O <sub>2</sub> (g)=O <sub>2</sub> (g)	0	0	205		
O <sub>3</sub> (aq)	(3/2)O <sub>2</sub> (g)=O <sub>3</sub> (aq)	-12.1	16.3	111		
O <sub>3</sub> (g)	(3/2)O <sub>2</sub> (g)=O <sub>3</sub> (g)	142.4	162.9	230.8	2.07	
OH <sup>-</sup> (aq)	(1/2)O <sub>2</sub> (g)+(1/2)H <sub>2</sub> (g)+e <sup>-</sup> =OH <sup>-</sup> (aq)	-230	-157	-10.8	2.8	

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

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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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