

## Appendix Four | Selected Thermodynamic Data\*

Substance and State	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J K <sup>-1</sup> mol <sup>-1</sup> )	Substance and State	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J K <sup>-1</sup> mol <sup>-1</sup> )
<b>Aluminum</b>				<b>Bromine</b>			
Al(s)	0	0	28	Br <sub>2</sub> (l)	0	0	152
Al <sub>2</sub> O <sub>3</sub> (s)	-1676	-1582	51	Br <sub>2</sub> (g)	31	3	245
Al(OH) <sub>3</sub> (s)	-1277	—	—	Br <sub>2</sub> (aq)	-3	4	130
AlCl <sub>3</sub> (s)	-704	-629	111	Br <sup>-</sup> (aq)	-121	-104	82
<b>Barium</b>				<b>Cadmium</b>			
Ba(s)	0	0	67	HBr(g)	-36	-53	199
BaCO <sub>3</sub> (s)	-1219	-1139	112	Cd(s)	0	0	52
BaO(s)	-582	-552	70	CdO(s)	-258	-228	55
Ba(OH) <sub>2</sub> (s)	-946	—	—	Cd(OH) <sub>2</sub> (s)	-561	-474	96
BaSO <sub>4</sub> (s)	-1465	-1353	132	CdS(s)	-162	-156	65
<b>Beryllium</b>				<b>Calcium</b>			
Be(s)	0	0	10	CdSO <sub>4</sub> (s)	-935	-823	123
BeO(s)	-599	-569	14	Ca(s)	0	0	41
Be(OH) <sub>2</sub> (s)	-904	-815	47	CaC <sub>2</sub> (s)	-63	-68	70

\* All values are assumed precise to at least  $\pm 1$ .

*(continued)*

## Appendix Four (continued)

Substance and State	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J K <sup>-1</sup> mol <sup>-1</sup> )	Substance and State	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J K <sup>-1</sup> mol <sup>-1</sup> )
CaCO <sub>3</sub> (s)	-1207	-1129	93	H <sub>2</sub> O(l)	-286	-237	70
CaO(s)	-635	-604	40	H <sub>2</sub> O(g)	-242	-229	189
Ca(OH) <sub>2</sub> (s)	-987	-899	83	Iodine			
Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> (s)	-4126	-3890	241	I <sub>2</sub> (s)	0	0	116
CaSO <sub>4</sub> (s)	-1433	-1320	107	I <sub>2</sub> (g)	62	19	261
CaSiO <sub>3</sub> (s)	-1630	-1550	84	I <sub>2</sub> (aq)	23	16	137
Carbon				I <sup>-</sup> (aq)	-55	-52	106
C(s) (graphite)	0	0	6	Iron			
C(s) (diamond)	2	3	2	Fe(s)	0	0	27
CO(g)	-110.5	-137	198	Fe <sub>3</sub> C(s)	21	15	108
CO <sub>2</sub> (g)	-393.5	-394	214	Fe <sub>0.95</sub> O(s)			
CH <sub>4</sub> (g)	-75	-51	186	(wustite)	-264	-240	59
CH <sub>3</sub> OH(g)	-201	-163	240	FeO(s)	-272	-255	61
CH <sub>3</sub> OH(l)	-239	-166	127	Fe <sub>3</sub> O <sub>4</sub> (s)			
H <sub>2</sub> CO(g)	-116	-110	219	(magnetite)	-1117	-1013	146
HCOOH(g)	-363	-351	249	Fe <sub>2</sub> O <sub>3</sub> (s)			
HCN(g)	135.1	125	202	(hematite)	-826	-740	90
C <sub>2</sub> H <sub>2</sub> (g)	227	209	201	FeS(s)	-95	-97	67
C <sub>2</sub> H <sub>4</sub> (g)	52	68	219	FeS <sub>2</sub> (s)	-178	-166	53
CH <sub>3</sub> CHO(g)	-166	-129	250	FeSO <sub>4</sub> (s)	-929	-825	121
C <sub>2</sub> H <sub>5</sub> OH(l)	-278	-175	161	Lead			
C <sub>2</sub> H <sub>6</sub> (g)	-84.7	-32.9	229.5	Pb(s)	0	0	65
C <sub>3</sub> H <sub>6</sub> (g)	20.9	62.7	266.9	PbO <sub>2</sub> (s)	-277	-217	69
C <sub>3</sub> H <sub>8</sub> (g)	-104	-24	270	PbS(s)	-100	-99	91
C <sub>2</sub> H <sub>4</sub> O(g)				PbSO <sub>4</sub> (s)	-920	-813	149
(ethylene oxide)	-53	-13	242	Magnesium			
CH <sub>2</sub> P CHCN(g)	185.0	195.4	274	Mg(s)	0	0	33
CH <sub>3</sub> COOH(l)	-484	-389	160	MgCO <sub>3</sub> (s)	-1113	-1029	66
C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> (s)	-1275	-911	212	MgO(s)	-602	-569	27
CCl <sub>4</sub> (l)	-135	-65	216	Mg(OH) <sub>2</sub> (s)	-925	-834	64
Chlorine				Manganese			
Cl <sub>2</sub> (g)	0	0	223	Mn(s)	0	0	32
Cl <sub>2</sub> (aq)	-23	7	121	MnO(s)	-385	-363	60
Cl <sup>-</sup> (aq)	-167	-131	57	Mn <sub>3</sub> O <sub>4</sub> (s)	-1387	-1280	149
HCl(g)	-92	-95	187	Mn <sub>2</sub> O <sub>3</sub> (s)	-971	-893	110
Chromium				MnO <sub>2</sub> (s)	-521	-466	53
Cr(s)	0	0	24	MnO <sub>4</sub> <sup>-</sup> (aq)	-543	-449	190
Cr <sub>2</sub> O <sub>3</sub> (s)	-1128	-1047	81	Mercury			
CrO <sub>3</sub> (s)	-579	-502	72	Hg(l)	0	0	76
Copper				Hg <sub>2</sub> Cl <sub>2</sub> (s)	-265	-211	196
Cu(s)	0	0	33	HgCl <sub>2</sub> (s)	-230	-184	144
CuCO <sub>3</sub> (s)	-595	-518	88	HgO(s)	-90	-59	70
Cu <sub>2</sub> O(s)	-170	-148	93	HgS(s)	-58	-49	78
CuO(s)	-156	-128	43	Nickel			
Cu(OH) <sub>2</sub> (s)	-450	-372	108	Ni(s)	0	0	30
CuS(s)	-49	-49	67	NiCl <sub>2</sub> (s)	-316	-272	107
Fluorine				NiO(s)	-241	-213	38
F <sub>2</sub> (g)	0	0	203	Ni(OH) <sub>2</sub> (s)	-538	-453	79
F <sup>-</sup> (aq)	-333	-279	-14	NiS(s)	-93	-90	53
HF(g)	-271	-273	174	Nitrogen			
Hydrogen				N <sub>2</sub> (g)	0	0	192
H <sub>2</sub> (g)	0	0	131	NH <sub>3</sub> (g)	-46	-17	193
H(g)	217	203	115	NH <sub>3</sub> (aq)	-80	-27	111
H <sup>+</sup> (aq)	0	0	0	NH <sub>4</sub> <sup>+</sup> (aq)	-132	-79	113
OH <sup>-</sup> (aq)	-230	-157	-11	NO(g)	90	87	211

## Appendix Four (continued)

Substance and State	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J K <sup>-1</sup> mol <sup>-1</sup> )	Substance and State	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J K <sup>-1</sup> mol <sup>-1</sup> )
NO <sub>2</sub> (g)	34	52	240	NaHCO <sub>3</sub> (s)	-948	-852	102
N <sub>2</sub> O(g)	82	104	220	NaCl(s)	-411	-384	72
N <sub>2</sub> O <sub>4</sub> (g)	10	98	304	NaH(s)	-56	-33	40
N <sub>2</sub> O <sub>4</sub> (l)	-20	97	209	NaI(s)	-288	-282	91
N <sub>2</sub> O <sub>5</sub> (s)	-42	134	178	NaNO <sub>2</sub> (s)	-359	—	—
N <sub>2</sub> H <sub>4</sub> (l)	51	149	121	NaNO <sub>3</sub> (s)	-467	-366	116
N <sub>2</sub> H <sub>3</sub> CH <sub>3</sub> (l)	54	180	166	Na <sub>2</sub> O(s)	-416	-377	73
HNO <sub>3</sub> (aq)	-207	-111	146	Na <sub>2</sub> O <sub>2</sub> (s)	-515	-451	95
HNO <sub>3</sub> (l)	-174	-81	156	NaOH(s)	-427	-381	64
NH <sub>4</sub> ClO <sub>4</sub> (s)	-295	-89	186	NaOH(aq)	-470	-419	50
NH <sub>4</sub> Cl(s)	-314	-203	96	Sulfur			
Oxygen				S(s) (rhombic)	0	0	32
O <sub>2</sub> (g)	0	0	205	S(s) (monoclinic)	0.3	0.1	33
O(g)	249	232	161	S <sup>2-</sup> (aq)	33	86	-15
O <sub>3</sub> (g)	143	163	239	S <sub>8</sub> (g)	102	50	431
Phosphorus				SF <sub>6</sub> (g)	-1209	-1105	292
P(s) (white)	0	0	41	H <sub>2</sub> S(g)	-21	-34	206
P(s) (red)	-18	-12	23	SO <sub>2</sub> (g)	-297	-300	248
P(s) (black)	-39	-33	23	SO <sub>3</sub> (g)	-396	-371	257
P <sub>4</sub> (g)	59	24	280	SO <sub>4</sub> <sup>2-</sup> (aq)	-909	-745	20
PF <sub>5</sub> (g)	-1578	-1509	296	H <sub>2</sub> SO <sub>4</sub> (l)	-814	-690	157
PH <sub>3</sub> (g)	5	13	210	H <sub>2</sub> SO <sub>4</sub> (aq)	-909	-745	20
H <sub>3</sub> PO <sub>4</sub> (s)	-1279	-1119	110	Tin			
H <sub>3</sub> PO <sub>4</sub> (l)	-1267	—	—	Sn(s) (white)	0	0	52
H <sub>3</sub> PO <sub>4</sub> (aq)	-1288	-1143	158	Sn(s) (gray)	-2	0.1	44
P <sub>4</sub> O <sub>10</sub> (s)	-2984	-2698	229	SnO(s)	-285	-257	56
Potassium				SnO <sub>2</sub> (s)	-581	-520	52
K(s)	0	0	64	Sn(OH) <sub>2</sub> (s)	-561	-492	155
KCl(s)	-436	-408	83	Titanium			
KClO <sub>3</sub> (s)	-391	-290	143	TiCl <sub>4</sub> (g)	-763	-727	355
KClO <sub>4</sub> (s)	-433	-304	151	TiO <sub>2</sub> (s)	-945	-890	50
K <sub>2</sub> O(s)	-361	-322	98	Uranium			
K <sub>2</sub> O <sub>2</sub> (s)	-496	-430	113	U(s)	0	0	50
KO <sub>2</sub> (s)	-283	-238	117	UF <sub>6</sub> (s)	-2137	-2008	228
KOH(s)	-425	-379	79	UF <sub>6</sub> (g)	-2113	-2029	380
KOH(aq)	-481	-440	9.20	UO <sub>2</sub> (s)	-1084	-1029	78
Silicon				U <sub>3</sub> O <sub>8</sub> (s)	-3575	-3393	282
SiO <sub>2</sub> (s) (quartz)	-911	-856	42	UO <sub>3</sub> (s)	-1230	-1150	99
SiCl <sub>4</sub> (l)	-687	-620	240	Xenon			
Silver				Xe(g)	0	0	170
Ag(s)	0	0	43	XeF <sub>2</sub> (g)	-108	-48	254
Ag <sup>+</sup> (aq)	105	77	73	XeF <sub>4</sub> (s)	-251	-121	146
AgBr(s)	-100	-97	107	XeF <sub>6</sub> (g)	-294	—	—
AgCN(s)	146	164	84	XeO <sub>3</sub> (s)	402	—	—
AgCl(s)	-127	-110	96	Zinc			
Ag <sub>2</sub> CrO <sub>4</sub> (s)	-712	-622	217	Zn(s)	0	0	42
AgI(s)	-62	-66	115	ZnO(s)	-348	-318	44
Ag <sub>2</sub> O(s)	-31	-11	122	Zn(OH) <sub>2</sub> (s)	-642	—	—
Ag <sub>2</sub> S(s)	-32	-40	146	ZnS(s)			
Sodium				(wurtzite)	-193	—	—
Na(s)	0	0	51	ZnS(s)			
Na <sup>+</sup> (aq)	-240	-262	59	(zinc blende)	-206	-201	58
NaBr(s)	-360	-347	84	ZnSO <sub>4</sub> (s)	-983	-874	120
Na <sub>2</sub> CO <sub>3</sub> (s)	-1131	-1048	136				

## Appendix Five | Equilibrium Constants and Reduction Potentials

**Table A5.1**
 $K_a$  for Some Common Monoprotic Acids

Name	Formula	Value of $K_a$
Hydrogen sulfate ion	$\text{HSO}_4^-$	$1.2 \times 10^{-2}$
Chlorous acid	$\text{HClO}_2$	$1.2 \times 10^{-2}$
Monochloroacetic acid	$\text{HC}_2\text{H}_2\text{ClO}_2$	$1.35 \times 10^{-3}$
Hydrofluoric acid	$\text{HF}$	$7.2 \times 10^{-4}$
Nitrous acid	$\text{HNO}_2$	$4.0 \times 10^{-4}$
Formic acid	$\text{HCO}_2\text{H}$	$1.8 \times 10^{-4}$
Lactic acid	$\text{HC}_3\text{H}_5\text{O}_3$	$1.38 \times 10^{-4}$
Benzoic acid	$\text{HC}_7\text{H}_5\text{O}_2$	$6.4 \times 10^{-5}$
Acetic acid	$\text{HC}_2\text{H}_3\text{O}_2$	$1.8 \times 10^{-5}$
Hydrated aluminum(III) ion	$[\text{Al}(\text{H}_2\text{O})_6]^{3+}$	$1.4 \times 10^{-5}$
Propanoic acid	$\text{HC}_3\text{H}_5\text{O}_2$	$1.3 \times 10^{-5}$
Hypochlorous acid	$\text{HOCl}$	$3.5 \times 10^{-8}$
Hypobromous acid	$\text{HOBr}$	$2 \times 10^{-9}$
Hydrocyanic acid	$\text{HCN}$	$6.2 \times 10^{-10}$
Boric acid	$\text{H}_3\text{BO}_3$	$5.8 \times 10^{-10}$
Ammonium ion	$\text{NH}_4^+$	$5.6 \times 10^{-10}$
Phenol	$\text{HOC}_6\text{H}_5$	$1.6 \times 10^{-10}$
Hypoiodous acid	$\text{HOI}$	$2 \times 10^{-11}$

**Table A5.2**

Stepwise Dissociation Constants for Several Common Polyprotic Acids

Name	Formula	$K_{a_1}$	$K_{a_2}$	$K_{a_3}$
Phosphoric acid	$\text{H}_3\text{PO}_4$	$7.5 \times 10^{-3}$	$6.2 \times 10^{-8}$	$4.8 \times 10^{-13}$
Arsenic acid	$\text{H}_3\text{AsO}_4$	$5 \times 10^{-3}$	$8 \times 10^{-8}$	$6 \times 10^{-10}$
Carbonic acid	$\text{H}_2\text{CO}_3$	$4.3 \times 10^{-7}$	$4.8 \times 10^{-11}$	
Sulfuric acid	$\text{H}_2\text{SO}_4$	Large	$1.2 \times 10^{-2}$	
Sulfurous acid	$\text{H}_2\text{SO}_3$	$1.5 \times 10^{-2}$	$1.0 \times 10^{-7}$	
Hydrosulfuric acid	$\text{H}_2\text{S}$	$1.0 \times 10^{-7}$	$\sim 10^{-19}$	
Oxalic acid	$\text{H}_2\text{C}_2\text{O}_4$	$6.5 \times 10^{-2}$	$6.1 \times 10^{-5}$	
Ascorbic acid (vitamin C)	$\text{H}_2\text{C}_6\text{H}_6\text{O}_6$	$7.9 \times 10^{-5}$	$1.6 \times 10^{-12}$	
Citric acid	$\text{H}_3\text{C}_6\text{H}_5\text{O}_7$	$8.4 \times 10^{-4}$	$1.8 \times 10^{-5}$	$4.0 \times 10^{-6}$

Table A5.3

 $K_b$  for Some Common Weak Bases

Name	Formula	Conjugate Acid	$K_b$
Ammonia	NH <sub>3</sub>	NH <sub>4</sub> <sup>+</sup>	$1.8 \times 10^{-5}$
Methylamine	CH <sub>3</sub> NH <sub>2</sub>	CH <sub>3</sub> NH <sub>3</sub> <sup>+</sup>	$4.38 \times 10^{-4}$
Ethylamine	C <sub>2</sub> H <sub>5</sub> NH <sub>2</sub>	C <sub>2</sub> H <sub>5</sub> NH <sub>3</sub> <sup>+</sup>	$5.6 \times 10^{-4}$
Diethylamine	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> NH	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> NH <sub>2</sub> <sup>+</sup>	$1.3 \times 10^{-3}$
Triethylamine	(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> N	(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> NH <sup>+</sup>	$4.0 \times 10^{-4}$
Hydroxylamine	HONH <sub>2</sub>	HONH <sub>3</sub> <sup>+</sup>	$1.1 \times 10^{-8}$
Hydrazine	H <sub>2</sub> NNH <sub>2</sub>	H <sub>2</sub> NNH <sub>3</sub> <sup>+</sup>	$3.0 \times 10^{-6}$
Aniline	C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>	C <sub>6</sub> H <sub>5</sub> NH <sub>3</sub> <sup>+</sup>	$3.8 \times 10^{-10}$
Pyridine	C <sub>5</sub> H <sub>5</sub> N	C <sub>5</sub> H <sub>5</sub> NH <sup>+</sup>	$1.7 \times 10^{-9}$

Table A5.4

Values of  $K_{sp}$  at 25°C for Common Ionic Solids

Ionic Solid	$K_{sp}$ (at 25°C)	Ionic Solid	$K_{sp}$ (at 25°C)	Ionic Solid	$K_{sp}$ (at 25°C)
Fluorides		Chromates ( <i>continued</i> )		Hydroxides ( <i>continued</i> )	
BaF <sub>2</sub>	$2.4 \times 10^{-5}$	Hg <sub>2</sub> CrO <sub>4</sub> *	$2 \times 10^{-9}$	Co(OH) <sub>2</sub>	$2.5 \times 10^{-16}$
MgF <sub>2</sub>	$6.4 \times 10^{-9}$	BaCrO <sub>4</sub>	$8.5 \times 10^{-11}$	Ni(OH) <sub>2</sub>	$1.6 \times 10^{-16}$
PbF <sub>2</sub>	$4 \times 10^{-8}$	Ag <sub>2</sub> CrO <sub>4</sub>	$9.0 \times 10^{-12}$	Zn(OH) <sub>2</sub>	$4.5 \times 10^{-17}$
SrF <sub>2</sub>	$7.9 \times 10^{-10}$	PbCrO <sub>4</sub>	$2 \times 10^{-16}$	Cu(OH) <sub>2</sub>	$1.6 \times 10^{-19}$
CaF <sub>2</sub>	$4.0 \times 10^{-11}$	Carbonates		Hg(OH) <sub>2</sub>	$3 \times 10^{-26}$
Chlorides		NiCO <sub>3</sub>	$1.4 \times 10^{-7}$	Sn(OH) <sub>2</sub>	$3 \times 10^{-27}$
PbCl <sub>2</sub>	$1.6 \times 10^{-5}$	CaCO <sub>3</sub>	$8.7 \times 10^{-9}$	Cr(OH) <sub>3</sub>	$6.7 \times 10^{-31}$
AgCl	$1.6 \times 10^{-10}$	BaCO <sub>3</sub>	$1.6 \times 10^{-9}$	Al(OH) <sub>3</sub>	$2 \times 10^{-32}$
Hg <sub>2</sub> Cl <sub>2</sub> *	$1.1 \times 10^{-18}$	SrCO <sub>3</sub>	$7 \times 10^{-10}$	Fe(OH) <sub>3</sub>	$4 \times 10^{-38}$
Bromides		CuCO <sub>3</sub>	$2.5 \times 10^{-10}$	Co(OH) <sub>3</sub>	$2.5 \times 10^{-43}$
PbBr <sub>2</sub>	$4.6 \times 10^{-6}$	ZnCO <sub>3</sub>	$2 \times 10^{-10}$	Sulfides	
AgBr	$5.0 \times 10^{-13}$	MnCO <sub>3</sub>	$8.8 \times 10^{-11}$	MnS	$2.3 \times 10^{-13}$
Hg <sub>2</sub> Br <sub>2</sub> *	$1.3 \times 10^{-22}$	FeCO <sub>3</sub>	$2.1 \times 10^{-11}$	FeS	$3.7 \times 10^{-19}$
Iodides		Ag <sub>2</sub> CO <sub>3</sub>	$8.1 \times 10^{-12}$	NiS	$3 \times 10^{-21}$
PbI <sub>2</sub>	$1.4 \times 10^{-8}$	CdCO <sub>3</sub>	$5.2 \times 10^{-12}$	CoS	$5 \times 10^{-22}$
AgI	$1.5 \times 10^{-16}$	PbCO <sub>3</sub>	$1.5 \times 10^{-15}$	ZnS	$2.5 \times 10^{-22}$
Hg <sub>2</sub> I <sub>2</sub> *	$4.5 \times 10^{-29}$	MgCO <sub>3</sub>	$1 \times 10^{-15}$	SnS	$1 \times 10^{-26}$
Sulfates		Hg <sub>2</sub> CO <sub>3</sub> *	$9.0 \times 10^{-15}$	CdS	$1.0 \times 10^{-28}$
CaSO <sub>4</sub>	$6.1 \times 10^{-5}$	Hydroxides		PbS	$7 \times 10^{-29}$
Ag <sub>2</sub> SO <sub>4</sub>	$1.2 \times 10^{-5}$	Ba(OH) <sub>2</sub>	$5.0 \times 10^{-3}$	CuS	$8.5 \times 10^{-45}$
SrSO <sub>4</sub>	$3.2 \times 10^{-7}$	Sr(OH) <sub>2</sub>	$3.2 \times 10^{-4}$	Ag <sub>2</sub> S	$1.6 \times 10^{-49}$
PbSO <sub>4</sub>	$1.3 \times 10^{-8}$	Ca(OH) <sub>2</sub>	$1.3 \times 10^{-6}$	HgS	$1.6 \times 10^{-54}$
BaSO <sub>4</sub>	$1.5 \times 10^{-9}$	AgOH	$2.0 \times 10^{-8}$	Phosphates	
Chromates		Mg(OH) <sub>2</sub>	$8.9 \times 10^{-12}$	Ag <sub>3</sub> PO <sub>4</sub>	$1.8 \times 10^{-18}$
SrCrO <sub>4</sub>	$3.6 \times 10^{-5}$	Mn(OH) <sub>2</sub>	$2 \times 10^{-13}$	Sr <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	$1 \times 10^{-31}$
		Cd(OH) <sub>2</sub>	$5.9 \times 10^{-15}$	Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	$1.3 \times 10^{-32}$
		Pb(OH) <sub>2</sub>	$1.2 \times 10^{-15}$	Ba <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	$6 \times 10^{-39}$
		Fe(OH) <sub>2</sub>	$1.8 \times 10^{-15}$	Pb <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	$1 \times 10^{-54}$

\*Contains Hg<sub>2</sub><sup>2+</sup> ions.  $K_{sp} = [\text{Hg}_2^{2+}][\text{X}^-]^2$  for Hg<sub>2</sub>X<sub>2</sub> salts.

Table A5.5

Standard Reduction Potentials at 25°C (298 K) for Many Common Half-Reactions

Half-Reaction	$\mathcal{E}^\circ$ (V)	Half-Reaction	$\mathcal{E}^\circ$ (V)
$\text{F}_2 + 2\text{e}^- \longrightarrow 2\text{F}^-$	2.87	$\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \longrightarrow 4\text{OH}^-$	0.40
$\text{Ag}^{2+} + \text{e}^- \longrightarrow \text{Ag}^+$	1.99	$\text{Cu}^{2+} + 2\text{e}^- \longrightarrow \text{Cu}$	0.34
$\text{Co}^{3+} + \text{e}^- \longrightarrow \text{Co}^{2+}$	1.82	$\text{Hg}_2\text{Cl}_2 + 2\text{e}^- \longrightarrow 2\text{Hg} + 2\text{Cl}^-$	0.27
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \longrightarrow 2\text{H}_2\text{O}$	1.78	$\text{AgCl} + \text{e}^- \longrightarrow \text{Ag} + \text{Cl}^-$	0.22
$\text{Ce}^{4+} + \text{e}^- \longrightarrow \text{Ce}^{3+}$	1.70	$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \longrightarrow \text{H}_2\text{SO}_3 + \text{H}_2\text{O}$	0.20
$\text{PbO}_2 + 4\text{H}^+ + \text{SO}_4^{2-} + 2\text{e}^- \longrightarrow \text{PbSO}_4 + 2\text{H}_2\text{O}$	1.69	$\text{Cu}^{2+} + \text{e}^- \longrightarrow \text{Cu}^+$	0.16
$\text{MnO}_4^- + 4\text{H}^+ + 3\text{e}^- \longrightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$	1.68	$2\text{H}^+ + 2\text{e}^- \longrightarrow \text{H}_2$	0.00
$\text{IO}_4^- + 2\text{H}^+ + 2\text{e}^- \longrightarrow \text{IO}_3^- + \text{H}_2\text{O}$	1.60	$\text{Fe}^{3+} + 3\text{e}^- \longrightarrow \text{Fe}$	-0.036
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \longrightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$	1.51	$\text{Pb}^{2+} + 2\text{e}^- \longrightarrow \text{Pb}$	-0.13
$\text{Au}^{3+} + 3\text{e}^- \longrightarrow \text{Au}$	1.50	$\text{Sn}^{2+} + 2\text{e}^- \longrightarrow \text{Sn}$	-0.14
$\text{PbO}_2 + 4\text{H}^+ + 2\text{e}^- \longrightarrow \text{Pb}^{2+} + 2\text{H}_2\text{O}$	1.46	$\text{Ni}^{2+} + 2\text{e}^- \longrightarrow \text{Ni}$	-0.23
$\text{Cl}_2 + 2\text{e}^- \longrightarrow 2\text{Cl}^-$	1.36	$\text{PbSO}_4 + 2\text{e}^- \longrightarrow \text{Pb} + \text{SO}_4^{2-}$	-0.35
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \longrightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	1.33	$\text{Cd}^{2+} + 2\text{e}^- \longrightarrow \text{Cd}$	-0.40
$\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \longrightarrow 2\text{H}_2\text{O}$	1.23	$\text{Fe}^{2+} + 2\text{e}^- \longrightarrow \text{Fe}$	-0.44
$\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^- \longrightarrow \text{Mn}^{2+} + 2\text{H}_2\text{O}$	1.21	$\text{Cr}^{3+} + \text{e}^- \longrightarrow \text{Cr}^{2+}$	-0.50
$\text{IO}_3^- + 6\text{H}^+ + 5\text{e}^- \longrightarrow \frac{1}{2}\text{I}_2 + 3\text{H}_2\text{O}$	1.20	$\text{Cr}^{3+} + 3\text{e}^- \longrightarrow \text{Cr}$	-0.73
$\text{Br}_2 + 2\text{e}^- \longrightarrow 2\text{Br}^-$	1.09	$\text{Zn}^{2+} + 2\text{e}^- \longrightarrow \text{Zn}$	-0.76
$\text{VO}_2^+ + 2\text{H}^+ + \text{e}^- \longrightarrow \text{VO}^{2+} + \text{H}_2\text{O}$	1.00	$2\text{H}_2\text{O} + 2\text{e}^- \longrightarrow \text{H}_2 + 2\text{OH}^-$	-0.83
$\text{AuCl}_4^- + 3\text{e}^- \longrightarrow \text{Au} + 4\text{Cl}^-$	0.99	$\text{Mn}^{2+} + 2\text{e}^- \longrightarrow \text{Mn}$	-1.18
$\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \longrightarrow \text{NO} + 2\text{H}_2\text{O}$	0.96	$\text{Al}^{3+} + 3\text{e}^- \longrightarrow \text{Al}$	-1.66
$\text{ClO}_2 + \text{e}^- \longrightarrow \text{ClO}_2^-$	0.954	$\text{H}_2 + 2\text{e}^- \longrightarrow 2\text{H}^-$	-2.23
$2\text{Hg}^{2+} + 2\text{e}^- \longrightarrow \text{Hg}_2^{2+}$	0.91	$\text{Mg}^{2+} + 2\text{e}^- \longrightarrow \text{Mg}$	-2.37
$\text{Ag}^+ + \text{e}^- \longrightarrow \text{Ag}$	0.80	$\text{La}^{3+} + 3\text{e}^- \longrightarrow \text{La}$	-2.37
$\text{Hg}_2^{2+} + 2\text{e}^- \longrightarrow 2\text{Hg}$	0.80	$\text{Na}^+ + \text{e}^- \longrightarrow \text{Na}$	-2.71
$\text{Fe}^{3+} + \text{e}^- \longrightarrow \text{Fe}^{2+}$	0.77	$\text{Ca}^{2+} + 2\text{e}^- \longrightarrow \text{Ca}$	-2.76
$\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \longrightarrow \text{H}_2\text{O}_2$	0.68	$\text{Ba}^{2+} + 2\text{e}^- \longrightarrow \text{Ba}$	-2.90
$\text{MnO}_4^- + \text{e}^- \longrightarrow \text{MnO}_4^{2-}$	0.56	$\text{K}^+ + \text{e}^- \longrightarrow \text{K}$	-2.92
$\text{I}_2 + 2\text{e}^- \longrightarrow 2\text{I}^-$	0.54	$\text{Li}^+ + \text{e}^- \longrightarrow \text{Li}$	-3.05
$\text{Cu}^+ + \text{e}^- \longrightarrow \text{Cu}$	0.52		