

Código

10230

Diplomatura en Ciencia y Tecnología

Materia: Química II

Tema: Tablas

Docente: Todos, .

Autor: .

Editorial:

QUIMICA II

TABLAS

ANEXO II. QUIMICA II

DISSOCIATION CONSTANTS OF ORGANIC BASES IN AQUEOUS SOLUTION

No.	Compound	Temp. °C	Step	pK _a	K _a	No.	Compound	Temp. °C	Step	pK _a	K _a
a1	Acetamide.....	25		0.63	2.34 × 10 ⁻¹	b15	Brucine.....	25	1	8.28	5.24 × 10 ⁻⁹
a2	Acridine.....	20		5.58	2.63 × 10 ⁻⁶	b16	Butane, 1-amino-3-methyl.....	25		10.60	2.51 × 10 ⁻¹¹
a3	α-Alanine.....	25		2.345	4.52 × 10 ⁻³	b17	Butane, 2-amino-2-methyl.....	19		10.85	1.41 × 10 ⁻¹¹
a4	Alanine, glycyl.....	25		3.153	7.03 × 10 ⁻⁴	b18	Butane, 1,4-diamino (Putrescine).....	10	1	11.15	7.08 × 10 ⁻¹²
a5	Alanine, methoxy- (DL).....	25		2.037	9.18 × 10 ⁻³			10	2	9.71	1.95 × 10 ⁻¹⁰
a6	Alanine, phenyl.....	25	2	9.18	6.61 × 10 ⁻¹⁰	b19	n-Butylamine.....	20		10.77	1.69 × 10 ⁻¹¹
a7	Allothreonine.....	25	1	2.108	7.80 × 10 ⁻³	b20	l-Butylamine.....	18		10.83	1.48 × 10 ⁻¹¹
a8	Allothreonine.....	25	2	9.096	8.02 × 10 ⁻¹⁰	b21	Butyric acid, 4-amino.....	25	1	4.0312	9.31 × 10 ⁻⁵
a9	n-Amylamine.....	25		10.63	2.34 × 10 ⁻¹¹			25	2	10.5557	2.78 × 10 ⁻¹¹
a10	Aniline.....	25		4.63	2.34 × 10 ⁻⁵	b22	n-Butyric acid, glycyl-2-amino.....	25	1	3.1546	7.01 × 10 ⁻⁴
a11	Aniline, n-allyl.....	25		4.17	6.76 × 10 ⁻⁵						
a12	Aniline, 4- (p-aminobenzoyl).....	25	1	2.932	1.17 × 10 ⁻³	c1	Cacodylic acid.....	25	1	1.57	2.69 × 10 ⁻²
a13	Aniline, 4-benzyl.....	25		2.17	6.76 × 10 ⁻³				2	6.27	5.37 × 10 ⁻⁷
a14	Aniline, 2-bromo.....	25		2.53	2.95 × 10 ⁻³	c2	β-Chlorotriethyl- ammonium.....	25		8.80	1.59 × 10 ⁻⁹
a15	Aniline, 3-bromo.....	25		3.58	2.63 × 10 ⁻⁴	c3	Cinnoline.....	20		2.37	4.27 × 10 ⁻³
a16	Aniline, 4-bromo.....	25		3.86	1.38 × 10 ⁻⁴	c4	Codeine.....	25		8.21	6.15 × 10 ⁻⁹
a17	N,N-dimethyl- Aniline, o-chloro.....	25		4.232	5.86 × 10 ⁻⁵	c5	Cyclohexaneamine, n-butyl.....	25		11.23	5.89 × 10 ⁻¹²
a18	Aniline, m-chloro.....	25		2.65	2.24 × 10 ⁻³	c6	Cyclohexylamine.....	24		10.66	2.19 × 10 ⁻¹¹
a19	Aniline, p-chloro.....	25		3.46	3.47 × 10 ⁻⁴	c7	Cystine.....	30	1	1.90	1.25 × 10 ⁻²
a20	Aniline, 3-chloro- N,N-dimethyl.....	20		4.15	7.08 × 10 ⁻⁵			30	2	8.24	5.76 × 10 ⁻⁹
a21	Aniline, 4-chloro- N,N-dimethyl.....	20		3.837	1.46 × 10 ⁻⁴	d1	n-Decylamine.....	25		10.64	2.29 × 10 ⁻¹¹
a22	Aniline, 3,5-dibromo.....	25		4.395	4.03 × 10 ⁻⁵	d2	Diethylamine.....	40		10.489	3.24 × 10 ⁻¹¹
a23	Aniline, 2,4-dichloro.....	22		2.34	4.57 × 10 ⁻³	d3	Diisobutylamine.....	21		10.91	1.23 × 10 ⁻¹¹
a24	Aniline, N,N-diethyl.....	22		2.05	8.91 × 10 ⁻³	d4	Diisopropylamine.....	28.5		10.96	1.09 × 10 ⁻¹¹
a25	Aniline, N,N-dimethyl.....	25		6.61	2.46 × 10 ⁻⁷	d5	Dimethylamine.....	25		10.732	1.85 × 10 ⁻¹¹
a26	Aniline, N,N-dimethyl-3-nitro.....	25		5.15	7.08 × 10 ⁻⁴	d6	n-Diphenylamine.....	25		0.79	1.62 × 10 ⁻¹
a27	Aniline, N-ethyl.....	24		2.626	2.37 × 10 ⁻³	d7	n-Dodecaneamine (Laurylamine).....	25		10.63	2.35 × 10 ⁻¹¹
a28	Aniline, 2-ethyl.....	25		5.12	7.59 × 10 ⁻⁶	e1	d-Ephedrine.....	10		10.139	7.26 × 10 ⁻¹¹
a29	Aniline, 2-fluoro.....	25		3.20	6.31 × 10 ⁻⁴	e2	l-Ephedrine.....	10		9.958	1.10 × 10 ⁻¹⁰
a30	Aniline, 3-fluoro.....	25		3.50	3.16 × 10 ⁻⁴	e3	Ethane, 1-amino-3-methoxy.....	10		9.89	1.29 × 10 ⁻¹⁰
a31	Aniline, 4-fluoro.....	25		4.65	2.24 × 10 ⁻⁵	e4	Ethane, 1,2-bis(methylamino).....	25	1	10.40	3.98 × 10 ⁻¹¹
a32	Aniline, 2-iodo.....	25		2.60	2.51 × 10 ⁻³			25	2	8.26	5.50 × 10 ⁻⁹
a33	Aniline, N-methyl.....	25		4.848	1.41 × 10 ⁻⁵	e5	Ethanol, 2-amino.....	25		9.50	3.16 × 10 ⁻¹⁰
a34	Aniline, 4-methylthio.....	25		4.35	4.46 × 10 ⁻⁵	e6	Ethylamine.....	20		10.807	1.56 × 10 ⁻¹¹
a35	Aniline, 3-nitro.....	25		2.466	3.42 × 10 ⁻³	e7	Ethylenediamine.....	0	1	10.712	1.94 × 10 ⁻¹¹
a36	Aniline, 4-nitro.....	25		1.0	1.00 × 10 ⁻¹			0	2	7.564	2.73 × 10 ⁻⁸
a37	Aniline, 2-sulfonic acid.....	25	2	2.459	3.47 × 10 ⁻³	g1	l-Glutamic acid.....	25	1	2.13	7.41 × 10 ⁻³
a38	Aniline, 3-sulfonic acid.....	25	2	3.738	1.82 × 10 ⁻⁴			25	2	4.31	4.90 × 10 ⁻⁵
a39	Aniline, 4-sulfonic acid.....	25	2	3.227	5.92 × 10 ⁻⁴	e2	Glutamic acid, α-monoethyl.....	25	1	3.846	1.42 × 10 ⁻⁴
a40	o-Anisidine.....	25		4.52	3.02 × 10 ⁻⁵			25	2	7.838	1.45 × 10 ⁻⁸
a41	m-Anisidine.....	25		4.23	5.89 × 10 ⁻⁵	e3	l-Glutamine.....	25		9.28	5.25 × 10 ⁻¹⁰
a42	p-Anisidine.....	25		5.34	4.57 × 10 ⁻⁶	e4	l-Glutathione.....	25	2	3.59	2.57 × 10 ⁻⁴
a43	Arginine.....	25	1	1.8217	1.51 × 10 ⁻²	e5	Glycine.....	25	1	2.3503	4.46 × 10 ⁻³
a44	Asparagine.....	25	2	8.9936	1.01 × 10 ⁻⁹			25	2	9.7796	1.68 × 10 ⁻¹⁰
a45	DL-Aspartic acid.....	20	1	2.213	6.12 × 10 ⁻³	e6	Glycine, n-acetyl.....	25		3.6698	2.14 × 10 ⁻⁴
a46	Azetidine (Trimethylimidine).....	25		8.85	1.41 × 10 ⁻⁹	e7	Glycine, dimethyl.....	5		10.3371	4.60 × 10 ⁻¹¹
a47	Aziridine.....	25		2.942	1.14 × 10 ⁻³	e8	Glycine, glycyl.....	25		3.1397	7.25 × 10 ⁻⁴
b1	Benzene, 4-aminoazo.....	25		8.44	3.63 × 10 ⁻⁹	e9	Glycine, glycylglycyl.....	25	1	3.225	5.96 × 10 ⁻⁴
b2	Benzene, 2-aminoethyl (β-Phenylamine).....	25		2.122	7.55 × 10 ⁻³			25	2	8.090	8.13 × 10 ⁻⁹
b3	Benzene, 4-dimethylaminoazo.....	25		4.006	1.00 × 10 ⁻⁴	e10	Glycine, leucyl.....	25	1	3.25	5.62 × 10 ⁻⁴
b4	Benzidine.....	30	1	4.66	2.19 × 10 ⁻⁵			25	2	8.28	5.25 × 10 ⁻⁹
b5	Benzimidazole.....	25	2	3.57	2.69 × 10 ⁻⁴	e11	Glycine, methyl (Sarcosine).....	25	1	2.21	6.16 × 10 ⁻³
b6	Benzimidazole, 2-ethyl.....	25		5.532	2.94 × 10 ⁻⁶			25	2	10.12	7.58 × 10 ⁻¹¹
b7	Benzimidazole, 2-methyl.....	25		6.18	6.61 × 10 ⁻⁷	g12	Glycine, phenyl.....	25	1	1.83	1.48 × 10 ⁻²
b8	Benzimidazole, 2-phenyl.....	25	1	5.23	5.89 × 10 ⁻⁶			25	2	4.39	4.07 × 10 ⁻⁵
b9	Benzoic acid, 2-amino (Anthranilic acid).....	25	2	11.91	1.23 × 10 ⁻¹²	g13	Glycine, N,n-propyl.....	25	1	2.35	4.46 × 10 ⁻³
b10	Benzoic acid, 4-amino.....	25	1	2.108	7.80 × 10 ⁻³			25	2	10.19	6.46 × 10 ⁻¹¹
b11	Benzylamine.....	25	2	4.946	1.13 × 10 ⁻⁵	g14	Glycine, tetraglycyl.....	20	1	3.10	7.94 × 10 ⁻⁴
b12	Betaine.....	25	1	2.501	3.15 × 10 ⁻³			20	2	8.02	9.55 × 10 ⁻⁹
b13	Biphenyl, 2-amino.....	22	2	4.874	1.33 × 10 ⁻⁵	g15	Glycylserine.....	25	1	2.9808	1.04 × 10 ⁻³
b14	Bornylamine(trans-).....	25		9.33	4.67 × 10 ⁻¹⁰			25	2	8.38	4.17 × 10 ⁻⁹
				1.83	1.48 × 10 ⁻²	h1	Hexadecaneamine.....	25		10.63	2.35 × 10 ⁻¹¹
				3.82	1.51 × 10 ⁻⁴	h2	Heptane, 1-amino.....	25		10.66	2.19 × 10 ⁻¹¹
				10.17	6.76 × 10 ⁻¹¹	h3	Heptane, 2-amino.....	19		10.88	1.58 × 10 ⁻¹¹
						h4	Heptane, 2-methylamino.....	17		10.99	1.02 × 10 ⁻¹¹
						h5	Hexadecaneamine.....	25		10.61	2.46 × 10 ⁻¹¹

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DISSOCIATION CONSTANTS OF ORGANIC BASES IN AQUEOUS SOLUTION (Continued)

No.	Compound	Temp. °C	Step	pK _a	K _a	No.	Compound	Temp. °C	Step	pK _a	K _a
h6	Hexamethylene-diamine.....	0	1	11.857	1.39×10^{-12}	p16	Piperazine.....	23.5	1	9.83	1.48×10^{-10}
h7	Hexanoic acid, 6-amino.....	0	2	0.762	1.73×10^{-11}	p17	Piperazine, 2,5-dimethyl(trans-)....	23.5	2	5.56	2.76×10^{-8}
h8	n-Hexylamine.....	25	1	4.373	4.23×10^{-5}			25	1	9.66	2.19×10^{-10}
h9	dl-Histidine.....	25	2	10.804	1.57×10^{-11}			25	2	5.20	6.31×10^{-8}
		25	1	10.56	2.75×10^{-11}	p18	Piperidine.....	25		11.123	7.53×10^{-12}
		25	2	1.80	1.58×10^{-2}	p19	Piperidine, 3-acetyl....	25		3.18	6.61×10^{-4}
		25	3	6.04	9.12×10^{-7}	p20	Piperidine, 1-n-butyl....	23		10.47	3.39×10^{-11}
h10	Histidine, β-alanyl (Carnosine).....	25		9.33	4.67×10^{-10}	p21	Piperidine, 1,2-dimethyl.....	25		10.22	6.03×10^{-11}
		20	1	2.73	1.86×10^{-3}	p22	Piperidine, 1-ethyl....	23		10.45	3.55×10^{-11}
		20	2	6.87	1.35×10^{-7}	p23	Piperidine, 1-methyl....	25		10.08	8.32×10^{-11}
		20	3	9.73	1.48×10^{-10}	p24	Piperidine, 2,2,6,6-tetramethyl.....	25		11.07	8.51×10^{-12}
i1	Imidazol.....	25		6.953	1.11×10^{-7}	p25	Piperidine, 2,2,4-trimethyl.....	30		11.04	9.12×10^{-12}
i2	Imidazol, 2,4-dimethyl.....	25		8.359	5.50×10^{-8}	p26	Proline.....	25	1	1.952	1.11×10^{-2}
i3	Imidazol, 1-methyl (Oxalimethyline).....	25		6.95	1.12×10^{-7}	p27	Proline, hydroxy.....	25	2	10.640	2.29×10^{-11}
i4	Indane, 1-amino (d-1-Hydrindamine).....	22.5		9.21	6.17×10^{-10}			25	1	1.818	1.52×10^{-2}
i5	Isobutyric acid, 2-amino.....	25	1	2.357	4.30×10^{-3}			25	2	9.662	2.18×10^{-10}
i6	Isoleucine.....	25	2	10.205	6.23×10^{-11}	p28	Propane, 1-amino-2,2-dimethyl.....	25		10.15	7.08×10^{-11}
		25	1	2.318	4.81×10^{-3}	p29	Propane, 1,2-diamino....	25	1	9.82	1.52×10^{-10}
i7	Isoquinoline (Leucoline).....	25	2	9.758	1.74×10^{-10}			25	2	6.61	2.46×10^{-7}
i8	Isoquinoline, 1-amino....	20		5.42	3.80×10^{-6}	p30	Propane, 1,3-diamino....	10	1	10.94	1.15×10^{-11}
i9	Isoquinoline, 7-hydroxy.....	20		7.59	2.57×10^{-8}			10	2	9.03	9.33×10^{-10}
		20	1	5.68	2.09×10^{-6}	p31	Propane, 1,2,3-triamino.....	20	1	9.59	2.57×10^{-10}
		20	2	8.90	1.26×10^{-9}			20	2	7.95	1.12×10^{-8}
l1	L-Leucine.....	25	1	2.328	4.70×10^{-3}	p32	Propanoic acid, 3-amino (β-Alanine)....	25	1	3.551	2.81×10^{-4}
l2	Leucine, glycyl.....	25	2	9.744	1.80×10^{-10}			25	2	10.238	5.78×10^{-11}
		25		3.18	6.61×10^{-4}	p33	Propylamine.....	20		10.708	1.96×10^{-11}
m1	Methionine.....	25	1	2.22	6.02×10^{-3}	p34	Pteridine.....	20		4.05	8.91×10^{-5}
m2	Methylamine.....	25	2	9.27	5.37×10^{-10}	p35	Pteridine, 2-amino-4,6-dihydroxy.....	20	2	6.59	2.57×10^{-7}
m3	Morphine.....	25		10.657	2.70×10^{-11}			20	3	9.31	4.90×10^{-10}
m4	Morpholine.....	25		8.21	6.16×10^{-9}	p36	Pteridine, 2-amino-4-hydroxy.....	20	1	2.27	5.37×10^{-3}
		25		8.33	4.67×10^{-9}			20	2	7.96	1.10×10^{-3}
n1	Naphthalene, 1-amino-6-hydroxy.....	25		3.97	1.07×10^{-4}	p37	Pteridine, 6-chloro....	20		3.68	2.09×10^{-4}
n2	Naphthalene, dimethylamino.....	25		4.566	2.72×10^{-5}	p38	Pteridine, 6-hydroxy-4-methyl.....	20	1	4.08	8.32×10^{-5}
n3	α-Naphthylamine.....	25		3.92	1.20×10^{-4}			20	2	6.41	3.89×10^{-7}
n4	β-Naphthylamine.....	25		4.16	6.92×10^{-5}	p39	Purine.....	20	1	2.30	5.01×10^{-3}
n5	α-Naphthylamine, n-methyl.....	27		3.67	2.13×10^{-4}			20	2	8.96	1.10×10^{-9}
n6	Neobornylamine(cis-)....	25		10.01	9.77×10^{-11}	p40	Purine, 6-amino (Adenine).....	25	1	4.12	7.59×10^{-5}
n7	Nicotine.....	25	1	8.02	9.55×10^{-9}			25	2	9.83	1.48×10^{-10}
		25	2	8.12	7.59×10^{-4}	p41	Purine, 2-dimethylamino....	20	1	4.00	1.00×10^{-4}
n8	n-Nonylamine.....	25		10.64	2.29×10^{-11}			20	2	10.24	5.75×10^{-11}
n9	Norleucine.....	25		2.335	4.62×10^{-3}	p42	Purine, 8-hydroxy.....	20	1	2.56	2.75×10^{-3}
								20	2	8.26	9.49×10^{-9}
o1	Octadecaneamine.....	25		10.60	2.51×10^{-11}	p43	Pyrazine.....	27		0.65	2.24×10^{-1}
o2	Octylamine.....	25		10.65	2.24×10^{-11}	p44	Pyrazine, 2-methyl....	27		1.45	3.54×10^{-2}
o3	Ornithine.....	25	1	1.705	1.97×10^{-2}	p45	Pyrazine, methylamino....	25		3.39	4.07×10^{-4}
		25	2	8.690	2.04×10^{-9}	p46	Pyridazine.....	20		2.24	5.76×10^{-3}
						p47	Pyrimidine, 2-amino....	20		3.45	3.54×10^{-4}
p1	Papaverine.....	25		6.40	3.98×10^{-7}	p48	Pyrimidine, 2-amino-4,6-dimethyl.....	20		4.82	1.51×10^{-5}
p2	Pentane, 3-amino.....	17		10.59	2.57×10^{-11}	p49	Pyrimidine, 2-amino-5-nitro.....	20		0.35	4.46×10^{-1}
p3	Pentane, 3-amino-3-methyl.....	16		11.01	9.77×10^{-12}	p50	Pyridine.....	25		5.25	5.62×10^{-6}
p4	n-Pentadecylamine.....	25		10.61	2.46×10^{-11}	p51	Pyridine, 2-aldoxime...	20	1	3.59	2.57×10^{-4}
p5	Pentanoic acid, 5-amino (Valeric acid).....	25	1	4.270	5.37×10^{-5}			20	2	10.18	6.61×10^{-11}
		25	2	10.766	1.71×10^{-11}	p52	Pyridine, 2-amino.....	20		6.82	1.51×10^{-7}
p6	Perimidine.....	20		6.35	4.47×10^{-7}	p53	Pyridine, 4-amino.....	25		9.1141	7.69×10^{-10}
p7	Phenanthridine.....	20		5.58	2.63×10^{-6}	p54	Pyridine, 2-benzyl....	25		5.13	7.41×10^{-6}
p8	1,10-Phenanthroline....	25		4.84	1.44×10^{-6}	p55	Pyridine, 3-bromo....	25		2.84	1.45×10^{-3}
p9	o-Phenetidine (2-Ethoxyaniline)....	28		4.43	3.72×10^{-6}	p56	Pyridine, 3-chloro....	25		2.84	1.45×10^{-3}
p10	m-Phenetidine (3-Ethoxyaniline)....	25		4.18	6.60×10^{-6}	p57	Pyridine, 2,5-diamino....	20		6.48	3.31×10^{-7}
p11	p-Phenetidine (4-Ethoxyaniline)....	28		5.20	6.31×10^{-6}	p58	Pyridine, 2,3-dimethyl (2,3-Lutidine).....	25		6.57	2.69×10^{-7}
p12	α-Picoline.....	20		5.97	1.07×10^{-6}	p59	Pyridine, 2,4-dimethyl (2,4-Lutidine).....	25		6.99	1.02×10^{-7}
p13	β-Picoline.....	20		5.68	2.09×10^{-6}	p60	Pyridine, 3,5-dimethyl (3,5-Lutidine).....	25		6.15	7.08×10^{-7}
p14	γ-Picoline.....	20		6.02	9.55×10^{-7}	p61	Pyridine, 2-ethyl....	25		5.89	1.28×10^{-6}
p15	Pilocarpine.....	30		6.87	1.35×10^{-7}	p62	Pyridine, 2-formyl....	20		3.80	1.59×10^{-4}
						p63	Pyridine, 2-hydroxy (2-Pyridol).....	20	1	0.75	9.82×10^{-1}
								20	2	11.65	2.24×10^{-12}

DISSOCIATION CONSTANTS OF ORGANIC BASES IN AQUEOUS SOLUTION (Continued)

Compound	Temp. °C	Step	pK _a	K _a	No.	Compound	Temp. °C	Step	pK _a	K _a
Pyridine, 4-hydroxy...	20	1	3.20	6.31 × 10 ⁻⁴	q15	Quinoxaline (Quinazoline).....	20		0.56	3.63 × 10 ⁻¹
Pyridine, methoxy....	20	2	11.12	7.59 × 10 ⁻¹²						
Pyridine, 4-methylamino.....	25		6.47	3.30 × 10 ⁻⁷	s1	Serine (2-amino-3-hydroxypropanoic acid).....	25	1	2.186	5.49 × 10 ⁻³
Pyridine, 2,4,6-trimethyl.....	20		9.65	2.24 × 10 ⁻¹⁰			25	2	9.208	6.19 × 10 ⁻¹⁰
Pyrrolidine.....	25		7.43	3.72 × 10 ⁻⁸	s2	Strychnine.....	25		8.26	5.49 × 10 ⁻⁹
Pyrrolidine, 1,2-dimethyl.....	25		11.27	5.37 × 10 ⁻¹²	t1	Taurine (2-Aminoethane sulfonic acid).....	25	2	9.0614	8.69 × 10 ⁻¹⁰
Pyrrolidine, n-methyl..	26		10.20	6.31 × 10 ⁻¹¹						
	25		10.32	4.79 × 10 ⁻¹¹	t2	Tetradecaneamine (Myristilamine).....	25		10.62	2.40 × 10 ⁻¹¹
Quinazoline.....	20	1	3.43	3.72 × 10 ⁻⁴	t3	Thiazole.....	20		2.44	3.63 × 10 ⁻³
Quinazoline, 5-hydroxy.	20	2	3.62	2.40 × 10 ⁻⁴	t4	Thiazole, 2-amino.....	20		5.36	4.36 × 10 ⁻⁵
	20		7.41	3.89 × 10 ⁻⁸	t5	Threonine.....	25	1	2.088	8.16 × 10 ⁻³
Quinine.....	25	1	8.52	3.02 × 10 ⁻⁹			25	2	9.10	7.94 × 10 ⁻¹⁰
	25	2	4.13	7.41 × 10 ⁻⁵	t6	o-Toluidine.....	25		4.44	3.63 × 10 ⁻⁵
Quinoline.....	20		4.90	1.25 × 10 ⁻⁵	t7	m-Toluidine.....	25		4.73	1.86 × 10 ⁻⁵
Quinoline, 3-amino.....	20		4.91	1.23 × 10 ⁻⁵	t8	p-Toluidine.....	25		5.08	8.32 × 10 ⁻⁶
Quinoline, 3-bromo.....	25		2.69	2.04 × 10 ⁻³	t9	1,3,5-Triazine, 2,4,6-triamino.....	25		5.00	1.00 × 10 ⁻⁵
Quinoline, 8-carboxy...	25		1.82	1.51 × 10 ⁻²	t10	Tridecaneamine.....	25		10.63	2.35 × 10 ⁻¹¹
Quinoline, 3-hydroxy (3-Quinolol).....	20	1	4.28	5.25 × 10 ⁻⁵	t11	Triethylamine.....	18		11.01	9.77 × 10 ⁻¹²
	20	2	8.08	8.32 × 10 ⁻⁹	t12	Trimethylamine.....	25		9.81	1.55 × 10 ⁻¹⁰
Quinoline, 8-hydroxy (8-Quinolol).....	20	1	5.017	1.21 × 10 ⁻⁵	t13	Tryptophan.....	25	1	2.43	3.72 × 10 ⁻³
	25	2	9.812	1.54 × 10 ⁻¹⁰			25	2	9.44	3.63 × 10 ⁻¹⁰
Quinoline, 8-hydroxy-5-sulfo.....	25	1	4.112	7.73 × 10 ⁻⁵	t14	Tyrosine.....	25	2	9.11	7.76 × 10 ⁻¹⁰
	25	2	8.757	1.75 × 10 ⁻⁹			25	3	10.13	7.41 × 10 ⁻¹¹
Quinoline, 6-methoxy..	20		5.03	9.33 × 10 ⁻⁶	t15	Tyrosineamide.....	25		7.33	4.68 × 10 ⁻⁸
Quinoline, 2-methyl (Quinaldine).....	20		5.83	1.48 × 10 ⁻⁶	u1	Urea.....	21		0.10	7.94 × 10 ⁻¹
Quinoline, 4-methyl (Lepidine).....	20		5.67	2.14 × 10 ⁻⁶	v1	Valine.....	25	1	2.286	5.17 × 10 ⁻³
Quinoline, 5-methyl...	20		5.20	6.31 × 10 ⁻⁶			25	2	9.719	1.91 × 10 ⁻¹⁰

DISSOCIATION CONSTANTS OF INORGANIC BASES IN AQUEOUS SOLUTIONS

(Approximately 0.1-0.01 N)

Compound	T°C	Step	K _b	pK _b
Ammonium hydroxide.....	25		1.79 × 10 ⁻⁵	4.75
Arsenous oxide.....	25		1.1 × 10 ⁻⁴	3.96
Beryllium hydroxide.....	25	2	5 × 10 ⁻¹¹	10.30
Calcium hydroxide.....	25	1	3.74 × 10 ⁻³	2.43
Calcium hydroxide.....	30	2	4.0 × 10 ⁻²	1.40
Deuteroammonium hydroxide.....	25		1.1 × 10 ⁻⁵	4.96
Hydrazine.....	20		1.7 × 10 ⁻⁸	5.77
Hydroxylamine.....	20		1.07 × 10 ⁻⁸	7.97
Lead Hydroxide.....	25		9.6 × 10 ⁻⁴	3.02
Silver Hydroxide.....	25		1.1 × 10 ⁻⁴	3.96
Zinc Hydroxide.....	25		9.6 × 10 ⁻⁴	3.02

DISSOCIATION CONSTANTS OF ORGANIC ACIDS IN AQUEOUS SOLUTIONS

Compound	T°C	Step	K	pK	Compound	T°C	Step	K	pK
Acetic	25		1.76×10^{-5}	4.75	Cyclopropane-1:1-dicarboxylic	25	1	1.51×10^{-3}	1.82
Acetoacetic	18		2.62×10^{-4}	3.58	Cyclopropane-1:1-dicarboxylic	25	2	3.72×10^{-4}	7.43
Acrylic	25		5.6×10^{-8}	4.25	DL-Cysteine	30	1	7.25×10^{-9}	8.14
Adipamic	25		2.35×10^{-5}	4.63	DL-Cysteine	30	2	4.6×10^{-11}	10.34
Adipic	25	1	3.71×10^{-5}	4.43	L-Cystine	25	1	1.4×10^{-8}	7.85
Adipic	25	2	3.87×10^{-5}	4.41	LCystine	25	2	1.4×10^{-10}	9.85
α -Alanine	25		1.35×10^{-10}	9.87	Deuteroacetic (in D ₂ O)	25		5.5×10^{-4}	5.25
Allantoin	25		1.10×10^{-9}	8.96	Dichloroacetic	25		3.32×10^{-2}	1.48
Alloxanic	25		2.3×10^{-7}	6.64	Dichloroacetylacetic	?		7.8×10^{-3}	2.11
α -Aminoacetic (glycine)	25		1.67×10^{-10}	9.78	Dichlorophenol (2,3-)	25		3.6×10^{-8}	7.44
α -Aminobenzoic	25		1.07×10^{-7}	6.97	Dihydroxybenzoic (2,2-)	25		1.14×10^{-3}	2.94
m -Aminobenzoic	25		1.67×10^{-5}	4.78	Dihydroxybenzoic (2,5-)	25		1.08×10^{-3}	2.97
p -Aminobenzoic	25		1.2×10^{-5}	4.92	Dihydroxybenzoic (3,4-)	25		3.3×10^{-5}	4.48
α -Aminobenzenesulfonic	25		3.3×10^{-3}	2.48	Dihydroxybenzoic (3,5-)	25		9.1×10^{-5}	4.04
m -Aminobenzenesulfonic	25		1.85×10^{-4}	3.73	Dihydroxymalic	25		1.12×10^{-2}	1.92
p -Aminobenzenesulfonic	25		5.81×10^{-4}	3.24	Dihydroxytartaric	25		1.2×10^{-2}	1.92
Anisic	25		3.38×10^{-5}	4.47	Dimethylglycine	25		1.3×10^{-10}	9.89
α - β -Anisylpropionic	25		1.59×10^{-5}	4.80	Dimethylmalic	25	1	6.83×10^{-4}	3.17
m - β -Anisylpropionic	25		2.24×10^{-5}	4.65	Dimethylmalic	25	2	8.72×10^{-7}	6.06
p - β -Anisylpropionic	25		2.04×10^{-5}	4.69	Dimethylmalonic	25		7.08×10^{-4}	3.15
Ascorbic	24	1	7.94×10^{-5}	4.10	Dinicotinic	25		1.6×10^{-3}	2.80
Ascorbic	16	2	1.62×10^{-12}	11.79	Dinitrophenol (2,4-)	15		1.1×10^{-4}	3.96
DL-Aspartic	25	1	1.38×10^{-4}	3.86	Dinitrophenol (3,6-)	15		7.1×10^{-5}	5.15
D-Aspartic	25	2	1.51×10^{-10}	9.82	Diphenylacetic	25		1.15×10^{-4}	3.94
Barbituric	25		9.8×10^{-8}	4.01	Ethylbenzoic	25		4.47×10^{-5}	4.35
Benzoic	25		6.46×10^{-5}	4.19	Ethylphenylacetic	25		4.27×10^{-5}	4.37
Benzosulfonic	25		2×10^{-1}	0.70	Fluorobenzoic	17		1.25×10^{-3}	2.90
Bromoacetic	25		2.05×10^{-3}	2.69	Formic	20		1.77×10^{-4}	3.75
α -Bromobenzoic	25		1.45×10^{-3}	2.84	Fumaric (trans-)	18	1	9.30×10^{-4}	3.03
m -Bromobenzoic	25		1.37×10^{-4}	3.86	Fumaric (trans-)	18	2	3.62×10^{-5}	4.44
n -Butyric	20		1.54×10^{-5}	4.81	Furancarboxylic	25		7.1×10^{-4}	3.15
iso-Butyric	18		1.44×10^{-5}	4.84	Furoic	25		6.76×10^{-4}	3.17
Cacodylic	25		6.4×10^{-7}	6.19	Gallic	25		3.9×10^{-5}	4.41
n -Caproic	18		1.43×10^{-5}	4.83	Glutaramic	25		3.98×10^{-5}	4.60
iso-Caproic	18		1.46×10^{-5}	4.84	Glutaric	25	1	4.58×10^{-5}	4.31
Chloroacetic	25		1.40×10^{-3}	2.85	Glutaric	25	2	3.89×10^{-5}	5.41
α -Chlorobenzoic	25		1.20×10^{-3}	2.92	Glycerol	25		7×10^{-15}	14.15
m -Chlorobenzoic	25		1.51×10^{-4}	3.82	Glycine	25		1.67×10^{-10}	9.78
p -Chlorobenzoic	25		1.04×10^{-4}	3.98	Glycol	25		6×10^{-15}	14.22
α -Chlorobutyric	R. T.		1.39×10^{-3}	2.86	Glycolic	25		1.48×10^{-4}	3.83
β -Chlorobutyric	R. T.		8.9×10^{-5}	4.05	Heptanoic	25		1.28×10^{-5}	4.89
γ -Chlorobutyric	R. T.		3.0×10^{-5}	4.52	Hexahydrobenzoic	25		1.26×10^{-5}	4.90
α -Chlorocinnamic	25		5.89×10^{-5}	4.23	Hexanoic	25		1.31×10^{-5}	4.88
m -Chlorocinnamic	25		5.13×10^{-5}	4.29	Hippuric	25		1.57×10^{-10}	3.80
p -Chlorocinnamic	25		3.89×10^{-5}	4.41	Histidine	25		6.7×10^{-10}	9.17
α -Chlorophenoxyacetic	25		8.91×10^{-4}	3.05	Hydroquinone	20		4.5×10^{-11}	10.35
m -Chlorophenoxyacetic	25		7.94×10^{-4}	3.10	α -Hydroxybenzoic	19	1	1.07×10^{-3}	2.97
α -Chlorophenylacetic	25		1.18×10^{-5}	4.07	α -Hydroxybenzoic	18	2	4×10^{-14}	13.40
m -Chlorophenylacetic	25		7.25×10^{-5}	4.14	m -Hydroxybenzoic	19	1	8.7×10^{-5}	4.06
p -Chlorophenylacetic	25		6.46×10^{-5}	4.19	m -Hydroxybenzoic	19	2	1.2×10^{-10}	9.92
β -(α -Chlorophenyl) propionic	25		2.63×10^{-4}	4.58	p -Hydroxybenzoic	19	1	3.3×10^{-5}	4.48
β -(m -Chlorophenyl) propionic	25		2.57×10^{-5}	4.59	p -Hydroxybenzoic	19	2	4.8×10^{-10}	9.32
β -(p -Chlorophenyl) propionic	25		2.46×10^{-5}	4.61	β -Hydroxybutyric	25		2×10^{-5}	4.70
α -Chloropropionic	25		1.47×10^{-3}	2.83	γ -Hydroxybutyric	25		1.9×10^{-5}	4.72
β -Chloropropionic	25		1.04×10^{-4}	3.98	β -Hydroxypropionic	25		3.1×10^{-5}	4.51
cis-Cinnamic	25		1.3×10^{-4}	3.89	γ -Hydroxyquinoline	20		3.1×10^{-10}	9.51
trans-Cinnamic	25		3.65×10^{-5}	4.44	Iodoacetic	25		7.5×10^{-4}	3.12
Citric	18	1	7.10×10^{-4}	3.14	α -Iodobenzoic	25		1.4×10^{-3}	2.85
Citric	18	2	1.68×10^{-5}	4.77	m -Iodobenzoic	25		1.6×10^{-4}	3.80
Citric	18	3	6.4×10^{-6}	6.39	Itaconic	25	1	1.40×10^{-4}	3.85
α -Cresol	25		6.3×10^{-11}	10.20	Itaconic	25	2	3.56×10^{-4}	5.45
m -Cresol	25		9.8×10^{-11}	10.01	Lactic	100		8.4×10^{-4}	3.08
p -Cresol	25		6.7×10^{-11}	10.17	Lutidinic	25		7.0×10^{-3}	2.15
Crotonic (trans-)	25		2.03×10^{-3}	4.69	Lysine	25		2.95×10^{-11}	10.53
Cyanoacetic	25		3.65×10^{-3}	2.45	Maleic	25	1	1.42×10^{-3}	1.83
γ -Cyanobutyric	25		3.80×10^{-3}	2.42					
α -Cyanophenoxyacetic	25		1.05×10^{-3}	2.98					
m -Cyanophenoxyacetic	25		9.33×10^{-4}	3.03					
p -Cyanophenoxyacetic	25		1.18×10^{-3}	2.93					
Cyanopropionic	25		3.6×10^{-3}	2.44					
Cyclohexane-1:1-dicarboxylic	25	1	3.55×10^{-4}	3.45					
Cyclohexane-1:1-dicarboxylic	25	2	7.76×10^{-7}	6.11					

DISSOCIATION CONSTANTS OF ORGANIC ACIDS IN AQUEOUS SOLUTIONS (continued)

Compound	T°C	Step	K	pK	Compound	T°C	Step	K	pK
Maleic	25	2	8.57×10^{-7}	6.07	<i>o</i> -Phthalic	25	1	1.3×10^{-3}	2.8
Malic	25	1	3.9×10^{-4}	3.40	<i>o</i> -Phthalic	25	2	3.9×10^{-8}	5.5
Malic	25	2	7.8×10^{-6}	5.11	<i>m</i> -Phthalic	25	1	2.9×10^{-4}	3.5
Malonic	25	1	1.49×10^{-3}	2.83	<i>m</i> -Phthalic	18	2	2.5×10^{-5}	4.6
Malonic	25	2	2.03×10^{-6}	5.69	<i>p</i> -Phthalic	25	1	3.1×10^{-4}	3.5
DL-Mandelic	25		1.4×10^{-4}	3.85	<i>p</i> -Phthalic	16	2	1.5×10^{-5}	4.8
Mesaconic	25	1	8.22×10^{-4}	3.09	Picric	25		4.2×10^{-1}	0.3
Mesaconic	25	2	1.78×10^{-5}	4.75	Pimelic	25		3.09×10^{-5}	4.7
Mesitylenic	25		4.8×10^{-5}	4.32	Propionic	25		1.34×10^{-5}	4.8
Methyl- <i>o</i> -aminobenzoic	25		4.6×10^{-5}	5.34	<i>iso</i> -Propylbenzoic	25		3.98×10^{-5}	4.4
Methyl- <i>m</i> -aminobenzoic	25		8×10^{-6}	5.10	2-Pyridinecarboxylic	25		3×10^{-6}	5.5
Methyl- <i>p</i> -aminobenzoic	25		9.2×10^{-6}	5.04	3-Pyridinecarboxylic	25		1.4×10^{-5}	4.8
<i>o</i> -Methylcinnamic	25		3.16×10^{-5}	4.50	4-Pyridinecarboxylic	25		1.1×10^{-5}	4.9
<i>m</i> -Methylcinnamic	25		3.63×10^{-5}	4.44	Pyrocatechol	20		1.4×10^{-10}	9.8
<i>p</i> -Methylcinnamic	25		2.76×10^{-5}	4.56					
β -Methylglutaric	25		5.75×10^{-5}	4.24	Quinolinic	25		3×10^{-3}	2.5
<i>n</i> -Methylglycine	18		1.2×10^{-10}	9.92					
Methylmalonic	25		1.17×10^{-4}	3.07	Resorcinol	25		1.55×10^{-10}	9.8
Methylsuccinic	25	1	7.4×10^{-5}	4.13					
Methylsuccinic	25	2	2.3×10^{-4}	5.64	Saccharin	18		2.1×10^{-12}	11.6
<i>o</i> -Monochlorophenol	25		3.2×10^{-9}	8.49	Suberic	25		2.99×10^{-5}	4.5
<i>m</i> -Monochlorophenol	25		1.4×10^{-9}	8.85	Succinic	25	1	6.89×10^{-5}	4.1
<i>p</i> -Monochlorophenol	25		6.6×10^{-10}	9.18	Succinic	25	2	2.47×10^{-6}	5.6
					Sulfanilic	25		5.9×10^{-4}	3.2
Naphthalenesulfonic	25		2.7×10^{-1}	0.57					
α -Naphthoic	25		2×10^{-4}	3.70	α -Tartaric	25	1	1.04×10^{-3}	2.9
β -Naphthoic	25		6.8×10^{-5}	4.17	α -Tartaric	25	2	4.55×10^{-5}	4.3
α -Naphthol	25		4.6×10^{-10}	9.34	<i>meso</i> -Tartaric	25	1	6×10^{-4}	3.2
β -Naphthol	25		3.1×10^{-10}	9.51	<i>meso</i> -Tartaric	25	2	1.53×10^{-5}	4.8
Nitrobenzene	0		1.05×10^{-4}	3.98	Theobromine	18		1.3×10^{-4}	7.8
<i>o</i> -Nitrobenzoic	18		6.95×10^{-3}	2.16	Terephthalic	25		3.1×10^{-4}	3.5
<i>m</i> -Nitrobenzoic	25		3.4×10^{-4}	3.47	Thioacetic	25		4.7×10^{-4}	3.3
<i>p</i> -Nitrobenzoic	25		3.93×10^{-4}	3.41	Thiophenecarboxylic	25		3.3×10^{-4}	3.4
<i>o</i> -Nitrophenol	25		6.8×10^{-5}	7.17	<i>o</i> -Toluic	25		1.22×10^{-4}	3.9
<i>m</i> -Nitrophenol	25		5.3×10^{-9}	8.28	<i>m</i> -Toluic	25		5.32×10^{-5}	4.2
<i>p</i> -Nitrophenol	25		7×10^{-8}	7.15	<i>p</i> -Toluic	25		4.33×10^{-5}	4.3
<i>o</i> -Nitrophenylacetic	25		1.00×10^{-4}	4.00	Trichloroacetic	25		2×10^{-1}	0.7
<i>m</i> -Nitrophenylacetic	25		1.07×10^{-4}	3.97	Trichlorophenol	25		1×10^{-6}	6.0
<i>p</i> -Nitrophenylacetic	25		1.41×10^{-4}	3.85	Trihydroxybenzoic (2,4,6-)	25		2.1×10^{-2}	1.6
<i>o</i> - β -Nitrophenylpropionic	25		3.16×10^{-5}	4.50	Trimethylacetic	18		9.4×10^{-6}	5.0
<i>p</i> - β -Nitrophenylpropionic	25		3.39×10^{-5}	4.47	Trinitrophenol (2,4,6-)	25		4.2×10^{-1}	0.3
					Tryptophan	25		4.2×10^{-10}	9.3
Nonanic	25		1.09×10^{-5}	4.96	Tyrosine	17		3.98×10^{-9}	8.4
Octanoic	25		1.28×10^{-5}	4.89					
Oxalic	25	1	5.90×10^{-2}	1.23	Uric	12		1.3×10^{-4}	3.8
Oxalic	25	2	6.40×10^{-5}	4.19					
Phenol	20		1.28×10^{-10}	9.89	<i>n</i> -Valeric	18		1.51×10^{-5}	4.8
Phenylacetic	18		5.2×10^{-5}	4.28	<i>iso</i> -Valeric	25		1.7×10^{-5}	4.7
<i>o</i> -Phenylbenzoic	25		3.47×10^{-4}	3.46	Veronal	25		3.7×10^{-4}	7.4
γ -Phenylbutyric	25		1.74×10^{-5}	4.76	Vinylacetic	25		4.57×10^{-5}	4.3
α -Phenylpropionic	25		2.27×10^{-5}	4.64					
β -Phenylpropionic	25		4.25×10^{-5}	4.37	Xanthine	40		1.24×10^{-10}	9.9

DISSOCIATION CONTANTS OF INORGANIC ACIDS IN AQUEOUS SOLUTIONS

(Approximately 0.1—0.01 N)

Compound	T°C	Step	K	pK	Compound	T°C	Step	K	pK
Arsenic	18	1	5.62×10^{-3}	2.25	Periodic	25		2.3×10^{-2}	1.64
Arsenic	18	2	1.70×10^{-7}	6.77	o-Phosphoric	25	1	7.52×10^{-3}	2.12
Arsenic	18	3	3.95×10^{-12}	11.60	o-Phosphoric	25	2	6.23×10^{-8}	7.21
Arsenious	25		6×10^{-10}	9.23	o-Phosphoric	18	3	2.2×10^{-13}	12.67
o-Boric	20	1	7.3×10^{-10}	9.14	Phosphorous	18	1	1.0×10^{-2}	2.00
o-Boric	20	2	1.8×10^{-13}	12.74	Phosphorous	18	2	2.6×10^{-7}	6.59
o-Boric	20	3	1.6×10^{-14}	13.80	Pyrophosphoric	18	1	1.4×10^{-1}	0.85
Carbonic	25	1	4.30×10^{-7}	6.37	Pyrophosphoric	18	2	3.2×10^{-2}	1.49
Carbonic	25	2	5.61×10^{-11}	10.25	Pyrophosphoric	18	3	1.7×10^{-6}	5.77
Chromic	25	1	1.8×10^{-1}	0.74	Pyrophosphoric	18	4	6×10^{-9}	8.22
Chromic	25	2	3.20×10^{-7}	6.49	Selenic	25	2	1.2×10^{-2}	1.92
Germanic	25	1	2.6×10^{-9}	8.59	Selenious	25	1	3.5×10^{-3}	2.46
Germanic	25	2	1.9×10^{-13}	12.72	Selenious	25	2	5×10^{-3}	7.31
Hydrocyanic	25		4.93×10^{-10}	9.31	m-Silicic	R.T.	1	2×10^{-10}	9.70
Hydrofluoric	25		3.53×10^{-4}	3.45	m-Silicic	R.T.	2	1×10^{-12}	12.00
Hydrogen sulfide	18	1	9.1×10^{-3}	7.04	o-Silicic	30	1	2.2×10^{-10}	9.66
Hydrogen sulfide	18	2	1.1×10^{-12}	11.96	o-Silicic	30	2	2×10^{-12}	11.70
Hydrogen peroxide	25		2.4×10^{-12}	11.62	o-Silicic	30	3	1×10^{-12}	12.00
Hypobromous	25		2.06×10^{-9}	8.69	o-Silicic	30	4	1×10^{-12}	12.00
Hypochlorous	18		2.95×10^{-8}	7.53	Sulfuric	25	2	1.20×10^{-2}	1.92
Hypoiodous	25		2.3×10^{-11}	10.64	Sulfurous	18	1	1.54×10^{-2}	1.81
Iodic	25		1.69×10^{-1}	0.77	Sulfurous	18	2	1.02×10^{-7}	6.91
Nitrous	12.5		4.6×10^{-4}	3.37	Telluric	18	1	2.09×10^{-8}	7.68
					Telluric	18	2	6.46×10^{-12}	11.29
					Tellurous	25	1	3×10^{-8}	2.48
					Tellurous	25	2	2×10^{-8}	7.70
					Tetraboric	25	1	$\sim 10^{-4}$	~ 4.00
					Tetraboric	25	2	$\sim 10^{-9}$	~ 9.00

DISSOCIATION CONSTANTS (K_b) OF AQUEOUS AMMONIA FROM 0 TO 50°C

Temperature (°C)	pK _a	K _a
0	4.862	1.374×10^{-5}
5	4.830	1.479×10^{-5}
10	4.804	1.570×10^{-5}
15	4.782	1.652×10^{-5}
20	4.767	1.710×10^{-5}
25	4.751	1.774×10^{-5}
30	4.740	1.820×10^{-5}
35	4.733	1.849×10^{-5}
40	4.730	1.862×10^{-5}
45	4.726	1.879×10^{-5}
50	4.723	1.892×10^{-5}

Values of K_a accurate to ± 0.005 ; determined by e.m.f. method by: Bates, R. G. and Pinching, G. D., *J. Am. Chem. Soc.*, 72, 1393, 1950.

(6)

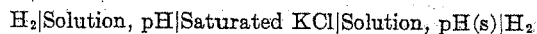
BUFFER SOLUTIONS OPERATIONAL DEFINITIONS OF pH

Prepared by R. A. Robinson

The operational definition of pH is:

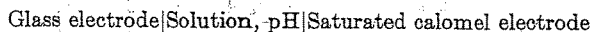
$$\text{pH} = \text{pH}(s) + E/k$$

where E is the e.m.f. of the cell:



the half cell on the left containing the solution whose pH is being measured and that on the right a standard buffer mixture of known pH; $k = 2.303RT/F$, where R is the gas constant, T the temperature in degrees Kelvin and F the value of the faraday.

Alternatively, the cell:



can be used, the glass electrode being calibrated using a standard buffer mixture or, if possible, two standard buffer mixtures whose pH values lie on either side of that of the solution which is being measured. Suitable standard buffer mixtures are:

- 0.05 M potassium hydrogen phthalate (pH = 4.008 at 25°C)
- 0.025 M potassium dihydrogen phosphate
- 0.025 M disodium hydrogen phosphate (pH = 6.865 at 25°C)
- 0.01 M borax (pH = 9.180 at 25°C)

For most purposes pH can be equated to $-\log_{10} \gamma_{\text{H}^+} m_{\text{H}^+}$, i.e., to the negative logarithm of the hydrogen ion activity. There is a small difference between those two quantities if pH > 9.2 or pH < 4.0, given by:

$$\begin{aligned} -\log \gamma_{\text{H}^+} m_{\text{H}^+} &= \text{pH} + 0.014(\text{pH} - 9.2) \text{ for } \text{pH} > 9.2 \\ &= \text{pH} + 0.009(4.0 - \text{pH}) \text{ for } \text{pH} < 4.0 \end{aligned}$$

It should be noted that in the table titled "Solutions giving Round Values of pH at 25°C" it is $-\log \gamma_{\text{H}^+} m_{\text{H}^+}$ and not pH which is quoted when there is a difference between them.

References:

R. G. Bates, "Electrometric pH Determinations: Theory and Practice" Wiley, New York, 1954.
R. A. Robinson and R. H. Stokes, "Electrolyte Solutions," 2nd edition, Butterworths, London; Academic Press, Inc. New York, 1959. R. C. Bates, J. Res. of N.B.S. 66 A, 179 (1962).

National Bureau of Standards

R. G. Bates and S. F. Acree, Res. 34, 373 (1945); W. J. Hammer, C. D. Pinching and S. F. Acree, *ibid.* 36, 47 (1946); G. G. Manor, N. J. DeLollis, P. W. Lindwall and S. F. Acree, *ibid.* 36, 543 (1946); R. G. Bates, *ibid.* 39, 411 (1947); R. G. Bates, V. E. Bower, R. G. Miller and E. R. Smith, *ibid.* 47, 433 (1951); V. E. Bower, R. G. Bates and E. R. Smith, *ibid.* 51, 189 (1953); V. E. Bower and R. G. Bates, *ibid.* 55, 197 (1955); R. G. Bates, V. E. Bower and E. R. Smith, *ibid.* 56, 305 (1956); V. E. Bower and R. G. Bates, *ibid.* 59, 261; R. G. Bates and V. E. Bower, Anal. Chem., 28, 1322 (1956).

PROPERTIES OF STANDARD AQUEOUS BUFFER SOLUTIONS AT 25°C

Solution	Buffer substance	Molality m	Weight of salt in air per liter solution	Density g/ml	Molarity M	Dilution value $\Delta\text{pH}_\frac{1}{2}$	$\Delta\text{pH}_\frac{1}{2}^a$	Buffer value, equiv. per pH	Temp coeff., $\text{dpH}_\frac{1}{2}/\text{dt}$, Units per °C
Tetroxalate	$\text{KH}_2(\text{C}_2\text{O}_4)_2 \cdot 2\text{H}_2\text{O}$	0.05	12.61	1.0032	0.04962	+0.186	-0.0028	0.070	+0.001
Tartrate	$\text{KHC}_2\text{H}_3\text{O}_6$, sat. sol'n. at 25°C	0.0341	.....	1.0036	0.034	+0.049	-0.0003	0.027	-0.0014
Phthalate	$\text{KHC}_8\text{O}_4\text{H}_4$	0.05	10.12	1.0017	0.04958	+0.052	-0.0009	0.016	+0.0012
Phosphate	KH_2PO_4 + Na_2HPO_4	0.025 ^b	3.39 3.53	1.0028	0.0249 ^b	+0.080	-0.0006	0.029	-0.0028
Phosphate	KH_2PO_4 + Na_2HPO_4	0.008695 ^c 0.03043 ^d	1.179 4.30	1.0020	0.008665 ^e 0.03032 ^d	+0.07 ^e	-0.0005 ^e	0.016	-0.0028
Borax	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$	0.01	3.80	0.9996	0.009971	+0.01	-0.0001	0.020	-0.0082
Calcium hydroxide	$\text{Ca}(\text{OH})_2$, sat. sol'n. at 25°C	0.0203	.....	0.9991	0.02025	-0.28	+0.0014	0.09	-0.033

^a $\Delta\text{pH}_\frac{1}{2} = \text{pH}_s (\text{M Molar solution}) - \text{pH}_m (\text{m molal solution})$.

^b Concentration of each phosphate salt.

^c KH_2PO_4 .

^d Na_2HPO_4 .

^e Calculated value.

(7)

BUFFER SOLUTIONS (Continued)

SOLUTIONS GIVING ROUND VALUES OF pH AT 25°C

Reproduced from "Electrolyte Solutions" by permission from Robinson and Stokes, authors, and Butterworth's Scientific Publications.

A*		B*		C*		D*		E*	
pH	z	pH	z	pH	z	pH	z	pH	z
1.00	67.0	2.20	49.5	4.10	1.3	5.80	3.6	7.00	46.6
1.10	52.8	2.30	45.8	4.20	3.0	5.90	4.6	7.10	45.7
1.20	42.5	2.40	42.2	4.30	4.7	6.00	5.6	7.20	44.7
1.30	33.6	2.50	38.8	4.40	6.6	6.10	6.8	7.30	43.4
1.40	26.6	2.60	35.4	4.50	8.7	6.20	8.1	7.40	42.0
1.50	20.7	2.70	32.1	4.60	11.1	6.30	9.7	7.50	40.3
1.60	16.2	2.80	28.9	4.70	13.6	6.40	11.6	7.60	38.5
1.70	13.0	2.90	25.7	4.80	16.5	6.50	13.9	7.70	36.6
1.80	10.2	3.00	22.3	4.90	19.4	6.60	16.4	7.80	34.5
1.90	8.1	3.10	18.8	5.00	22.6	6.70	19.3	7.90	32.0
2.00	6.5	3.20	15.7	5.10	25.5	6.80	22.4	8.00	29.2
2.10	5.1	3.30	12.9	5.20	28.8	6.90	25.9	8.10	26.2
2.20	3.9	3.40	10.4	5.30	31.6	7.00	29.1	8.20	22.9
		3.50	8.2	5.40	34.1	7.10	32.1	8.30	19.9
		3.60	6.3	5.50	36.6	7.20	34.7	8.40	17.2
		3.70	4.5	5.60	38.8	7.30	37.0	8.50	14.7
		3.80	2.9	5.70	40.6	7.40	39.1	8.60	12.2
		3.90	1.4	5.80	42.3	7.50	41.1	8.70	10.3
		4.00	0.1	5.90	43.7	7.60	42.8	8.80	8.5
						7.70	44.2	8.90	7.0
						7.80	45.3	9.00	5.7
						7.90	46.1		
						8.00	46.7		

F*		G*		H*		I*		J*	
pH	z	pH	z	pH	z	pH	z	pH	z
8.00	20.5	9.20	0.9	9.60	5.0	10.90	3.3	12.00	6.0
8.10	19.7	9.30	3.6	9.70	6.2	11.00	4.1	12.10	8.0
8.20	18.8	9.40	6.2	9.80	7.6	11.10	5.1	12.20	10.2
8.30	17.7	9.50	8.8	9.90	9.1	11.20	6.3	12.30	12.8
8.40	16.6	9.60	11.1	10.00	10.7	11.30	7.6	12.40	16.2
8.50	15.2	9.70	13.1	10.10	12.2	11.40	9.1	12.50	20.4
8.60	13.5	9.80	15.0	10.20	13.8	11.50	11.1	12.60	25.6
8.70	11.6	9.90	16.7	10.30	15.2	11.60	13.5	12.70	32.2
8.80	9.6	10.00	18.3	10.40	16.5	11.70	16.2	12.80	41.2
8.90	7.1	10.10	19.5	10.50	17.8	11.80	19.4	12.90	53.0
9.00	4.6	10.20	20.5	10.60	19.1	11.90	23.0	13.00	66.0
9.10	2.0	10.30	21.3	10.70	20.2	12.00	26.9		
		10.40	22.1	10.80	21.2				
		10.50	22.7	10.90	22.0				
		10.60	23.3	11.00	22.7				
		10.70	23.8						
		10.80	24.25						

*A. 25 ml of 0.2 molar KCl + x ml of 0.2 molar HCl.

*B. 50 ml of 0.1 molar potassium hydrogen phthalate + x ml of 0.1 molar HCl.

*C. 50 ml of 0.1 molar potassium hydrogen phthalate + x ml of 0.1 molar NaOH.

*D. 50 ml of 0.1 molar potassium dihydrogen phosphate + x ml of 0.1 molar NaOH.

*E. 50 ml of 0.1 molar tris(hydroxymethyl) aminomethane + x ml of 0.1 M HCl.

*F. 50 ml of 0.025 molar borax + x ml of 0.1 molar HCl.

*G. 50 ml of 0.025 molar borax + x ml of 0.1 molar NaOH.

*H. 50 ml of 0.05 molar sodium bicarbonate + x ml of 0.1 molar NaOH.

*I. 50 ml of 0.05 molar disodium hydrogen phosphate + x ml of 0.1 molar NaOH.

*J. 25 ml of 0.2 molar KCl + x ml of 0.2 molar NaOH.

Final Volume of Mixtures = 100 ml

BUFFER SOLUTIONS (Continued)

STANDARD VALUES OF pH AT TEMPERATURE 0-95°C

Temperature	Tetroxalate 0.05 molal	Tartrate 0.0341 molal (sat'd at 25°C)	Phthalate 0.05 molal	Phosphate ^a	Phosphate ^b	Borax 0.01 molal	Calcium hydroxide (sat'd at 25°C)
0	1.666	.....	4.003	6.984	7.534	9.464	13.423
5	1.668	.....	3.999	6.951	7.500	9.395	13.207
10	1.670	.....	3.998	6.923	7.472	9.332	13.003
15	1.672	.....	3.999	6.900	7.448	9.276	12.810
20	1.675	.....	4.002	6.881	7.429	9.225	12.627
25	1.679	3.557	4.008	6.865	7.413	9.180	12.454
30	1.683	3.552	4.015	6.853	7.400	9.139	12.289
35	1.688	3.549	4.024	6.844	7.389	9.102	12.133
38	1.691	3.548	4.030	6.840	7.384	9.081	12.043
40	1.694	3.547	4.035	6.838	7.380	9.068	11.984
45	1.700	3.547	4.047	6.834	7.373	9.038	11.841
50	1.707	3.549	4.060	6.833	7.367	9.011	11.705
55	1.715	3.554	4.075	6.834	.....	8.985	11.574
60	1.723	3.560	4.091	6.836	.....	8.962	11.449
70	1.743	3.580	4.126	6.845	.....	8.921	.....
80	1.766	3.609	4.164	6.859	.....	8.885	.....
90	1.792	3.650	4.205	6.877	.....	8.850	.....
95	1.806	3.674	4.227	6.886	.....	8.833	.....

^a Solution 0.025 m KH₂PO₄ and 0.025 m Na₂HPO₄.

^b Solution 0.008695 m KH₂PO₄ and 0.03043 m Na₂HPO₄.

APPROXIMATE pH VALUES

The following tables give approximate pH values for a number of substances such as acids, bases, foods, biological fluids, etc. All values are rounded off to the nearest tenth and are based on measurements made at 25° C. A few buffer systems with their pH values are also given.

From Modern pH and Chlorine Control, W. A. Taylor & Co., by permission

ACIDS

Hydrochloric, N.....	0.1	Oxalic, 0.1N.....	1.6	Acetic, 0.01N.....	3.4
Hydrochloric, 0.1N.....	1.1	Tartaric, 0.1N.....	2.2	Benzoic, 0.01N.....	3.1
Hydrochloric, 0.01N.....	2.0	Malic, 0.1N.....	2.2	Alum, 0.1N.....	3.2
Sulfuric, N.....	0.3	Citric, 0.1N.....	2.2	Carbonic (saturated).....	3.8
Sulfuric, 0.1N.....	1.2	Formic, 0.1N.....	2.3	Hydrogen sulfide, 0.1N.....	4.1
Sulfuric, 0.01N.....	2.1	Lactic, 0.1N.....	2.4	Arsenious (saturated).....	5.0
Orthophosphoric, 0.1N.....	1.5	Acetic, N.....	2.4	Hydrocyanic, 0.1N.....	5.1
Sulfurous, 0.1N.....	1.5	Acetic, 0.1N.....	2.9	Boric, 0.1N.....	5.2

BASES

Sodium hydroxide, N.....	14.0	Lime (saturated).....	12.4	Magnesia (saturated).....	10.5
Sodium hydroxide, 0.1N.....	13.0	Trisodium phosphate, 0.1N.....	12.0	Sodium sesquicarbonate, 0.1M.....	10.1
Sodium hydroxide, 0.01N.....	12.0	Sodium carbonate, 0.1N.....	11.6	Ferrous hydroxide (saturated).....	9.5
Potassium hydroxide, N.....	14.0	Ammonia, N.....	11.6	Calcium carbonate (saturated).....	9.4
Potassium hydroxide, 0.1N.....	13.0	Ammonia, 0.1N.....	11.1	Borax, 0.1N.....	9.2
Potassium hydroxide, 0.01N.....	12.0	Ammonia, 0.01N.....	10.6	Sodium bicarbonate, 0.1N.....	8.4
Sodium metasilicate, 0.1N.....	12.6	Potassium cyanide, 0.1N.....	11.0		

BIOLOGIC MATERIALS

Blood, plasma, human.....	7.3-7.5	Gastric contents, human.....	1.0-3.0	Milk, human.....	6.6-7.6
Spinal fluid, human.....	7.3-7.5	Duodenal contents, human.....	4.8-8.2	Bile, human.....	6.8-7.0
Blood, whole, dog.....	6.9-7.2	Feces, human.....	4.6-8.4		
Saliva, human.....	6.5-7.5	Urine, human.....	4.8-8.4		

FOODS

Apples.....	2.9-3.3	Gooseberries.....	2.8-3.0	Potatoes.....	5.6-6.0
Apricots.....	3.6-4.0	Grapefruit.....	3.0-3.3	Pumpkin.....	4.8-5.2
Asparagus.....	5.4-5.8	Grapes.....	3.5-4.5	Raspberries.....	3.2-3.6
Bananas.....	4.5-4.7	Hominy (lye).....	6.8-8.0	Rhubarb.....	3.1-3.2
Beans.....	5.0-6.0	Jams, fruit.....	3.5-4.0	Salmon.....	6.1-6.3
Beers.....	4.0-5.0	Jellies, fruit.....	2.8-3.4	Sauerkraut.....	3.4-3.6
Beets.....	4.9-5.5	Lemons.....	2.2-2.4	Shrimp.....	6.8-7.0
Blackberries.....	3.2-3.6	Limes.....	1.8-2.0	Soft drinks.....	2.0-4.0
Bread, white.....	5.0-6.0	Maple syrup.....	6.5-7.0	Spinach.....	5.1-5.7
Butter.....	6.1-6.4	Milk, cows.....	6.3-6.6	Squash.....	5.0-5.4
Cabbage.....	5.2-5.4	Olives.....	3.6-3.8	Strawberries.....	3.0-3.5
Carrots.....	4.9-5.3	Oranges.....	3.0-4.0	Sweet potatoes.....	5.3-5.6
Cheese.....	4.8-6.4	Oysters.....	6.1-6.6	Tomatoes.....	4.0-4.4
Cherries.....	3.2-4.0	Peaches.....	3.4-3.6	Tuna.....	5.9-6.1
Cider.....	2.9-3.3	Pears.....	3.6-4.0	Turnips.....	5.2-5.6
Corn.....	6.0-6.5	Peas.....	5.8-6.4	Vinegar.....	2.4-3.4
Crackers.....	6.5-8.5	Pickles, dill.....	3.2-3.6	Water, drinking.....	6.5-8.0
Dates.....	6.2-6.4	Pickles, sour.....	3.0-3.4	Wines.....	2.8-3.8
Eggs, fresh white.....	7.6-8.0	Pimento.....	4.6-5.2		
Flour, wheat.....	5.5-6.5	Plums.....	2.8-3.0		

FORMULAS FOR CALCULATING TITRATION DATA, pH VS. ML. OF REAGENT

A Substance Titrated V_0 ml. of solution M_0 its molarity	B Initial $[H^+]$ or $[OH^-]$	C Intermediate Points 10, 50, 99, etc., per cent neutralized, V_1 ml. of reagent of M_1 molarity added	D Equivalence Point	E Excess of Reagent V_1 volume reagent M_1 its molarity V_T total volume
(1) Strong Acid.....	$[H^+] = M_0$	$[H^+] = \frac{V_0M_0 - V_1M_1}{V_0 + V_1}$	$\sqrt{K_w}$	$[OH^-] = \frac{V_1M_1}{V_T}$
(2) Strong Base.....	$[OH^-] = M_0$	$[OH^-] = \frac{V_0M_0 - V_1M_1}{V_0 + V_1}$	$\sqrt{K_w}$	$[H^+] = \frac{V_1M_1}{V_T}$
(3) Weak Acid ($K_a = 10^{-5}$ to 10^{-8}).....	$[H^+] = \sqrt{M_0K_a}$	$[H^+] = \frac{[Acid]}{[Salt]} K_a$	$[OH^-] = \sqrt{\frac{K_w}{K_a}} c$	$[OH^-] = \frac{V_1M_1}{V_T}$ (Value in column D to be added)
(4) Weak Base ($K_b = 10^{-5}$ to 10^{-8}).....	$[OH^-] = \sqrt{M_0K_b}$	$[OH^-] = \frac{[Base]}{[Salt]} K_b$	$[H^+] = \sqrt{\frac{K_w}{K_b}} c$	$[H^+] = \frac{V_1M_1}{V_T}$ (Value in column D to be added)
(5) Salt of a Very Weak Acid (e.g. KCN).	$[OH^-] = \sqrt{\frac{K_w}{K_a}} c$	$[H^+] = \frac{[Acid]}{[Salt]} K_a$	$[H^+] = \sqrt{[Acid]K_a}$	$[H^+] = \frac{V_1M_1}{V_T}$ (Correct for value in column D)
(6) Salt of a Very Weak Base.....	$[H^+] = \sqrt{\frac{K_w}{K_b}} c$	$[OH^-] = \frac{[Base]}{[Salt]} K_b$	$[OH^-] = \sqrt{[Base]K_b}$	$[OH^-] = \frac{V_1M_1}{V_T}$ (Add to $[OH^-]$ found in column D)

CONVERSION FORMULAE FOR SOLUTIONS HAVING CONCENTRATIONS EXPRESSED IN VARIOUS WAYS

A = Weight per cent of solute
 B = Molecular weight of solvent
 E = Molecular weight of solute
 F = Grams of solute per liter of solution
 G = Molality
 M = Molarity
 N = Mole fraction
 R = Density of solution grams per cc

Concentration of solute— SOUGHT	Concentration of solute—GIVEN				
	A	N	G	M	F
A	—	$\frac{100N \times E}{N \times E + (1 - N)B}$	$\frac{100G \times E}{1000 + G \times E}$	$\frac{M \times E}{10R}$	$\frac{F}{10R}$
N	$\frac{\frac{A}{E} + \frac{100 - A}{B}}{\frac{A}{E} + \frac{100 - A}{B}}$	—	$\frac{B \times G}{B \times G + 1000}$	$\frac{B \times M}{M(B - E) + 1000R}$	$\frac{B \times F}{F(B - E) + 1000R \times E}$
G	$\frac{1000A}{E(100 - A)}$	$\frac{1000N}{B - N \times B}$	—	$\frac{1000M}{1000R - (M \times E)}$	$\frac{1000F}{E(1000R - F)}$
M	$\frac{10R \times A}{E}$	$\frac{1000R \times N}{N \times E + (1 - N)B}$	$\frac{1000R \times G}{1000 + E \times G}$	—	$\frac{F}{E}$
F	10AR	$\frac{1000R \times N \times E}{N \times E + (1 - N)B}$	$\frac{1000R \times G \times E}{1000 + G \times E}$	$M \times E$	—

ACID BASE INDICATORS

Indicator	Approximate pH range	Color-change	Preparation
Methyl Violet	0.0-1.6	yel to bl	0.01-0.05% in water
Crystal Violet	0.0-1.8	yel to bl	0.02% in water
Ethyl Violet	0.0-2.4	yel to bl	0.1 g in 50 ml of MeOH + 50 ml of water
Malachite Green	0.2-1.8	yel to bl grn	water
Methyl Green	0.2-1.8	yel to bl	0.1 % in water
2-(p-dimethylaminophenylazo)pyridine	0.2-1.8	yel to bl	0.1 % in EtOH
	4.4-5.6	red to yel	
o-Cresolsulfonephthalein (Cresol Red)	0.4-1.8	yel to red	0.1 g in 26.2 ml 0.01N NaOH + 223.8 ml water
	7.0-8.8	yel to red	
Quinaldine Red	1.0-2.2	col to red	1% in EtOH
p-(p-dimethylaminophenylazo)-benzoic acid, Na-salt (Paramethyl Red)	1.0-3.0	red to yel	EtOH
m-(p-anilnophenylazo)benzene sulfonic acid, Na-salt (Metanil Yellow)	1.2-2.4	red to yel	0.01% in water
4-Phenylazodiphenylamine	1.2-2.6	red to yel	0.01 g in 1 ml 1N HCl + 50 ml EtOH + 49 ml water
Thymolsulfonephthalein (Thymol Blue)	1.2-2.8	red to yel	0.1 g in 21.5 ml
	8.0-9.6	yel to bl	0.01N NaOH + 229.5 ml water
m-Cresolsulfonephthalein (Metacresol Purple)	1.2-2.8	red to yel	0.1 g in 26.2 ml
	7.4-9.0	yel to purp	0.01N NaOH + 223.8 ml water
p-(p-anilinophenylazo)benzenesulfonic acid, Na-salt (Orange IV)	1.4-2.8	red to yel	0.01% in water
4-o-Tolylazo-o-toluidine	1.4-2.8	or to yel	water
Erythrosine, disodium salt	2.2-3.6	or to red	0.1 % in water
Benzopurpurine 48	2.2-4.2	vt to red	0.1 % in water
N,N-dimethyl-p-(m-tolylazo)aniline	2.6-4.8	red to yel	0.1 % in water
4,4'-Bix(2-amino-1-naphthylazo)2,2'-stilbenedisulfonic acid	3.0-4.0	purp to red	0.1 g in 5.9 ml 0.05N NaOH + 94.1 ml water
Tetrabromophenolphthaleinethyl ester, K-salt	3.0-4.2	yel to bl	0.1 % in EtOH
3',3'',5',5''-tetrabromophenol-sulfonephthalein (Bromophenol Blue)	3.0-4.6	yel to bl	0.1 g in 14.9 ml 0.01N NaOH + 235.1 ml water
2,4-Dinitrophenol	2.8-4.0	col to yel	saturated water solution
N,N-Dimethyl-p-phenylazoaniline (p-Dimethylaminoazobenzene)	2.8-4.4	red to yel	0.1 g in 90 ml in EtOH + 10 ml water
Congo Red	3.0-5.0	blue to red	0.1 % in water
Methyl Orange-Xylene Cyanole solution	3.2-4.2	purp to grn	ready solution
Methyl Orange	3.2-4.4	red to yel	0.01% in water
Ethyl Orange	3.4-4.8	red to yel	0.05-0.2% in water or aqueous EtOH
4-(4-Dimethylamino-1-naphthylazo)-3-methoxybenzenesulfonic acid	3.5-4.8	vt to yel	0.1 % in 60% EtOH
3',3'',5',5''-Tetrabromo-m-cresol-sulfonephthalein (Bromocresol Green)	3.8-5.4	yel to blue	0.1 g in 14.3 ml 0.01N NaOH + 235.7 ml water
Resazurin	3.8-6.4	or to vt	water
4-Phenylazo-1-naphthylamine	4.0-5.6	red to yel	0.1 % in EtOH
Ethyl Red	4.0-5.8	col to red	0.1 g in 50 ml MeOH + 50 ml water
2-(p-Dimethylaminophenylazo)-pyridine	0.2-1.8	yel to red	0.1 % in EtOH
	4.4-5.6	red to yel	
4-(p-ethoxyphenylazo)-m-phenylene-diamine monohydrochloride	4.4-5.8	or to yel	0.1 % in water
Lacmoid	4.4-6.2	red to bl	0.2% in EtOH
Alizarin Red S	4.6-6.0	yel to red	dilute solution in water
Methyl Red	4.8-6.0	red to yel	0.02 g in 60 ml EtOH + 40 ml water

ACID BASE INDICATORS (Continued)

Indicator	Approximate pH range	Color-change	Preparation
Propyl Red	4.8-6.6	red to yel	EtOH
5',5''-Dibromo-o-cresolsulfone-phthalein (Bromocresol Purple)	5.2-6.8	yel to purp	0.1 g in 18.5 ml 0.01N NaOH + 231.5 ml water
3',3''-Dichlorophenolsulfonephthalein (Chlorophenol Red)	5.2-6.8	yel to red	0.1 g in 23.6 ml 0.01N NaOH + 226.4 ml water
p-Nitrophenol	5.4-6.6	col to yel	0.1 % in water
Alizarin	5.6-7.2	yel to red	0.1 % in MeOH
	11.0-12.4	red to purp	
2-(2,4-Dinitrophenylazo)-1-naphthol-3,6-disulfonic acid, di-Na salt	6.0-7.0	yel to bl	0.1 % in water
3',3''-Dibromothymolsulfonephthalein (Bromothymol Blue)	6.0-7.6	yel to bl	0.1 g in 16 ml 0.01N NaOH + 234 ml water
6,8-Dinitro-2,4-(1H)quinazolinedione (m-Dinitrobenzoylene urea)	6.4-8.0	col to yel	25 g in 115 ml M NaOH + 50 ml boiling water
Brilliant Yellow	6.6-7.8	yel to or	0.292 g of NaCl in 100 ml water
Phenolsulfonephthalein (Phenol Red)	6.6-8.0	yel to red	1 % in water
			0.1 g in 28.2 ml 0.01N NaOH + 221.8 ml water
Neutral Red	6.8-8.0	red to amb	0.01 g in 50 ml EtOH + 50 ml water
m-Nitrophenol	6.8-8.6	col to yel	0.3 % in water
o-Cresolsulfonephthalein (Cresol Red)	0.0-1.0	red to yel	0.1 g in 26.2 ml 0.01N NaOH + 223.8 ml water
	7.0-8.8	yel to red	EtOH
Curcumin	7.4-8.6	yel to red	
	10.2-11.8		
m-Cresolsulfonephthalein (Metacresol Purple)	1.2-2.8	red to yel	0.1 g in 26.2 ml 0.01N NaOH + 223.8 ml water
4,4'-Bis(4-amino-1-naphthylazo)-2,2'stilbene disulfonic acid	7.4-9.0	yel to purp	0.1 g in 5.9 ml 0.05N NaOH + 94.1 ml water
Thymolsulfonephthalein (Thymol Blue)	8.0-9.0	bl to red	0.1 g in 21.5 ml 0.01N NaOH + 228.5 ml water
	1.2-2.8	red to yel	0.04 % in EtOH
o-Cresolphthalein	8.0-9.6	col to red	1 % in dil. alkali
p-Naphtholbenzene	8.2-9.8	or to bl	0.05 g in 50 ml EtOH + 50 ml water
Phenolphthalein	8.2-10.0	col to pink	
Ethyl-bis(2,4-dimethylphenyl)acetate	8.4-9.6	col to bl	saturated solution in 50 % acetone alcohol
Thymolphthalein	9.4-10.6	col to bl	0.04 g in 50 ml EtOH + 50 ml water
5-(p-Nitrophenylazo)salicylic acid, Na-salt (Alizarin Yellow R)	10.1-12.0	yel to red	0.01 % in water
p-(2,4-Dihydroxyphenylazo)benzenesulfonic acid, Na-salt	11.4-12.6	yel to or	0.1 % in water
5,5'-Indigodisulfonic acid, di-Na-salt	11.4-13.0	bl to yel	water
2,4,6-Trinitrotoluene	11.5-13.0	col to or	0.1-0.5 % in EtOH
1,3,5-Trinitrobenzene	12.0-14.0	col to or	0.1-0.5 % in EtOH
Clayton Yellow	12.2-13.2	yel to amb	0.1 % in water

SOLUBILITY PRODUCT

The solubility product (or ion product constant) is the product of the concentrations of the ions in the saturated solution of a difficultly soluble salt. The concentrations are expressed as moles per liter of solution. The number of cations (or anions) resulting from the dissociation of one molecule of the salt, appears in the formula for calculations of the solubility product as the exponent of the concentration of the cation (or anion).

If two solutions, each containing one of the ions of a difficultly soluble salt, are mixed, no precipitation takes place unless the product of the ion concentrations in the mixture is greater than the solubility product.

In a solution containing two salts which yield a common ion the ratio of solubilities of the two salts is the ratio of the solubility products.

Substance	Solubility product at temperature noted	Substance	Solubility product at temperature noted
Aluminum hydroxide.....	4×10^{-13} (15°)	Lead iodide.....	7.47×10^{-9} (15°)
Aluminum hydroxide.....	1.1×10^{-15} (18°)	Lead iodide.....	1.39×10^{-8} (25°)
Aluminum hydroxide.....	3.7×10^{-15} (25°)	Lead oxalate.....	2.74×10^{-11} (18°)
Barium carbonate.....	7×10^{-9} (16°)	Lead sulfate.....	1.06×10^{-8} (18°)
Barium carbonate.....	8.1×10^{-9} (25°)	Lead sulfide.....	3.4×10^{-28} (18°)
Barium chromate.....	1.6×10^{-10} (18°)	Lithium carbonate.....	1.7×10^{-3} (25°)
Barium chromate.....	2.4×10^{-10} (28°)	Magnesium ammonium phosphate..	2.5×10^{-13} (25°)
Barium fluoride.....	1.6×10^{-6} (9.5°)	Magnesium carbonate.....	2.6×10^{-5} (12°)
Barium fluoride.....	1.7×10^{-6} (18°)	Magnesium fluoride.....	7.1×10^{-9} (18°)
Barium fluoride.....	1.73×10^{-6} (25.8°)	Magnesium fluoride.....	6.4×10^{-9} (27°)
Barium iodate, Ba(IO ₃) ₂ · 2H ₂ O.....	8.4×10^{-11} (10°)	Magnesium hydroxide.....	1.2×10^{-11} (18°)
Barium iodate, Ba(IO ₃) ₂ · 2H ₂ O.....	6.5×10^{-10} (25°)	Magnesium oxalate.....	8.57×10^{-5} (18°)
Barium oxalate, BaC ₂ O ₄ · 3H ₂ O.....	1.62×10^{-7} (18°)	Manganese hydroxide.....	4×10^{-14} (18°)
Barium oxalate, BaC ₂ O ₄ · 2H ₂ O.....	1.2×10^{-7} (18°)	Manganese sulfide.....	1.4×10^{-15} (18°)
Barium oxalate, BaC ₂ O ₄ · H ₂ O.....	2.18×10^{-7} (18°)	Mercuric sulfide.....	4×10^{-53} to 2×10^{-49} (18°)
Barium sulfate.....	0.87×10^{-10} (18°)	Mercurous bromide.....	1.3×10^{-21} (25°)
Barium sulfate.....	1.08×10^{-10} (25°)	Mercurous chloride.....	2×10^{-18} (25°)
Barium sulfate.....	1.98×10^{-10} (50°)	Mercurous iodide.....	1.2×10^{-28} (25°)
Cadmium oxalate CdC ₂ O ₄ · 3H ₂ O.....	1.53×10^{-8} (18°)	Nickel sulfide.....	1.4×10^{-24} (18°)
Cadmium sulfide.....	3.6×10^{-29} (18°)	Potassium acid tartrate [K ⁺ [HC ₄ H ₄ O ₆] ⁻]	3.8×10^{-4} (18°)
Calcium carbonate (calcite).....	0.99×10^{-8} (15°)	Silver bromate.....	3.97×10^{-5} (20°)
Calcium carbonate (calcite).....	0.87×10^{-8} (25°)	Silver bromate.....	5.77×10^{-5} (25°)
Calcium fluoride.....	3.4×10^{-11} (18°)	Silver bromide.....	4.1×10^{-13} (18°)
Calcium fluoride.....	3.95×10^{-11} (26°)	Silver bromide.....	7.7×10^{-12} (25°)
Calcium iodate, Ca(IO ₃) ₂ · 6H ₂ O.....	22.2×10^{-8} (10°)	Silver carbonate.....	6.15×10^{-12} (25°)
Calcium iodate, Ca(IO ₃) ₂ · 6H ₂ O.....	64.4×10^{-8} (18°)	Silver chloride.....	0.21×10^{-10} (4.7°)
Calcium oxalate, CaC ₂ O ₄ · H ₂ O.....	1.78×10^{-9} (18°)	Silver chloride.....	0.37×10^{-10} (9.7°)
Calcium oxalate, CaC ₂ O ₄ · H ₂ O.....	2.57×10^{-9} (25°)	Silver chloride.....	1.56×10^{-10} (25°)
Calcium sulfate.....	2.45×10^{-5} (25°C)	Silver chloride.....	13.2×10^{-10} (50°)
Calcium tartrate, CaC ₄ H ₄ O ₆ · 2H ₂ O.....	0.77×10^{-6} (18°)	Silver chloride.....	215×10^{-10} (100°)
Cobalt sulfide.....	3×10^{-26} (18°)	Silver chromate.....	1.2×10^{-12} (14.8°)
Cupric iodate.....	1.4×10^{-7} (25°)	Silver chromate.....	9×10^{-12} (25°)
Cupric oxalate.....	2.87×10^{-8} (25°)	Silver cyanide [Ag ⁺ [Ag(CN) ₂] ⁻]	2.2×10^{-12} (20°)
Cupric sulfide.....	8.5×10^{-45} (18°)	Silver dichromate.....	2×10^{-7} (25°)
Cuprous bromide.....	4.15×10^{-8} (18-20°)	Silver hydroxide.....	1.52×10^{-8} (20°)
Cuprous chloride.....	1.02×10^{-6} (18-20°)	Silver iodate.....	0.92×10^{-8} (9.4°)
Cuprous iodide.....	5.06×10^{-12} (18-20°)	Silver iodide.....	0.32×10^{-16} (13°)
Cuprous sulfide.....	2×10^{-47} (16-18°)	Silver iodide.....	1.5×10^{-16} (25°)
Cuprous thiocyanate.....	1.6×10^{-11} (18°)	Silver sulfide.....	1.6×10^{-49} (18°)
Ferric hydroxide.....	1.1×10^{-36} (18°)	Silver thiocyanate.....	0.49×10^{-12} (18°)
Ferrous hydroxide.....	1.64×10^{-14} (18°)	Silver thiocyanate.....	1.16×10^{-12} (25°)
Ferrous oxalate.....	2.1×10^{-7} (25°)	Strontium carbonate.....	1.6×10^{-9} (25°)
Ferrous sulfide.....	3.7×10^{-19} (18°)	Strontium fluoride.....	2.8×10^{-9} (18°)
Lead carbonate.....	3.3×10^{-14} (18°)	Strontium oxalate.....	5.61×10^{-8} (18°)
Lead chromate.....	1.77×10^{-14} (18°)	Strontium sulfate.....	2.77×10^{-7} (2.9°)
Lead fluoride.....	2.7×10^{-8} (9°)	Strontium sulfate.....	3.81×10^{-7} (17.4°)
Lead fluoride.....	3.2×10^{-8} (18°)	Zinc hydroxide.....	1.8×10^{-14} (18-20°)
Lead fluoride.....	3.7×10^{-8} (26.6°)	Zinc oxalate, ZnC ₂ O ₄ · 2H ₂ O.....	1.35×10^{-9} (18°)
Lead iodate.....	5.3×10^{-14} (9.2°)	Zinc sulfide.....	1.2×10^{-22} (18°)
Lead iodate.....	1.2×10^{-18} (18°)		
Lead iodate.....	2.6×10^{-13} (25.8°)		

ELECTROCHEMICAL SERIES

Table I
Alphabetical listing
Compiled by J. F. Hunsberger
Values listed are Standard Reduction Potentials

Reaction	Potential, volts	Reaction	Potential, volts
$\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$	0.7996	$\text{Ce}^{+3} + 3\text{e}^- \rightarrow \text{Ce(Hg)}$	-1.4373
$\text{Ag}^{+2} + \text{e}^- \rightarrow \text{Ag}^{+1}(4\text{fHClO}_4)$	1.987	$\text{Ce}^{+4} + \text{e}^- \rightarrow \text{Ce}^{+3}$	1.4430
$\text{AgAc} + \text{e}^- \rightarrow \text{Ag} + \text{Ac}^-$	0.64		(1.61)
$\text{AgBr} + \text{e}^- \rightarrow \text{Ag} + \text{Br}^-$	0.0713	$\text{Ce}^{+4} + \text{e}^- \rightarrow \text{Ce}^{+3}(0.5\text{f H}_2\text{SO}_4)$	1.4587
$\text{AgBrO}_3 + \text{e}^- \rightarrow \text{Ag} + \text{BrO}_3^-$	0.680	$\text{CeOH}^{+3} + \text{H}^+ + \text{e}^- \rightarrow \text{Ce}^{+3} + \text{H}_2\text{O}$	1.7134
$\text{AgC}_2\text{O}_4 + 2\text{e}^- \rightarrow \text{Ag} + \text{C}_2\text{O}_4^{2-}$	0.4776	$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-$	1.3583
$\text{AgCl} + \text{e}^- \rightarrow \text{Ag} + \text{Cl}^-$	0.2223	$\text{HClO} + \text{H}^+ + \text{e}^- \rightarrow 1/2\text{Cl}_2 + \text{H}_2\text{O}$	1.63
$\text{AgCN} + \text{e}^- \rightarrow \text{Ag} + \text{CN}^-$	-0.02	$\text{HClO} + \text{H}^+ + 2\text{e}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$	1.49
$\text{Ag}_2\text{CO}_3 + 2\text{e}^- \rightarrow 2\text{Ag} + \text{CO}_3^{2-}$	0.4769	$\text{ClO}^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Cl}^- + 2\text{OH}^-$	0.90
$\text{Ag}_2\text{CrO}_4 + 2\text{e}^- \rightarrow 2\text{Ag} + \text{CrO}_4^{2-}$	0.4463	$\text{ClO}_2 + \text{e}^- \rightarrow \text{ClO}_2^-$	1.15
$\text{Ag}_4\text{Fe(CN)}_6 + 4\text{e}^- \rightarrow 4\text{Ag} + \text{Fe(CN)}_6^{4-}$	0.1943	$\text{ClO}_2 + \text{H}^+ + \text{e}^- \rightarrow \text{HClO}_2$	1.27
$\text{AgI} + \text{e}^- \rightarrow \text{Ag} + \text{I}^-$	-0.1519	$\text{HClO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{HClO} + \text{H}_2\text{O}$	1.64
$\text{AgIO}_3 + \text{e}^- \rightarrow \text{Ag} + \text{IO}_3^-$	0.3551	$\text{HClO}_2 + 3\text{H}^+ + 3\text{e}^- \rightarrow 1/2\text{Cl}_2 + 2\text{H}_2\text{O}$	1.63
$\text{Ag}_2\text{MoO}_4 + 2\text{e}^- \rightarrow 2\text{Ag} + \text{MoO}_4^{2-}$	0.49	$\text{HClO}_2 + 3\text{H}^+ + 4\text{e}^- \rightarrow \text{Cl}^- + 2\text{H}_2\text{O}$	1.56
$\text{AgNO}_2 + \text{e}^- \rightarrow \text{Ag} + \text{NO}_2^-$	0.59	$\text{ClO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{ClO}_2 + 2\text{OH}^-$	0.59
$\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{Ag} + 2\text{OH}^-$	0.342	$\text{ClO}_2^- + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Cl}^- + 4\text{OH}^-$	0.76
$\text{Ag}_2\text{O}_3 + \text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{AgO} + 2\text{OH}^-$	0.74	$\text{ClO}_2(\text{aq}) + \text{e}^- \rightarrow \text{ClO}_2^-$	0.954
$2\text{AgO} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Ag}_2\text{O} + 2\text{OH}^-$	0.599	$\text{ClO}_2^- + 2\text{H}^+ + \text{e}^- \rightarrow \text{ClO}_2 + \text{H}_2\text{O}$	1.15
$\text{AgOCN} + \text{e}^- \rightarrow \text{Ag} + \text{OCN}^-$	0.41	$\text{ClO}_2^- + 3\text{H}^+ + 2\text{e}^- \rightarrow \text{HClO}_2 + \text{H}_2\text{O}$	1.21
$\text{Ag}_2\text{S} + 2\text{e}^- \rightarrow 2\text{Ag} + \text{S}^{2-}$	-0.7051		(1.23)
$\text{Ag}_2\text{S} + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{Ag} + \text{H}_2\text{S}$	-0.0366	$\text{ClO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightarrow 1/2\text{Cl}_2 + 3\text{H}_2\text{O}$	1.47
$\text{AgSCN} + \text{e}^- \rightarrow \text{Ag} + \text{SCN}^-$	0.0895	$\text{ClO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{Cl}^- + 3\text{H}_2\text{O}$	1.45
$\text{Ag}_2\text{SeO}_3 + 2\text{e}^- \rightarrow 2\text{Ag} + \text{SeO}_3^{2-}$	0.3629	$\text{ClO}_3^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{ClO}_2^- + 2\text{OH}^-$	0.35
$\text{Ag}_2\text{SO}_4 + 2\text{e}^- \rightarrow 2\text{Ag} + \text{SO}_4^{2-}$	0.653	$\text{ClO}_3^- + 3\text{H}_2\text{O} + 6\text{e}^- \rightarrow \text{Cl}^- + 6\text{OH}^-$	0.62
$\text{Ag}_2(\text{WO}_4) + 2\text{e}^- \rightarrow 2\text{Ag} + \text{WO}_4^{2-}$	0.466	$\text{ClO}_3^- + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{ClO}_2 + \text{H}_2\text{O}$	1.19
$\text{Al}^{+3} + 3\text{e}^- \rightarrow \text{Al}(0.1\text{f NaOH})$	-1.706	$\text{ClO}_4^- + 8\text{H}^+ + 7\text{e}^- \rightarrow 1/2\text{Cl}_2 + 4\text{H}_2\text{O}$	1.34
$\text{H}_2\text{AlO}_3^- + \text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Al} + 4\text{OH}^-$	-2.35	$\text{ClO}_4^- + 8\text{H}^+ + 8\text{e}^- \rightarrow \text{Cl}^- + 4\text{H}_2\text{O}$	1.37
$\text{As} + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{AsH}_3$	-0.54	$\text{ClO}_4^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{ClO}_3^- + 2\text{OH}^-$	0.17
$\text{As}_2\text{O}_3 + 6\text{H}^+ + 6\text{e}^- \rightarrow 2\text{As} + 3\text{H}_2\text{O}$	0.234	$(\text{CN})_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{HCN}$	0.37
$\text{HAsO}_2 + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{As} + 2\text{H}_2\text{O}$	0.2475	$2\text{HCNO} + 2\text{H}^+ + 2\text{e}^- \rightarrow (\text{CN})_2 + 2\text{H}_2\text{O}$	0.33
$\text{AsO}_2^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{As} + 4\text{OH}^-$	-0.68	$(\text{CNS})_2 + 2\text{e}^- \rightarrow 2\text{CNS}^-$	0.77
$\text{H}_3\text{AsO}_4 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{HAsO}_2 + 2\text{H}_2\text{O}(1\text{f HCl})$	0.58	$\text{Co}^{+2} + 2\text{e}^- \rightarrow \text{Co}$	-0.28
$\text{AsO}_4^{3-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{AsO}_2^- + 4\text{OH}^-$	-0.71	$\text{Co}^{+3} + \text{e}^- \rightarrow \text{Co}^{+2}(3\text{f HNO}_3)$	1.842
$\text{AsO}_4^{3-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{AsO}_2^- + 4\text{OH}^- (1\text{f NaOH})$	-0.08	$\text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{HCOOH}$	-0.2
$\text{Au}^+ + \text{e}^- \rightarrow \text{Au}$	1.68	$2\text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{C}_2\text{O}_4$	-0.49
$\text{Au}^{+3} + 2\text{e}^- \rightarrow \text{Au}^{+1}$	1.29	$\text{Co}(\text{NH}_3)_6^{+3} + \text{e}^- \rightarrow \text{Co}(\text{NH}_3)_6^{+2}$	0.1
$\text{Au}^{+3} + 3\text{e}^- \rightarrow \text{Au}$	1.42	$\text{Co}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Co} + 2\text{OH}^-$	-0.73
$\text{AuBr}_2^- + \text{e}^- \rightarrow \text{Au} + 2\text{Br}^-$	0.963	$\text{Co}(\text{OH})_3 + \text{e}^- \rightarrow \text{Co}(\text{OH})_2 + \text{OH}^-$	0.2 (0.17)
$\text{AuBr}_4^- + 3\text{e}^- \rightarrow \text{Au} + 4\text{Br}^-$	0.858	$\text{Cr}^{+2} + 2\text{e}^- \rightarrow \text{Cr}$	-0.557
$\text{AuCl}_4^- + 3\text{e}^- \rightarrow \text{Au} + 4\text{Cl}^-$	0.994	$\text{Cr}^{+3} + \text{e}^- \rightarrow \text{Cr}^{+2}$	-0.41
$\text{Au}(\text{OH})_3 + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{Au} + 3\text{H}_2\text{O}$	1.45	$\text{Cr}^{+3} + 3\text{e}^- \rightarrow \text{Cr}$	-0.74
$\text{H}_2\text{BO}_3^- + 5\text{H}_2\text{O} + 8\text{e}^- \rightarrow \text{BH}_4^- + 8\text{OH}^-$	-1.24	$\text{Cr}^{+6} + 3\text{e}^- \rightarrow \text{Cr}^{+3}(2\text{f H}_2\text{SO}_4)$	1.10
$\text{H}_2\text{BO}_3^- + \text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{B} + 4\text{OH}^-$	-2.5	$\text{Cr}^{+6} + 3\text{e}^- \rightarrow \text{Cr}^{+3}(1\text{f NaOH})$	-0.12
$\text{H}_3\text{BO}_3 + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{B} + 3\text{H}_2\text{O}$	-0.73	$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{+3} + 7\text{H}_2\text{O}$	1.33
$\text{Ba}^{+2} + 2\text{e}^- \rightarrow \text{Ba}$	-2.90	$\text{CrO}_2^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Cr} + 4\text{OH}^-$	-1.2
$\text{Ba}^{+2} + 2\text{e}^- \rightarrow \text{Ba(Hg)}$	-1.570	$\text{HCrO}_4^- + 7\text{H}^+ + 3\text{e}^- \rightarrow \text{Cr}^{+3} + 4\text{H}_2\text{O}$	1.195
$\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Ba} + 2\text{OH}^- + 8\text{H}_2\text{O}$	-2.97	$\text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Cr}(\text{OH})_3 + 5\text{OH}^-$	-0.12
$\text{Be}^{+2} + 2\text{e}^- \rightarrow \text{Be}$	-1.70	$\text{Cr}(\text{OH})_3 + 3\text{e}^- \rightarrow \text{Cr} + 3\text{OH}^-$	-1.3
	(-1.85)	$\text{Cs}^+ + \text{e}^- \rightarrow \text{Cs}$	-2.923
$\text{Be}_2\text{O}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow 2\text{Be} + 6\text{OH}^-$	-2.28	$\text{Cu}^+ + \text{e}^- \rightarrow \text{Cu}$	0.522
$\text{Bi}(\text{Cl})_4^- + 3\text{e}^- \rightarrow \text{Bi} + 4\text{Cl}^-$	0.168	$\text{Cu}^{+2} + 2\text{CN}^- + \text{e}^- \rightarrow \text{Cu(CN)}_2^-$	1.12
$\text{Bi}_2\text{O}_3 + 3\text{H}_2\text{O} + 6\text{e}^- \rightarrow 2\text{Bi} + 6\text{OH}^-$	-0.46	$\text{Cu}^{+2} + \text{e}^- \rightarrow \text{Cu}^+$	0.158
$\text{Bi}_2\text{O}_4 + 4\text{H}^+ + 2\text{e}^- \rightarrow 2\text{BiO}^+ + 2\text{H}_2\text{O}$	1.59		(0.167)
$\text{BiO}^+ + 2\text{H}^+ + 3\text{e}^- \rightarrow \text{Bi} + \text{H}_2\text{O}$	0.32	$\text{Cu}^{+2} + 2\text{e}^- \rightarrow \text{Cu}$	0.3402
$\text{BiOCl} + 2\text{H}^+ + 3\text{e}^- \rightarrow \text{Bi} + \text{Cl}^- + \text{H}_2\text{O}$	0.1583	$\text{Cu}^{+2} + 2\text{e}^- \rightarrow \text{Cu(Hg)}$	0.345
$\text{BiOOH} + \text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Bi} + 3\text{OH}^-$	-0.46	$\text{CuI}_2 + \text{e}^- \rightarrow \text{Cu} + 2\text{I}^-$	0.00
$\text{Br}_2(\text{aq}) + 2\text{e}^- \rightarrow 2\text{Br}^-$	1.087	$\text{Cu}_2\text{O} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{Cu} + 2\text{OH}^-$	-0.361
$\text{Br}_2(\text{l}) + 2\text{e}^- \rightarrow 2\text{Br}^-$	1.065	$\text{Cu}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Cu} + 2\text{OH}^-$	-0.224
$\text{HBrO} + \text{H}^+ + \text{e}^- \rightarrow 1/2\text{Br}_2 + \text{H}_2\text{O}$	1.59	$2\text{Cu}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Cu}_2\text{O} + 2\text{OH}^- + \text{H}_2\text{O}$	-0.09
$\text{HBrO} + \text{H}^+ + 2\text{e}^- \rightarrow \text{Br}^- + \text{H}_2\text{O}$	1.33	$\text{D}^+ + \text{e}^- \rightarrow 1/2\text{D}_2$	-0.0034
$2\text{HBrO} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{Br}_2(\text{l}) + 2\text{H}_2\text{O}$	1.6	$2\text{D}^+ + 2\text{e}^- \rightarrow \text{D}_2$	-0.044
$\text{BrO}^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Br}^- + 2\text{OH}^- (1\text{f NaOH})$	0.70	$\text{Eu}^{+3} + \text{e}^- \rightarrow \text{Eu}^{+2}$	-0.43
$\text{BrO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightarrow 1/2\text{Br}_2 + 3\text{H}_2\text{O}$	1.52	$1/2\text{F}_2 + \text{e}^- \rightarrow \text{F}^-$	2.85
$\text{BrO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{Br}^- + 3\text{H}_2\text{O}$	1.44	$1/2\text{F}_2 + \text{H}^+ + \text{e}^- \rightarrow \text{HF}$	3.03
$\text{BrO}_3^- + 3\text{H}_2\text{O} + 6\text{e}^- \rightarrow \text{Br}^- + 6\text{OH}^-$	0.61	$\text{F}_2 + 2\text{e}^- \rightarrow 2\text{F}^-$	2.87
$\text{C}_6\text{H}_4\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{C}_6\text{H}_4(\text{OH})_2$	0.6992	$\text{F}_2\text{O} + 2\text{H}^+ + 4\text{e}^- \rightarrow \text{H}_2\text{O} + 2\text{F}^-$	2.1
$\text{Ca}^+ + \text{e}^- \rightarrow \text{Ca}$	-3.02	$\text{Fe}^{+2} + 2\text{e}^- \rightarrow \text{Fe}$	-0.409
$\text{Ca}^{+2} + 2\text{e}^- \rightarrow \text{Ca}$	-2.76	$\text{Fe}^{+3} + \text{e}^- \rightarrow \text{Fe}$	-0.036
Calomel Electrode, Molal KCl	0.2800	$\text{Fe}^{+3} + 3\text{e}^- \rightarrow \text{Fe}$	0.770
*Calomel Electrode, N KCl	0.2807	$\text{Fe}^{+3} + \text{e}^- \rightarrow \text{Fe}^{+2}(1\text{f HCl})$	0.770
*Calomel Electrode 0.1 N KCl	0.3337	$\text{Fe}^{+3} + \text{e}^- \rightarrow \text{Fe}^{+2}(1\text{f HClO}_4)$	0.747
*Calomel Electrode, Sat'd. KCl	0.2415	$\text{Fe}^{+3} + \text{e}^- \rightarrow \text{Fe}^{+2}(1\text{f H}_3\text{PO}_4)$	0.438
*Calomel Electrode, Sat'd NaCl	0.2360	$\text{Fe}^{+3} + \text{e}^- \rightarrow \text{Fe}^{+2}(0.5\text{f H}_2\text{SO}_4)$	0.679
$\text{Ca}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Ca} + 2\text{OH}^-$	-3.02	$\text{Fe}(\text{CN})_6^{3-} + \text{e}^- \rightarrow \text{Fe}(\text{CN})_6^{4-}(0.01\text{f NaOH})$	0.46
		$\text{Fe}(\text{CN})_6^{3-} + \text{e}^- \rightarrow \text{Fe}(\text{CN})_6^{4-}(1\text{f H}_2\text{SO}_4)$	0.69
$\text{Cd}^{+2} + 2\text{e}^- \rightarrow \text{Cd}$	-0.4026	$\text{FeO}_4^{2-} + 8\text{H}^+ + 3\text{e}^- \rightarrow \text{Fe}^{+3} + 4\text{H}_2\text{O}$	1.9
$\text{Cd}^{+2} + 2\text{e}^- \rightarrow \text{Cd(Hg)}$	-0.3521	$\text{Fe}(\text{OH})_3 + \text{e}^- \rightarrow \text{Fe}(\text{OH})_2 + \text{OH}^-$	-0.56
$\text{Cd}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Cd(Hg)} + 2\text{OH}^-$	-0.761	$\text{Fe}(\text{phenanthroline})_3^{+3} + \text{e}^- \rightarrow \text{Fe}(\text{ph})_3^{+2}$	1.14
	(-0.81)	$\text{Fe}(\text{phenanthroline})_3^{+3} + \text{e}^- \rightarrow \text{Fe}(\text{ph})_3^{+2}(2\text{f H}_2\text{SO}_4)$	1.056
$\text{CdSO}_4 \cdot 8/3\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Cd(Hg)} + \text{CdSO}_4(\text{sat'd aq})$	-0.4346	$\text{Ga}^{+3} + 3\text{e}^- \rightarrow \text{Ga}$	-0.560
$\text{Ce}^{+3} + 3\text{e}^- \rightarrow \text{Ce}$	-2.335	$\text{H}_2\text{GaO}_5 + \text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Ga} + 4\text{OH}^-$	-1.22

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ELECTROCHEMICAL SERIES—TABLE I (Continued)

Reaction	Potential, volts	Reaction	Potential, volts
$\text{GeO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{GeO} + \text{H}_2\text{O}$	-0.12	$\text{NO}_2^- + \text{H}_2\text{O} + \text{e}^- \rightarrow \text{NO} + 2\text{OH}^-$	-0.46
$\text{H}_2\text{GeO}_3 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Ge} + 3\text{H}_2\text{O}$	-0.13	$2\text{NO}_2^- + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{N}_2\text{O}_4^{2-} + 4\text{OH}^-$	-0.18
$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$	0.0000	$2\text{NO}_2^- + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{N}_2\text{O} + 6\text{OH}^-$	0.15
$1/2\text{H}_2 + \text{e}^- \rightarrow \text{H}^-$	-2.23	$\text{NO}_2^- + 3\text{H}^+ + 2\text{e}^- \rightarrow \text{HNO}_2 + \text{H}_2\text{O}$	0.94
$2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$	-0.8277	$\text{NO}_2^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{NO} + 2\text{H}_2\text{O}$	0.96
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}$	1.776	$2\text{NO}_2^- + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{N}_2\text{O}_4 + 2\text{H}_2\text{O}$	0.81
$\text{HfO}_2 + 2\text{H}^+ + 4\text{e}^- \rightarrow \text{Hf} + \text{H}_2\text{O}$	-1.68	$\text{NO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{NO}_2 + 2\text{OH}^-$	0.01
$\text{HfO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Hf} + 2\text{H}_2\text{O}$	-1.57	$2\text{NO}_2^- + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{N}_2\text{O}_4 + 4\text{OH}^-$	-0.85
$\text{HfO}(\text{OH})_2 + \text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Hf} + 4\text{OH}^-$	-2.60	$\text{Np}^{+3} + 3\text{e}^- \rightarrow \text{Np}$	-1.9
$\text{Hg}^{+2} + 2\text{e}^- \rightarrow \text{Hg}$	0.851	$\text{Np}^{+4} + \text{e}^- \rightarrow \text{Np}^{+3}(\text{1fHClO}_4)$	0.155
$2\text{Hg}^{+2} + 2\text{e}^- \rightarrow \text{Hg}_2^{+2}$	0.905	$\text{Np}^{+5} + \text{e}^- \rightarrow \text{Np}^{+4}(\text{1fHClO}_4)$	0.739
$1/2\text{Hg}_2^{+2} + \text{e}^- \rightarrow \text{Hg}$	0.7986	$\text{Np}^{+6} + \text{e}^- \rightarrow \text{Np}^{+5}(\text{1fHClO}_4)$	1.137
$\text{Hg}_2^{+2} + 2\text{e}^- \rightarrow 2\text{Hg}$	0.7961	$1/2\text{O}_2 + 2\text{H}^+(10^{-7}\text{M}) + 2\text{e}^- \rightarrow \text{H}_2\text{O}$	0.815
$\text{Hg}_2(\text{AcO})_2 + 2\text{e}^- \rightarrow 2\text{Hg} + 2\text{AcO}^-$	0.5113	$\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O}_2$	0.682
$\text{Hg}_2\text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Hg} + 2\text{Br}^-$	0.1396	$\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$	1.229
$\text{Hg}_2\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Hg} + 2\text{Cl}^-$	0.2682	$\text{O}_2 + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{HO}_2^- + \text{OH}^-$	-0.076
$\text{Hg}_2\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Hg} + 2\text{Cl}^-(0.1\text{f NaOH})$	0.3419	$\text{O}_2 + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2\text{O}_2 + 2\text{OH}^-$	-0.146
	(0.268)	$\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$	0.401
$\text{Hg}_2\text{HPO}_4 + \text{H}^+ + 2\text{e}^- \rightarrow 2\text{Hg} + \text{H}_2\text{PO}_4^-$	0.639	$\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{O}_2 + \text{H}_2\text{O}$	2.07
$\text{Hg}_2\text{I}_2 + 2\text{e}^- \rightarrow 2\text{Hg} + 2\text{I}^-$	-0.0405	$\text{O}_2 + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{O}_2 + 2\text{OH}^-$	1.24
$\text{Hg}_2\text{O} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{Hg} + 2\text{OH}^-$	0.123	$\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O}$	2.42
$\text{HgO} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Hg} + 2\text{OH}^-$	0.0984	$\text{OH}^- + \text{e}^- \rightarrow \text{OH}^-$	1.4
$\text{Hg}_2\text{SO}_4 + 2\text{e}^- \rightarrow 2\text{Hg} + \text{SO}_4^{2-}$	0.6158	$\text{HO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow 3\text{OH}^-$	0.87
$\text{HO}_2 + \text{H}^+ + \text{e}^- \rightarrow \text{H}_2\text{O}_2$	1.5	$\text{OsO}_4 + 8\text{H}^+ + 8\text{e}^- \rightarrow \text{Os} + 4\text{H}_2\text{O}$	0.85
$\text{I}_2 + 2\text{e}^- \rightarrow 2\text{I}^-$	0.535	$\text{P} + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{PH}_3(\text{g})$	-0.04
$\text{I}_3^- + 2\text{e}^- \rightarrow 3\text{I}^-$	0.5338	$\text{P} + 3\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{PH}_3(\text{g}) + 3\text{OH}^-$	-0.87
$\text{In}^{+2} + \text{e}^- \rightarrow \text{In}^{+1}$	-0.40	$\text{Pb}^{+2} + 2\text{e}^- \rightarrow \text{Pb}$	-0.1263
$\text{In}^{+3} + \text{e}^- \rightarrow \text{In}^{+2}$	-0.49		(-0.126)
$\text{In}^{+3} + 2\text{e}^- \rightarrow \text{In}^{+1}$	-0.40	$\text{Pb}^{+2} + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg})$	-0.1205
$\text{In}^{+3} + 3\text{e}^- \rightarrow \text{In}$	-0.338	$\text{PbBr}_2 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + 2\text{Br}^-$	-0.275
$\text{H}_3\text{IO}_6^{2-} + 2\text{e}^- \rightarrow \text{IO}_3^- + 3\text{OH}^-$	-0.70	$\text{PbCl}_2 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + 2\text{Cl}^-$	-0.262
$\text{H}_3\text{IO}_6 + \text{H}^+ + 2\text{e}^- \rightarrow \text{IO}_3^- + 3\text{H}_2\text{O}$	-1.7	$\text{PbF}_2 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + 2\text{F}^-$	-0.3444
$\text{HIO} + \text{H}^+ + \text{e}^- \rightarrow 1/2\text{I}_2 + \text{H}_2\text{O}$	1.45	$\text{PbHPO}_4 + \text{H}^+ + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + \text{HPO}_4^-$	-0.2448
$\text{HIO} + \text{H}^+ + 2\text{e}^- \rightarrow \text{I}^- + \text{H}_2\text{O}$	0.99	$\text{PbI}_2 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + 2\text{I}^-$	-0.358
$\text{IO}^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{I}^- + 2\text{OH}^-$	0.49	$\text{PbO} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Pb} + 2\text{OH}^-$	-0.576
$\text{IO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightarrow 1/2\text{I}_2 + 3\text{H}_2\text{O}$	1.195	$\text{PbO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Pb}^{+2} + 2\text{H}_2\text{O}$	1.46
$\text{IO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{I}^- + 3\text{H}_2\text{O}$	1.085	$\text{HPbO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Pb} + 3\text{OH}^-$	-0.54
$2\text{IO}_3^- + 12\text{H}^+ + 10\text{e}^- \rightarrow \text{I}_2 + 6\text{H}_2\text{O}$	1.19	$\text{PbO}_2 + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{PbO} + 2\text{OH}^-$	0.28
$\text{IO}_3^- + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{IO}^- + 4\text{OH}^-$	0.56	$\text{PbO}_2 + \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{PbSO}_4 + 2\text{H}_2\text{O}$	1.685
$\text{IO}_3^- + 3\text{H}_2\text{O} + 6\text{e}^- \rightarrow \text{I}^- + 6\text{OH}^-$	0.26	$\text{PbSO}_4 + 2\text{e}^- \rightarrow \text{Pb} + \text{SO}_4^{2-}$	-0.356
$\text{IrCl}_6^{2-} + \text{e}^- \rightarrow \text{IrCl}_6^{3-}$	-1.02	$\text{PbSO}_4 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + \text{SO}_4^{2-}$	-0.3505
$\text{IrCl}_6^{3-} + 3\text{e}^- \rightarrow \text{Ir} + 6\text{Cl}^-$	0.77	$\text{Pd}^{+2} + 2\text{e}^- \rightarrow \text{Pd}$	0.83
$\text{Ir}_2\text{O}_3 + 3\text{H}_2\text{O} + 6\text{e}^- \rightarrow 2\text{Ir} + 6\text{OH}^-$	0.1	$\text{Pd}^{+2} + 2\text{e}^- \rightarrow \text{Pd}(\text{1fHCl})$	0.623
$\text{K}^+ + \text{e}^- \rightarrow \text{K}$	-2.924	$\text{Pd}^{+2} + 2\text{e}^- \rightarrow \text{Pd}(\text{4fHClO}_4)$	0.987
	(-2.923)	$\text{PdCl}_4^{2-} + 2\text{e}^- \rightarrow \text{Pd} + 4\text{Cl}^-$	0.623
$\text{La}^{+3} + 3\text{e}^- \rightarrow \text{La}$	-2.37	$\text{PdCl}_2^{2-} + 2\text{e}^- \rightarrow \text{PdCl}_2 + 2\text{Cl}^-$	1.29
$\text{La}(\text{OH})_3 + 3\text{e}^- \rightarrow \text{La} + 3\text{OH}^-$	-2.76	$\text{Pd}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Pd} + 2\text{OH}^-$	0.1
$\text{Li}^+ + \text{e}^- \rightarrow \text{Li}$	-3.045	$\text{H}_2\text{PO}_2^- + \text{e}^- \rightarrow \text{P} + 2\text{OH}^-$	-1.82
	(-3.02)	$\text{H}_3\text{PO}_2 + \text{H}^+ + \text{e}^- \rightarrow \text{P} + 2\text{H}_2\text{O}$	-0.51
$\text{Mg}^{+2} + 2\text{e}^- \rightarrow \text{Mg}$	-2.375	$\text{H}_3\text{PO}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_3\text{PO}_2 + \text{H}_2\text{O}$	-0.50
$\text{Mg}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Mg} + 2\text{OH}^-$	-2.67		(-0.59)
$\text{Mn}^{+2} + 2\text{e}^- \rightarrow \text{Mn}$	-1.029	$\text{H}_3\text{PO}_3 + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{P} + 3\text{H}_2\text{O}$	-0.49
$\text{Mn}^{+3} + \text{e}^- \rightarrow \text{Mn}^{+2}$	1.51	$\text{HPO}_3^{2-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2\text{PO}_3^- + 3\text{OH}^-$	-1.65
$\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Mn}^{+2} + 2\text{H}_2\text{O}$	1.208	$\text{HPO}_3^{2-} + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{P} + 5\text{OH}^-$	-1.71
$\text{MnO}_4^- + \text{e}^- \rightarrow \text{MnO}_4^{2-}$	0.564	$\text{H}_3\text{PO}_4 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_3\text{PO}_3 + \text{H}_2\text{O}$	-0.276
$\text{MnO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$	+1.679		(-0.2)
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{+2} + 4\text{H}_2\text{O}$	1.491	$\text{PO}_4^{3-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{HPO}_3^{2-} + 3\text{OH}^-$	-1.05
$\text{MnO}_4^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{MnO}_2 + 4\text{OH}^-$	0.588	$\text{Pt}^{+2} + 2\text{e}^- \rightarrow \text{Pt}$	~1.2
$\text{MnO}_4^{2-} + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{MnO}_2 + 4\text{OH}^-$	0.58	$\text{PtCl}_6^{2-} + 2\text{e}^- \rightarrow \text{Pt} + 4\text{Cl}^-$	0.73
$\text{Mn}(\text{OH})_2 + \text{Mn} + 2\text{OH}^-$	-1.47	$\text{PtCl}_6^{2-} + 2\text{e}^- \rightarrow \text{PtCl}_4^{2-} + 2\text{Cl}^-$	0.74
$\text{Mn}(\text{OH})_2 + \text{e}^- \rightarrow \text{Mn}(\text{OH})_2 + \text{OH}^-$	-0.40	$\text{Pt}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Pt} + 2\text{OH}^-$	0.16
$\text{H}_2\text{MoO}_4 + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{Mo} + 4\text{H}_2\text{O}$	0.0	$\text{Pu}^{+4} + \text{e}^- \rightarrow \text{Pu}^{+3}(\text{1fHClO}_4)$	0.982
$\text{N}_2 + 2\text{H}_2\text{O} + 4\text{H}^+ + 2\text{e}^- \rightarrow 2\text{NH}_4\text{OH}^+$	-1.87	$\text{Pu}^{+5} + \text{e}^- \rightarrow \text{Pu}^{+4}(\text{0.5fHCl})$	1.099
$3\text{N}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{HN}_3$	-3.1	$\text{Pu}^{+6} + \text{e}^- \rightarrow \text{Pu}^{+5}(\text{1fHClO}_4)$	0.9184
$\text{N}_2\text{H}_5^+ + 3\text{H}^+ + 2\text{e}^- \rightarrow 2\text{NH}_4^+$	1.27	$\text{Pu}^{+6} + 2\text{e}^- \rightarrow \text{Pu}^{+4}(\text{1fHCl})$	1.052
$\text{N}_2\text{O} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{N}_2 + \text{H}_2\text{O}$	1.77	Quinhydrone Elec. $\text{H}^+, a = 1$	0.6995
$\text{H}_2\text{N}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{N}_2 + 2\text{H}_2\text{O}$	2.65	$\text{Rb}^+ + \text{e}^- \rightarrow \text{Rb}$	-2.925
$\text{N}_2\text{O}_4 + 2\text{e}^- \rightarrow 2\text{NO}_2^-$	0.88		(-2.99)
$\text{N}_2\text{O}_4 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{HNO}_2$	1.07	$\text{Re}^{+3} + 3\text{e}^- \rightarrow \text{Re}$	0.3 ~
$\text{N}_2\text{O}_4 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{NO} + 2\text{H}_2\text{O}$	1.03	$\text{ReO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{ReO}_2 + 2\text{H}_2\text{O}$	0.51
$\text{Na}^+ + \text{e}^- \rightarrow \text{Na}$	-2.7109	$\text{ReO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Re} + 2\text{H}_2\text{O}$	0.26
$\text{Nb}_2\text{O}_5 + 10\text{H}^+ + 10\text{e}^- \rightarrow 2\text{Nb} + 5\text{H}_2\text{O}$	-0.62	$\text{ReO}_4^- + 2\text{H}^+ + \text{e}^- \rightarrow \text{ReO}_3(\text{aq}) + \text{H}_2\text{O}$	0.768
$\text{Nb}^{+5} + 2\text{e}^- \rightarrow \text{Nb}^{+3}(\text{2fHCl})$	0.344	$\text{ReO}_4^- + 4\text{H}_2\text{O} + 7\text{e}^- \rightarrow \text{Re} + 8\text{OH}^-$	-0.81
$\text{Nd}^{+3} + 3\text{e}^- \rightarrow \text{Nd}$	-2.246	$\text{ReO}_4^- + 8\text{H}^+ + 7\text{e}^- \rightarrow \text{Re} + 4\text{H}_2\text{O}$	0.367
$2\text{NH}_4\text{OH}^+ + \text{H}^+ + 2\text{e}^- \rightarrow \text{N}_2\text{H}_5^+ + 2\text{H}_2\text{O}$	1.42	$\text{Rh}^{+4} + \text{e}^- \rightarrow \text{Rh}^{+3}$	1.43
$\text{Ni}^{+2} + 2\text{e}^- \rightarrow \text{Ni}$	-0.23	$\text{Rh}(\text{Cl})_6^{3-} + 3\text{e}^- \rightarrow \text{Rh} + 6\text{Cl}^-$	0.44
$\text{Ni}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Ni} + 2\text{OH}^-$	-0.66	$\text{Ru}^{+3} + \text{e}^- \rightarrow \text{Ru}^{+2}(\text{0.1fHClO}_4)$	-0.11
$\text{NiO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Ni}^{+2} + 2\text{H}_2\text{O}$	1.93	$\text{Ru}^{+3} + \text{e}^- \rightarrow \text{Ru}^{+2}(\text{1-6fHCl})$	-0.084
$\text{NiO}_2 + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Ni}(\text{OH})_2 + 2\text{OH}^-$	0.49	$\text{Ru}^{+4} + \text{e}^- \rightarrow \text{Ru}^{+3}(\text{0.1fHClO}_4)$	0.49
$2\text{NO} + 2\text{e}^- \rightarrow \text{N}_2\text{O}_2^{2-}$	0.10	$\text{Ru}^{+4} + \text{e}^- \rightarrow \text{Ru}^{+3}(\text{2fHCl})$	0.858
$2\text{NO} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$	1.59	$\text{RuO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Ru} + 2\text{H}_2\text{O}$	-0.8
$2\text{NO} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{N}_2\text{O} + 2\text{OH}^-$	0.76	$\text{RuO}_4^- + \text{e}^- \rightarrow \text{RuO}_4^{2-}$	0.59
$\text{HNO}_2 + \text{H}^+ + \text{e}^- \rightarrow \text{NO} + \text{H}_2\text{O}$	0.99	$\text{RuO}_4(\text{aq}) + \text{e}^- \rightarrow \text{RuO}_4^-$	1.00
$2\text{HNO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{H}_2\text{N}_2\text{O}_2 + 2\text{H}_2\text{O}$	0.80	$\text{S} + 2\text{e}^- \rightarrow \text{S}^{2-}$	-0.508
$2\text{HNO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{N}_2\text{O} + 3\text{H}_2\text{O}$	1.27	$\text{S} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{S}_{(\text{aq})}$	0.141
	(1.29)	$\text{S} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{HS}^- + \text{OH}^-$	-0.478

ELECTROCHEMICAL SERIES—TABLE I (Continued)

Reaction	Potential, volts	Reaction	Potential, volts
$\text{S}_2\text{O}_8^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow 2\text{H}_2\text{SO}_4$	0.6	$\text{TeO}_4^{2-} + 8\text{H}^+ + 7\text{e}^- \rightarrow \text{Te} + 4\text{H}_2\text{O}$	0.472
$\text{S}_2\text{O}_8^{2-} + 2\text{e}^- \rightarrow 2\text{SO}_4^{2-}$	2.0	$\text{H}_6\text{TeO}_{6(s)} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{TeO}_{2(s)} + 4\text{H}_2\text{O}$	1.02
$\text{S}_4\text{O}_6^{2-} + 2\text{e}^- \rightarrow 2\text{S}_2\text{O}_3^{2-}$	(2.05)	$\text{Th}^{+4} + 4\text{e}^- \rightarrow \text{Th}$	-1.90
$\text{Sb} + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{H}_3\text{Sb}$	0.09	$\text{ThO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Th} + 2\text{H}_2\text{O}$	-1.80
$\text{Sb}^{+3} + 2\text{e}^- \rightarrow \text{Sb}^{+3}(3.5f\text{HCl})$	(0.10)	$\text{ThO}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Th} + 4\text{OH}^-$	-2.64
$\text{Sb}_2\text{O}_3 + 6\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Sb} + 3\text{H}_2\text{O}$	-0.51	$\text{Ti}^{+2} + 2\text{e}^- \rightarrow \text{Ti}$	-1.63
$\text{Sb}_2\text{O}_5 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Sb}_2\text{O}_3 + 2\text{H}_2\text{O}$	0.75	$\text{Ti}^{+3} + \text{e}^- \rightarrow \text{Ti}^{+2}$	-2.0
$\text{Sb}_2\text{O}_5 + 6\text{H}^+ + 6\text{e}^- \rightarrow 2\text{SbO}^+ + 3\text{H}_2\text{O}$	0.1445	$\text{TiO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Ti} + 2\text{H}_2\text{O}$	-0.86
$\text{Sb}_2\text{O}_5 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Sb}_2\text{O}_3 + 2\text{H}_2\text{O}$	(0.152)	$\text{Ti(OH)}^{+3} + \text{H}^+ + \text{e}^- \rightarrow \text{Ti}^{+3} + \text{H}_2\text{O}$	0.06
$\text{Sb}_2\text{O}_5 + 6\text{H}^+ + 6\text{e}^- \rightarrow 2\text{SbO}^+ + 3\text{H}_2\text{O}$	0.69	$\text{Ti}^+ + \text{e}^- \rightarrow \text{Ti}$	-0.3363
$\text{SbO}^+ + 2\text{H}^+ + 3\text{e}^- \rightarrow \text{Sb} + 2\text{H}_2\text{O}$	0.64	$\text{Ti}^+ + \text{e}^- \rightarrow \text{Ti(Hg)}$	-0.3338
$\text{SbO}_2^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Sb} + 4\text{OH}^-$	0.212	$\text{Ti}^{+3} + \text{e}^- \rightarrow \text{Ti}^{+2}$	-0.37
$\text{SbO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{SbO}_2^- + 2\text{OH}^-$	-0.66	$\text{Ti}^{+3} + 2\text{e}^- \rightarrow \text{Ti}^{+1}$	1.247
$\text{Sc}^{+3} + 3\text{e}^- \rightarrow \text{Sc}$	-0.59	$\text{Ti}^{+3} + 2\text{e}^- \rightarrow \text{Ti}^{+1}(\text{If HCl})$	0.783
$\text{Se} + 2\text{e}^- \rightarrow \text{Se}^{2-}$	-2.08	$\text{TiBr} + \text{e}^- \rightarrow \text{Ti(Hg)} + \text{Br}^-$	-0.606
$\text{Se} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{Se(aq)}$	-0.78	$\text{TiCl} + \text{e}^- \rightarrow \text{Ti(Hg)} + \text{Cl}^-$	-0.555
$\text{H}_2\text{SeO}_3 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Se} + 3\text{H}_2\text{O}$	-0.36	$\text{TiH} + \text{e}^- \rightarrow \text{Ti(Hg)} + \text{H}^-$	-0.769
$\text{SeO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Se} + 6\text{OH}^-$	0.74	$\text{Ti}_2\text{O}_3 + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow 2\text{Ti}^+ + 6\text{OH}^-$	0.02
$\text{SeO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{SeO}_3 + \text{H}_2\text{O}$	-0.35	$\text{TiOH} + \text{e}^- \rightarrow \text{Ti} + \text{OH}^-$	-0.3445
$\text{SeO}_4^{2-} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{SeO}_3^{2-} + 2\text{OH}^-$	1.15	$\text{Ti(OH)}_3 + 2\text{e}^- \rightarrow \text{TiOH} + 2\text{OH}^-$	-0.05
$\text{SiF}_6^{2-} + 4\text{e}^- \rightarrow \text{Si} + 6\text{F}^-$	0.03	$\text{Ti}_2\text{SO}_4 + 2\text{e}^- \rightarrow \text{Ti(Hg)} + \text{SO}_4^{2-}$	-0.4360
$\text{SiO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Si} + 2\text{H}_2\text{O}$	-1.2	$\text{U}^{+3} + 3\text{e}^- \rightarrow \text{U}$	-1.8
$\text{SiO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Si} + 6\text{OH}^-$	-0.84	$\text{U}^{+4} + \text{e}^- \rightarrow \text{U}^{+3}$	-0.61
$\text{Sn}^{+2} + 2\text{e}^- \rightarrow \text{Sn}$	-1.73	$\text{U}^{+4} + \text{e}^- \rightarrow \text{U}^{+3}(\text{If HClO}_4)$	-0.631
$\text{Sn}^{+4} + 2\text{e}^- \rightarrow \text{Sn}^{+2}$	-0.1364	$\text{U}^{+5} + \text{e}^- \rightarrow \text{U}^{+4}(\text{If HCl})$	1.02
$\text{Sn}^{+4} + 2\text{e}^- \rightarrow \text{Sn}^{+2}(0.1f\text{HCl})$	0.15	$\text{U}^{+6} + \text{e}^- \rightarrow \text{U}^{+5}(\text{If HClO}_4)$	0.063
$\text{Sn}^{+4} + 2\text{e}^- \rightarrow \text{Sn}^{+2}(\text{If HCl})$	0.070	$\text{UO}_2^{+2} + 4\text{H}^+ + \text{e}^- \rightarrow \text{U}^{+4} + 2\text{H}_2\text{O}$	0.62
$\text{HSnO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Sn} + 3\text{OH}^-$	0.139	$\text{UO}_2^{+2} + \text{e}^- \rightarrow \text{UO}_2^+$	0.062
$\text{Sn(OH)}_6^{2-} + 2\text{e}^- \rightarrow \text{HSnO}_2^- + 3\text{OH}^- + \text{H}_2\text{O}$	-0.79	$\text{UO}_2^{+2} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{U}^{+4} + 2\text{H}_2\text{O}$	0.334
$2\text{H}_2\text{SO}_3 + \text{H}^+ + 2\text{e}^- \rightarrow \text{HS}_2\text{O}_4^- + 2\text{H}_2\text{O}$	-0.96	$\text{UO}_2^{+2} + 4\text{H}^+ + 6\text{e}^- \rightarrow \text{U} + 2\text{H}_2\text{O}$	-0.82
$\text{H}_2\text{SO}_3 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{S} + 3\text{H}_2\text{O}$	-0.08	$\text{V}^{+2} + 2\text{e}^- \rightarrow \text{V}$	-1.2
$2\text{SO}_3^{2-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{S}_2\text{O}_4^{2-} + 4\text{OH}^-$	0.45	$\text{V}^{+3} + \text{e}^- \rightarrow \text{V}^{+2}$	-0.255
$2\text{SO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{S}_2\text{O}_3^{2-} + 6\text{OH}^-$	-1.12	$\text{V}^{+5} + \text{e}^- \rightarrow \text{V}^{+4}(\text{If NaOH})$	-0.74
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{SO}_3 + \text{H}_2\text{O}$	-0.58	$\text{VO}^{+2} + 2\text{H}^+ + \text{e}^- \rightarrow \text{V}^{+3} + \text{H}_2\text{O}$	0.337
$2\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{S}_2\text{O}_6^{2-} + \text{H}_2\text{O}$	0.20	$\text{VO}_2^+ + 2\text{H}^+ + \text{e}^- \rightarrow \text{VO}^{+2} + \text{H}_2\text{O}$	1.00
$\text{SO}_4^{2-} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{SO}_3^{2-} + 2\text{OH}^-$	-0.2	$\text{V(OH)}_4^{+2} + 2\text{H}^+ + \text{e}^- \rightarrow \text{VO}^{+2} + 3\text{H}_2\text{O}$	1.00
$\text{Sr}^{+2} + 2\text{e}^- \rightarrow \text{Sr}$	-0.92	$\text{V(OH)}_4^{+2} + 4\text{H}^+ + 5\text{e}^- \rightarrow \text{V} + 4\text{H}_2\text{O}$	-0.25
$\text{Sr}^{+2} + 2\text{e}^- \rightarrow \text{Sr(Hg)}$	-2.89	$\text{W}_2\text{O}_5 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{WO}_2 + \text{H}_2\text{O}$	-0.04
$\text{Sr(OH)}_2 \cdot 8\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Sr} + 2\text{OH}^- + 8\text{H}_2\text{O}$	-1.793	$\text{WO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{W} + 2\text{H}_2\text{O}$	-0.12
$\text{Ta}_2\text{O}_5 + 10\text{H}^+ + 10\text{e}^- \rightarrow 2\text{Ta} + 5\text{H}_2\text{O}$	-2.99	$\text{WO}_3 + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{W} + 3\text{H}_2\text{O}$	-0.09
$\text{TcO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{TcO}_{2(s)} + 2\text{H}_2\text{O}$	-0.71	$2\text{WO}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{W}_2\text{O}_5 + \text{H}_2\text{O}$	-0.03
$\text{Te} + 2\text{e}^- \rightarrow \text{Te}^{2-}$	0.738	$\text{Y}^{+3} + 3\text{e}^- \rightarrow \text{Y}$	-2.37
$\text{Te} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{Te(Ag)}$	-0.92	$\text{Zn}^{+2} + 2\text{e}^- \rightarrow \text{Zn}$	-0.7628
$\text{Te}^{+4} + 4\text{e}^- \rightarrow \text{Te}(2.5f\text{HCl})$	-0.69	$\text{Zn}^{+2} + 2\text{e}^- \rightarrow \text{Zn(Hg)}$	-0.7628
$\text{TeO}_2 + 4\text{H}_2 + 4\text{e}^- \rightarrow \text{Te} + 2\text{H}_2\text{O}$	(-0.72)	$\text{ZnO}_2^{2-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Zn} + 4\text{OH}^-$	-1.216
$\text{TeO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Te} + 6\text{OH}^-$	0.63	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Zn(Hg)} + \text{SO}_4^{2-}(\text{Sat'd ZnSO}_4)$	-0.7993
	0.593	$\text{ZrO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Zr} + 2\text{H}_2\text{O}$	-1.43
	-0.02	$\text{ZrO(OH)}_2 + \text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Zr} + 4\text{OH}^-$	-2.32

ELECTROCHEMICAL SERIES

Table II
Compiled by J. F. Hunsberger
Values listed are Standard Reduction Potentials

This table is divided into two parts. The first part lists reduction reactions which are positive with respect to the potential of the Standard Hydrogen Electrode. In this first part of Table II the reduction reactions are written in increasing order of the positive potential, beginning with 0.00 and ending with +3.03 volts. The second part of this Table II lists reduction reactions having reduction potentials more negative than that of the Standard Hydrogen Electrode. This second part of the table lists reactions in their order of increasing negative potential, beginning with 0.00 and ending with -3.1 volts.

PART I

Reaction	Potential, volts	Reaction	Potential, volts
$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$	0.0000	$\text{Pd(OH)}_2 + 2\text{e}^- \rightarrow \text{Pd} + 2\text{OH}^-$	0.1
$\text{Cu}_2^{+2} + \text{e}^- \rightarrow \text{Cu} + 2\text{I}^-$	0.00	$\text{Co(NH}_3)_6^{+3} + \text{e}^- \rightarrow \text{Co(NH}_3)_6^{+2}$	0.1
$\text{H}_2\text{MoO}_4 + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{Mo} + 4\text{H}_2\text{O}$	0.0	$\text{Hg}_2\text{O} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{Hg} + 2\text{OH}^-$	0.123
$\text{NO}_3^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{NO}_2^- + 2\text{OH}^-$	0.01	$\text{Sn}^{+4} + 2\text{e}^- \rightarrow \text{Sn}^{+2}(\text{If HCl})$	0.139
$\text{Ti}_2\text{O}_3 + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow 2\text{Ti}^+ + 6\text{OH}^-$	0.02	$\text{Hg}_2\text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Hg} + 2\text{Br}^-$	0.1396
$\text{SeO}_4^{2-} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{SeO}_3^{2-} + 2\text{OH}^-$	0.03	$\text{S} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{S(aq)}$	0.141
$\text{Ti(OH)}^{+3} + \text{H}^+ + \text{e}^- \rightarrow \text{Ti}^{+3} + \text{H}_2\text{O}$	0.06	$\text{Sb}_2\text{O}_3 + 6\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Sb} + 3\text{H}_2\text{O}$	0.1445
$\text{UO}_2^{+2} + \text{e}^- \rightarrow \text{UO}_2^+$	0.062		(0.152)
$\text{U}^{+6} + \text{e}^- \rightarrow \text{U}^{+5}(\text{If HClO}_4)$	0.063	$2\text{NO}_2^- + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{N}_2\text{O} + 6\text{OH}^-$	0.15
$\text{Sn}^{+4} + 2\text{e}^- \rightarrow \text{Sn}^{+2}(0.1f\text{HCl})$	0.070	$\text{ReO}_4^- + 8\text{H}^+ + 7\text{e}^- \rightarrow \text{Re} + 4\text{H}_2\text{O}$	0.15
$\text{AgBr} + \text{e}^- \rightarrow \text{Ag} + \text{Br}^-$	0.0713	$\text{Sn}^{+4} + 2\text{e}^- \rightarrow \text{Sn}^{+2}$	0.15
$\text{AgSCN} + \text{e}^- \rightarrow \text{Ag} + \text{SCN}^-$	0.0895	$\text{Np}^{+4} + \text{e}^- \rightarrow \text{Np}^{+3}(\text{If HClO}_4)$	0.155
$\text{S}_4\text{O}_6^{2-} + 2\text{e}^- \rightarrow 2\text{S}_2\text{O}_3^{2-}$	0.09	$\text{Cu}^{+2} + \text{e}^- \rightarrow \text{Cu}^+$	0.158
	(0.10)		(0.167)
$\text{HgO} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Hg} + 2\text{OH}^-$	0.0984	$\text{BiOCl} + 2\text{H}^+ + 3\text{e}^- \rightarrow \text{Bi} + \text{Cl}^- + \text{H}_2\text{O}$	0.1583
$2\text{NO} + 2\text{e}^- \rightarrow \text{N}_2\text{O}_2^{2-}$	0.10	$\text{Pt(OH)}_2 + 2\text{e}^- \rightarrow \text{Pt} + 2\text{OH}^-$	0.16
$\text{Ir}_2\text{O}_3 + 3\text{H}_2\text{O} + 6\text{e}^- \rightarrow 2\text{Ir} + 6\text{OH}^-$	0.1	$\text{Bi(ClO}_4)_3 + 3\text{e}^- \rightarrow \text{Bi} + 4\text{Cl}^-$	0.168

ELECTROCHEMICAL SERIES—TABLE II (Continued)

Reaction	Potential, volts	Reaction	Potential, volts
$\text{ClO}_4^- + \text{H}_2\text{O} + 2e^- \rightarrow \text{ClO}_3^- + 2\text{OH}^-$	0.17	$\text{PtCl}_6^{2-} + 2e^- \rightarrow \text{Pt} + 4\text{Cl}^-$	0.73
$\text{Ag}_2\text{Fe}(\text{CN})_6 + 4e^- \rightarrow 4\text{Ag} + \text{Fe}(\text{CN})_6^{4-}$	0.1943	$\text{TeO}_4^{2-} + 4\text{H}^+ + 3e^- \rightarrow \text{TeO}_{2(\text{te})} + 2\text{H}_2\text{O}$	0.738
$\text{SO}_4^{2-} + 4\text{H}^+ + 2e^- \rightarrow \text{H}_2\text{SO}_3 + \text{H}_2\text{O}$	0.20	$\text{Np}^{+5} + e^- \rightarrow \text{Np}^{+4}(\text{if HClO}_4)$	0.739
$\text{Co}(\text{OH})_3 + e^- \rightarrow \text{Co}(\text{OH})_2 + \text{OH}^-$	0.2	$\text{Ag}_2\text{O}_3 + \text{H}_2\text{O} + 2e^- \rightarrow 2\text{AgO} + 2\text{OH}^-$	0.74
$\text{SbO}^+ + 2\text{H}^+ + 3e^- \rightarrow \text{Sb} + 2\text{H}_2\text{O}$	(0.17)	$\text{H}_2\text{SeO}_3 + 4\text{H}^+ + 4e^- \rightarrow \text{Se} + 3\text{H}_2\text{O}$	0.74
$\text{AgCl} + e^- \rightarrow \text{Ag} + \text{Cl}^-$	0.212	$\text{PtCl}_6^{2-} + 2e^- \rightarrow \text{PtCl}_4^{2-} + 2\text{Cl}^-$	0.74
*Calomel Electrode, Sat'd NaCl	0.2223	$\text{Fe}^{+3} + e^- \rightarrow \text{Fe}^{+2}(\text{if HClO}_4)$	0.747
$\text{As}_2\text{O}_3 + 6\text{H}^+ + 6e^- \rightarrow 2\text{As} + 3\text{H}_2\text{O}$	0.2360	$\text{Sb}^{+5} + 2e^- \rightarrow \text{Sb}^{+3}(3.5\text{f HCl})$	0.75
*Calomel Electrode, Sat'd KCl	0.234	$\text{ClO}_2^- + 2\text{H}_2\text{O} + 4e^- \rightarrow \text{Cl}^- + 4\text{OH}^-$	0.76
$\text{HASO}_2 + 3\text{H}^+ + 3e^- \rightarrow \text{As} + 2\text{H}_2\text{O}$	0.2415	$\text{NiO}_2 + 2\text{H}_2\text{O} + 2e^- \rightarrow \text{Ni}(\text{OH})_2 + 2\text{OH}^-$	0.76
$\text{IO}_3^- + 3\text{H}_2\text{O} + 6e^- \rightarrow \text{I}^- + 6\text{OH}^-$	0.2475	$2\text{NO} + \text{H}_2\text{O} + 2e^- \rightarrow \text{N}_2\text{O} + 2\text{OH}^-$	0.76
$\text{ReO}_2 + 4\text{H}^+ + 4e^- \rightarrow \text{Re} + 2\text{H}_2\text{O}$	0.26	$\text{ReO}_4^- + 2\text{H}^+ + e^- \rightarrow \text{ReO}_{3(\text{te})} + 2\text{H}_2\text{O}$	0.768
$\text{Hg}_2\text{Cl}_2 + 2e^- \rightarrow 2\text{Hg} + 2\text{Cl}^-$	0.2682	$(\text{CNS})_2 + 2e^- \rightarrow 2\text{CNS}^-$	0.77
Calomel Electrode, Molal KCl	0.2800	$\text{Fe}^{+3} + e^- \rightarrow \text{Fe}^{+2}$	0.770
$\text{PbO}_2 + \text{H}_2\text{O} + 2e^- \rightarrow \text{PbO} + 2\text{OH}^-$	0.28	$\text{Fe}^{+3} + e^- \rightarrow \text{Fe}^{+2}(\text{if HCl})$	0.770
*Calomel Electrode, N KCl	0.2807	$\text{IrCl}_6^{3-} + 3e^- \rightarrow \text{Ir} + 6\text{Cl}^-$	0.77
$\text{Re}^{+3} + 3e^- \rightarrow \text{Re}$	0.3	$\text{Ti}^{+3} + 2e^- \rightarrow \text{Ti}^{+1}(\text{if HCl})$	0.783
$\text{BiO}^+ + 2\text{H}^+ + 3e^- \rightarrow \text{Bi} + \text{H}_2\text{O}$	0.32	$\text{Hg}_2^{+2} + 2e^- \rightarrow 2\text{Hg}$	0.7961
$2\text{HCNO} + 2\text{H}^+ + 2e^- \rightarrow (\text{CN})_2 + 2\text{H}_2\text{O}$	0.33	$1/2\text{Hg}_2^{+2} + e^- \rightarrow \text{Hg}$	0.7986
*Calomel Electrode 0.1 N KCl	0.3337	$\text{Ag}^+ + e^- \rightarrow \text{Ag}$	0.7996
$\text{UO}_2^{+2} + 4\text{H}^+ + 2e^- \rightarrow \text{U}^{+4} + 2\text{H}_2\text{O}$	0.334	$2\text{HNO}_2 + 4\text{H}^+ + 4e^- \rightarrow \text{H}_2\text{N}_2\text{O}_2 + 2\text{H}_2\text{O}$	0.80
$\text{VO}^{+2} + 2\text{H}^+ + e^- \rightarrow \text{V}^{+3} + \text{H}_2\text{O}$	0.337	$2\text{NO}_3^- + 4\text{H}^+ + 2e^- \rightarrow \text{N}_2\text{O}_4 + 2\text{H}_2\text{O}$	0.81
$\text{Cu}^{+2} + 2e^- \rightarrow \text{Cu}$	0.3402	$1/2\text{O}_2 + 2\text{H}^+(10^{-7}\text{M}) + 2e^- \rightarrow \text{H}_2\text{O}$	0.815
$\text{Hg}_2\text{Cl}_2 + 2e^- \rightarrow 2\text{Hg} + 2\text{Cl}^-(0.1\text{fNaOH})$	0.3419	$\text{Pd}^{+2} + 2e^- \rightarrow \text{Pd}$	0.83
$\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2e^- \rightarrow 2\text{Ag} + 2\text{OH}^-$	(0.268)	$\text{OsO}_4 + 8\text{H}^+ + 8e^- \rightarrow \text{Os} + 4\text{H}_2\text{O}$	0.85
$\text{Nb}^{+5} + 2e^- \rightarrow \text{Nb}^{+3}(2\text{fHCl})$	0.342	$\text{Hg}^{+2} + 2e^- \rightarrow \text{Hg}$	0.851
$\text{Cu}^{+2} + 2e^- \rightarrow \text{Cu}(\text{Hg})$	0.344	$\text{AuBr}_4^- + 3e^- \rightarrow \text{Au} + 4\text{Br}^-$	0.858
$\text{ClO}_3^- + \text{H}_2\text{O} + 2e^- \rightarrow \text{ClO}_2^- + 2\text{OH}^-$	0.345	$\text{Ru}^{+4} + e^- \rightarrow \text{Ru}^{+3}(2\text{fHCl})$	0.858
$\text{AgIO}_3 + e^- \rightarrow \text{Ag} + \text{IO}_3^-$	0.35	$\text{TiO}_2 + 4\text{H}^+ + 4e^- \rightarrow \text{Ti} + 2\text{H}_2\text{O}$	0.86
$\text{Ag}_2\text{SeO}_3 + 2e^- \rightarrow 2\text{Ag} + \text{SeO}_3^{2-}$	0.3551	$\text{HO}_2^- + \text{H}_2\text{O} + 2e^- \rightarrow 3\text{OH}^-$	0.87
$\text{ReO}_4^- + 8\text{H}^+ + 7e^- \rightarrow \text{Re} + 4\text{H}_2\text{O}$	0.3629	$\text{N}_2\text{O}_4 + 2e^- \rightarrow 2\text{NO}_2^-$	0.88
$(\text{CN})_2 + 2\text{H}^+ + 2e^- \rightarrow 2\text{HCN}$	0.367	$\text{ClO}^- + \text{H}_2\text{O} + 2e^- \rightarrow \text{Cl}^- + 2\text{OH}^-$	0.90
$\text{O}_2 + 2\text{H}_2\text{O} + 4e^- \rightarrow 4\text{OH}^-$	0.37	$2\text{Hg}^{+2} + 2e^- \rightarrow \text{Hg}_2^{+2}$	0.905
$\text{AgOCN} + e^- \rightarrow \text{Ag} + \text{OCN}^-$	0.401	$\text{Pu}^{+6} + e^- \rightarrow \text{Pu}^{+5}(\text{if HClO}_4)$	0.9184
$\text{Fe}^{+3} + e^- \rightarrow \text{Fe}^{+2}(\text{if H}_3\text{PO}_4)$	0.41	$\text{NO}_3^- + 3\text{H}^+ + 2e^- \rightarrow \text{HNO}_2 + \text{H}_2\text{O}$	0.94
$\text{Rh}(\text{Cl})_3 + 3e^- \rightarrow \text{Rh} + 6\text{Cl}^-$	0.438	$\text{ClO}_2(\text{aq}) + e^- \rightarrow \text{ClO}_2^-$	0.954
$\text{Ag}_2\text{CrO}_4 + 2e^- \rightarrow 2\text{Ag} + \text{CrO}_4^{2-}$	0.44	$\text{NO}_3^- + 4\text{H}^+ + 3e^- \rightarrow \text{NO} + 2\text{H}_2\text{O}$	0.96
$\text{H}_2\text{SO}_3 + 4\text{H}^+ + 4e^- \rightarrow \text{S} + 3\text{H}_2\text{O}$	0.4463	$\text{AuBr}_2^- + e^- \rightarrow \text{Au} + 2\text{Br}^-$	0.963
$\text{Fe}(\text{CN})_6^{3-} + e^- \rightarrow \text{Fe}(\text{CN})_6^{4-}(0.1\text{fNaOH})$	0.45	$\text{Pu}^{+4} + e^- \rightarrow \text{Pu}^{+3}(\text{if HClO}_4)$	0.982
$\text{Ag}_2(\text{WO}_4) + 2e^- \rightarrow 2\text{Ag} + \text{WO}_4^{2-}$	0.46	$\text{Pd}^{+2} + 2e^- \rightarrow \text{Pd}(4\text{fHClO}_4)$	0.987
$\text{TeO}_4^{2-} + 8\text{H}^+ + 7e^- \rightarrow \text{Te} + 4\text{H}_2\text{O}$	0.466	$\text{HIO} + \text{H}^+ + 2e^- \rightarrow \text{I}^- + \text{H}_2\text{O}$	0.99
$\text{Ag}_2\text{CO}_3 + 2e^- \rightarrow 2\text{Ag} + \text{CO}_3^{2-}$	0.472	$\text{HNO}_2 + \text{H}^+ + e^- \rightarrow \text{NO} + \text{H}_2\text{O}$	0.99
$\text{Ag}_2\text{C}_2\text{O}_4 + 2e^- \rightarrow 2\text{Ag} + \text{C}_2\text{O}_4^{2-}$	0.4769	$\text{AuCl}_4^- + 3e^- \rightarrow \text{Au} + 4\text{Cl}^-$	0.994
$\text{Ag}_2\text{MoO}_4 + 2e^- \rightarrow 2\text{Ag} + \text{MoO}_4^{2-}$	0.4776	$\text{RuO}_{4(\text{te})} + e^- \rightarrow \text{RuO}_4^-$	1.00
$\text{IO}^- + \text{H}_2\text{O} + 2e^- \rightarrow \text{I}^- + 2\text{OH}^-$	0.49	$\text{VO}_2^+ + 2\text{H}^+ + e^- \rightarrow \text{VO}^{+2} + \text{H}_2\text{O}$	1.00
$\text{NiO}_2 + 2\text{H}_2\text{O} + 2e^- \rightarrow \text{Ni}(\text{OH})_2 + 2\text{OH}^-$	0.49	$\text{V}(\text{OH})_4^+ + 2\text{H}^+ + e^- \rightarrow \text{VO}^{+2} + 3\text{H}_2\text{O}$	1.00
$\text{Ru}^{+4} + e^- \rightarrow \text{Ru}^{+3}(0.1\text{fHClO}_4)$	0.49	$\text{H}_6\text{TeO}_{6(\text{te})} + 2\text{H}^+ + 2e^- \rightarrow \text{TeO}_{2(\text{te})} + 4\text{H}_2\text{O}$	1.02
$\text{ReO}_4^- + 4\text{H}^+ + 3e^- \rightarrow \text{ReO}_2 + 2\text{H}_2\text{O}$	0.49	$\text{IrCl}_6^{2-} + e^- \rightarrow \text{IrCl}_6^{3-}$	1.02
$\text{Hg}_2(\text{AcO})_2 + 2e^- \rightarrow 2\text{Hg} + 2\text{AcO}^-$	0.51	$\text{U}^{+5} + e^- \rightarrow \text{U}^{+4}(\text{if HCl})$	1.02
$\text{Cu}^+ + e^- \rightarrow \text{Cu}$	0.5113	$\text{N}_2\text{O}_4 + 4\text{H}^+ + 4e^- \rightarrow 2\text{NO} + 2\text{H}_2\text{O}$	1.03
$\text{I}_3^- + 2e^- \rightarrow 3\text{I}^-$	0.522	$\text{Pu}^{+6} + 2e^- \rightarrow \text{Pu}^{+4}(\text{if HCl})$	1.052
$\text{I}_2 + 2e^- \rightarrow 2\text{I}^-$	0.5338	$\text{Fe}(\text{phenanthroline})_3^{+3} + e^- \rightarrow \text{Fe}(\text{ph})_3^{+2}(2\text{fH}_2\text{SO}_4)$	1.056
$\text{IO}_3^- + 2\text{H}_2\text{O} + 4e^- \rightarrow \text{IO}^- + 4\text{OH}^-$	0.535	$\text{Br}_{2(\text{li})} + 2e^- \rightarrow 2\text{Br}^-$	1.065
$\text{MnO}_4^- + e^- \rightarrow \text{MnO}_4^{2-}$	0.56	$\text{N}_2\text{O}_4 + 2\text{H}^+ + 2e^- \rightarrow 2\text{HNO}_2$	1.07
$\text{MnO}_4^{+1} + 2\text{H}_2\text{O} + 3e^- \rightarrow \text{MnO}_2 + 4\text{OH}^-$	0.564	$\text{IO}_3^- + 6\text{H}^+ + 6e^- \rightarrow \text{I}^- + 3\text{H}_2\text{O}$	1.085
$\text{H}_3\text{AsO}_4 + 2\text{H}^+ + 2e^- \rightarrow \text{HASO}_2 + 2\text{H}_2\text{O}(\text{if HCl})$	0.58	$\text{Br}_{2(\text{aq})} + 2e^- \rightarrow 2\text{Br}^-$	1.087
$\text{MnO}_4^- + 2\text{H}_2\text{O} + 3e^- \rightarrow \text{MnO}_2 + 4\text{OH}^-$	0.58	$\text{Pu}^{+5} + e^- \rightarrow \text{Pu}^{+4}(0.5\text{fHCl})$	1.099
$\text{AgNO}_2 + e^- \rightarrow \text{Ag} + \text{NO}_2^-$	0.588	$\text{Cr}^{+6} + 3e^- \rightarrow \text{Cr}^{+3}(2\text{fH}_2\text{SO}_4)$	1.10
$\text{ClO}_2^- + \text{H}_2\text{O} + 2e^- \rightarrow \text{ClO}_2 + 2\text{OH}^-$	0.59	$\text{Cu}^{+2} + 2\text{CN}^- + e^- \rightarrow \text{Cu}(\text{CN})_2^-$	1.12
$\text{RuO}_4^- + e^- \rightarrow \text{RuO}_4^{2-}$	0.59	$\text{Np}^{+6} + e^- \rightarrow \text{Np}^{+5}(\text{if HClO}_4)$	1.137
$\text{TeO}_2 + 4\text{H}_2 + 4e^- \rightarrow \text{Te} + 2\text{H}_2\text{O}$	0.59	$\text{Fe}(\text{phenanthroline})_3^{+3} + e^- \rightarrow \text{Fe}(\text{ph})_3^{+2}$	1.14
$2\text{AgO} + \text{H}_2\text{O} + 2e^- \rightarrow \text{Ag}_2\text{O} + 2\text{OH}^-$	0.593	$\text{SeO}_4^{2-} + 4\text{H}^+ + 2e^- \rightarrow \text{H}_2\text{SeO}_3 + \text{H}_2\text{O}$	1.15
$\text{S}_2\text{O}_8^{2-} + 4\text{H}^+ + 2e^- \rightarrow 2\text{H}_2\text{SO}_4$	0.599	$\text{ClO}_3^- + e^- \rightarrow \text{ClO}_2^-$	1.15
$\text{BrO}_3^- + 3\text{H}_2\text{O} + 6e^- \rightarrow \text{Br}^- + 6\text{OH}^-$	0.6	$\text{ClO}_3^- + 2\text{H}^+ + e^- \rightarrow \text{ClO}_2 + \text{H}_2\text{O}$	1.15
$\text{Hg}_2\text{SO}_4 + 2e^- \rightarrow 2\text{Hg} + \text{SO}_4^{2-}$	0.61	$\text{ClO}_3^- + 2\text{H}^+ + 2e^- \rightarrow \text{ClO}_3^- + \text{H}_2\text{O}$	1.19
$\text{ClO}_3^- + 3\text{H}_2\text{O} + 6e^- \rightarrow \text{Cl}^- + 6\text{OH}^-$	0.6158	$2\text{IO}_3^- + 12\text{H}^+ + 10e^- \rightarrow \text{I}_2 + 6\text{H}_2\text{O}$	1.19
$\text{UO}_2^{+2} + 4\text{H}^+ + e^- \rightarrow \text{U}^{+4} + 2\text{H}_2\text{O}$	0.62	$\text{HCrO}_4^- + 7\text{H}^+ + 3e^- \rightarrow \text{Cr}^{+3} + 4\text{H}_2\text{O}$	1.195
$\text{Pd}^{+2} + 2e^- \rightarrow \text{Pd}(\text{if HCl})$	0.62	$\text{IO}_3^- + 6\text{H}^+ + 5e^- \rightarrow 1/2\text{I}_2 + 3\text{H}_2\text{O}$	1.195
$\text{PdCl}_4^{2-} + 2e^- \rightarrow \text{Pd} + 4\text{Cl}^-$	0.623	$\text{Pt}^{+2} + 2e^- \rightarrow \text{Pt}$	~1.2
$\text{Te}^{+4} + 4e^- \rightarrow \text{Te}(2.5\text{fHCl})$	0.623	$\text{MnO}_2 + 4\text{H}^+ + 2e^- \rightarrow \text{Mn}^{+2} + 2\text{H}_2\text{O}$	1.208
$\text{Hg}_2\text{HPO}_4 + \text{H}^+ + 2e^- \rightarrow 2\text{Hg} + \text{H}_2\text{PO}_4^-$	0.63	$\text{ClO}_3^- + 3\text{H}^+ + 2e^- \rightarrow \text{HClO}_2 + \text{H}_2\text{O}$	1.21
$\text{AgAc} + e^- \rightarrow \text{Ag} + \text{Ac}^-$	0.639	$\text{O}_2 + 4\text{H}^+ + 4e^- \rightarrow 2\text{H}_2\text{O}$	(1.23)
$\text{Sb}_2\text{O}_5(\text{li}) + 6\text{H}^+ + 4e^- \rightarrow 2\text{SbO}^+ + 3\text{H}_2\text{O}$	0.64	$\text{O}_3 + \text{H}_2\text{O} + 2e^- \rightarrow \text{O}_2 + 2\text{OH}^-$	1.229
$\text{Ag}_2\text{SO}_4 + 2e^- \rightarrow 2\text{Ag} + \text{SO}_4^{2-}$	0.64	$\text{Ti}^{+3} + 2e^- \rightarrow \text{Ti}^{+1}$	1.24
$\text{Fe}^{+3} + e^- \rightarrow \text{Fe}^{+2}(0.5\text{fH}_2\text{SO}_4)$	0.653	$\text{ClO}_2 + \text{H}^+ + e^- \rightarrow \text{HClO}_2$	1.247
$\text{AgBrO}_3 + e^- \rightarrow \text{Ag} + \text{BrO}_3^-$	0.679	$2\text{HNO}_2 + 4\text{H}^+ + 4e^- \rightarrow \text{N}_2\text{O} + 3\text{H}_2\text{O}$	1.27
$\text{O}_2 + 2\text{H}^+ + 2e^- \rightarrow \text{H}_2\text{O}_2$	0.680		1.27
$\text{Fe}(\text{CN})_6^{3-} + e^- \rightarrow \text{Fe}(\text{CN})_6^{4-}(\text{if H}_2\text{SO}_4)$	0.682		(1.29)
$\text{Sb}_2\text{O}_5 + 4\text{H}^+ + 4e^- \rightarrow \text{Sb}_2\text{O}_3 + 2\text{H}_2\text{O}$	0.69	$\text{N}_2\text{H}_5^+ + 3\text{H}^+ + 2e^- \rightarrow 2\text{NH}_4^+$	1.27
$\text{C}_6\text{H}_4\text{O}_2 + 2\text{H}^+ + 2e^- \rightarrow \text{C}_6\text{H}_4(\text{OH})_2$	0.69	$\text{Au}^{+3} + 2e^- \rightarrow \text{Au}^{+1}$	~1.29
Quinhydrone Elec. $\text{H}^+, a = 1$	0.6992	$\text{PdCl}_6^{2-} + 2e^- \rightarrow \text{PdCl}_4^{2-} + 2\text{Cl}^-$	1.29
$\text{BrO}^- + \text{H}_2\text{O} + 2e^- \rightarrow \text{Br}^- + 2\text{OH}^-(\text{if NaOH})$	0.6995	$\text{HBrO} + \text{H}^+ + 2e^- \rightarrow \text{Br}^- + \text{H}_2\text{O}$	1.33
$\text{H}_3\text{IO}_6^{2-} + 2e^- \rightarrow \text{IO}_3^- + 3\text{OH}^-$	0.70	$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6e^- \rightarrow 2\text{Cr}^{+3} + 7\text{H}_2\text{O}$	1.33
	~0.70	$\text{ClO}_4^- + 8\text{H}^+ + 7e^- \rightarrow 1/2\text{Cl}_2 + 4\text{H}_2\text{O}$	1.34
		$\text{Cl}_{2(\text{g})} + 2e^- \rightarrow 2\text{Cl}^-$	1.3583
		$\text{ClO}_4^- + 8\text{H}^+ + 8e^- \rightarrow \text{Cl}^- + 4\text{H}_2\text{O}$	1.37

ELECTROCHEMICAL SERIES—TABLE II (Continued)

Reaction	Potential, volts	Reaction	Potential, volts
$\text{OH}^- + \text{e}^- \rightarrow \text{OH}^-$	1.4	$\text{HClO}_2 + 3\text{H}^+ + 3\text{e}^- \rightarrow 1/2\text{Cl}_2 + 2\text{H}_2\text{O}$	1.63
$\text{Au}^{+3} + 3\text{e}^- \rightarrow \text{Au}$	1.42	$\text{HClO} + \text{H}^+ + \text{e}^- \rightarrow 1/2\text{Cl}_2 + \text{H}_2\text{O}$	1.63
$2\text{NH}_4\text{OH}^+ + \text{H}^+ + 2\text{e}^- \rightarrow \text{N}_2\text{H}_5^+ + 2\text{H}_2\text{O}$	1.42	$\text{HClO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{HClO} + \text{H}_2\text{O}$	1.64
$\text{Rh}^{+4} + \text{e}^- \rightarrow \text{Rh}^{+3}$	1.43	$\text{MnO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$	1.679
$\text{BrO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{Br}^- + 3\text{H}_2\text{O}$	1.44	$\text{Au}^+ + \text{e}^- \rightarrow \text{Au}$	1.68
$\text{Ce}^{+4} + \text{e}^- \rightarrow \text{Ce}^{+3}$	1.4430	$\text{PbO}_2 + \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{PbSO}_4 + 2\text{H}_2\text{O}$	1.685
$\text{Au}(\text{OH})_3 + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{Au} + 3\text{H}_2\text{O}$	(1.61)	$\text{H}_2\text{IO}_6 + \text{H}^+ + 2\text{e}^- \rightarrow \text{IO}_3^- + 3\text{H}_2\text{O}$	~1.7
$\text{ClO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{Cl}^- + 3\text{H}_2\text{O}$	1.45	$\text{CeOH}^{+3} + \text{H}^+ + \text{e}^- \rightarrow \text{Ce}^{+3} + \text{H}_2\text{O}$	1.7134
$\text{HIO} + \text{H}^+ + \text{e}^- \rightarrow 1/2\text{I}_2 + \text{H}_2\text{O}$	1.45	$\text{N}_2\text{O} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{N}_2 + \text{H}_2\text{O}$	1.77
$\text{Ce}^{+4} + \text{e}^- \rightarrow \text{Ce}^{+3} (0.5f\text{H}_2\text{SO}_4)$	1.4587	$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}$	1.776
$\text{PbO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Pb}^{+2} + 2\text{H}_2\text{O}$	1.46	$\text{Co}^{+3} + \text{e}^- \rightarrow \text{Co}^{+2} (3f\text{HNO}_3)$	1.842
$\text{ClO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightarrow 1/2\text{Cl}_2 + 3\text{H}_2\text{O}$	1.47	$\text{FeO}_4^{2-} + 8\text{H}^+ + 3\text{e}^- \rightarrow \text{Fe}^{+3} + 4\text{H}_2\text{O}$	1.9
$\text{HClO} + \text{H}^+ + 2\text{e}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$	1.49	$\text{NiO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Ni}^{+2} + 2\text{H}_2\text{O}$	1.93
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{+2} + 4\text{H}_2\text{O}$	1.491	$\text{Ag}^{+2} + \text{e}^- \rightarrow \text{Ag}^{+1} (4f\text{HClO}_4)$	1.987
$\text{HO}_2 + \text{H}^+ + \text{e}^- \rightarrow \text{H}_2\text{O}_2$	1.5	$\text{S}_2\text{O}_8^{2-} + 2\text{e}^- \rightarrow 2\text{SO}_4^{2-}$	2.0
$\text{Mn}^{+3} + \text{e}^- \rightarrow \text{Mn}^{+2}$	1.51	$\text{O}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{O}_2 + \text{H}_2\text{O}$	(2.05)
$\text{BrO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightarrow 1/2\text{Br}_2 + 3\text{H}_2\text{O}$	1.52	$\text{F}_2\text{O} + 2\text{H}^+ + 4\text{e}^- \rightarrow \text{H}_2\text{O} + 2\text{F}^-$	2.07
$\text{HClO}_2 + 3\text{H}^+ + 4\text{e}^- \rightarrow \text{Cl}^- + 2\text{H}_2\text{O}$	1.56	$\text{O}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O}$	2.1
$\text{Bi}_2\text{O}_3 + 4\text{H}^+ + 2\text{e}^- \rightarrow 2\text{BiO}^+ + 2\text{H}_2\text{O}$	1.59	$\text{H}_2\text{N}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{N}_2 + 2\text{H}_2\text{O}$	2.42
$\text{HBrO} + \text{H}^+ + \text{e}^- \rightarrow 1/2\text{Br}_2 + \text{H}_2\text{O}$	1.59	$1/2\text{F}_2 + \text{e}^- \rightarrow \text{F}^-$	2.65
$2\text{NO} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$	1.59	$\text{F}_2 + 2\text{e}^- \rightarrow 2\text{F}^-$	2.85
$2\text{HBrO} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{Br}_{2(l)} + 2\text{H}_2\text{O}$	1.6	$1/2\text{F}_2 + \text{H}^+ + \text{e}^- \rightarrow \text{HF}$	2.87
			3.03

PART 2

Reaction	Potential, volts	Reaction	Potential, volts
$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$	0.0000	$\text{In}^{+2} + \text{e}^- \rightarrow \text{In}^{+1}$	-0.40
$\text{D}^+ + \text{e}^- \rightarrow 1/2\text{D}_2$	-0.0034	$\text{In}^{+3} + 2\text{e}^- \rightarrow \text{In}^{+1}$	-0.40
$\text{AgCN} + \text{e}^- \rightarrow \text{Ag} + \text{CN}^-$	-0.02	$\text{Mn}(\text{OH})_3 + \text{e}^- \rightarrow \text{Mn}(\text{OH})_2 + \text{OH}^-$	-0.40
$\text{TeO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Te} + 6\text{OH}^-$	-0.02	$\text{Cd}^{+2} + 2\text{e}^- \rightarrow \text{Cd}$	-0.4026
$2\text{WO}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{W}_2\text{O}_5 + \text{H}_2\text{O}$	-0.03	$\text{Fe}^{+2} + 2\text{e}^- \rightarrow \text{Fe}$	-0.409
$\text{Fe}^{+3} + 3\text{e}^- \rightarrow \text{Fe}$	-0.036	$\text{Cr}^{+3} + \text{e}^- \rightarrow \text{Cr}^{+2}$	-0.41
$\text{Ag}_2\text{S} + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{Ag} + \text{H}_2\text{S}$	-0.0366	$\text{Eu}^{+3} + \text{e}^- \rightarrow \text{Eu}^{+2}$	-0.43
$\text{P} + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{PH}_3(\text{g})$	-0.04	$\text{CdSO}_4 \cdot 8/3\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Cd}(\text{Hg}) + \text{CdSO}_4 (\text{sat'd aq})$	-0.4346
$\text{W}_2\text{O}_5 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{WO}_2 + \text{H}_2\text{O}$	-0.04	$\text{Ti}_2\text{SO}_4 + 2\text{e}^- \rightarrow \text{Ti}(\text{Hg}) + \text{SO}_4^{2-}$	-0.4360
$\text{Hg}_2\text{I}_2 + 2\text{e}^- \rightarrow 2\text{Hg} + 2\text{I}^-$	-0.0405	$\text{Bi}_2\text{O}_3 + 3\text{H}_2\text{O} + 6\text{e}^- \rightarrow 2\text{Bi} + 6\text{OH}^-$	-0.46
$2\text{D}^+ + 2\text{e}^- \rightarrow \text{D}_2$	-0.044	$\text{BiOOH} + \text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Bi} + 3\text{OH}^-$	-0.46
$\text{Ti}(\text{OH})_3 + 2\text{e}^- \rightarrow \text{TiOH} + 2\text{OH}^-$	-0.05	$\text{NO}_2^- + \text{H}_2\text{O} + \text{e}^- \rightarrow \text{NO} + 2\text{OH}^-$	-0.46
$\text{O}_2 + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{HO}_2^- + \text{OH}^-$	-0.076	$\text{S} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{HS}^- + \text{OH}^-$	-0.478
$\text{AsO}_4^{3-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{AsO}_2^- + 4\text{OH}^- (\text{If NaOH})$	-0.08	$\text{H}_3\text{PO}_3 + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{P} + 3\text{H}_2\text{O}$	-0.49
$2\text{H}_2\text{SO}_3 + \text{H}^+ + 2\text{e}^- \rightarrow \text{HS}_2\text{O}_4^- + 2\text{H}_2\text{O}$	-0.08	$\text{In}^{+3} + \text{e}^- \rightarrow \text{In}^{+2}$	-0.49
$\text{Ru}^{+3} + \text{e}^- \rightarrow \text{Ru}^{+2} (1-6f\text{HCl})$	-0.084	$2\text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{C}_2\text{O}_4$	-0.49
$2\text{Cu}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Cu}_2\text{O} + 2\text{OH}^- + \text{H}_2\text{O}$	-0.09	$\text{H}_3\text{PO}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_3\text{PO}_2 + \text{H}_2\text{O}$	-0.50
$\text{WO}_3 + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{W} + 3\text{H}_2\text{O}$	-0.09		(-0.59)
$\text{Ru}^{+3} + \text{e}^- \rightarrow \text{Ru}^{+2} (0.1f\text{HClO}_4)$	-0.11	$\text{S} + 2\text{e}^- \rightarrow \text{S}^{2-}$	-0.508
$\text{Cr}^{+6} + 3\text{e}^- \rightarrow \text{Cr}^{+3} (1f\text{NaOH})$	-0.12	$\text{H}_3\text{PO}_3 + \text{H}^+ + \text{e}^- \rightarrow \text{P} + 2\text{H}_2\text{O}$	-0.51
$\text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Cr}(\text{OH})_3 + 5\text{OH}^-$	-0.12	$\text{Sb} + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{H}_3\text{Sb}$	-0.51
$\text{GeO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{GeO} + \text{H}_2\text{O}$	-0.12	$\text{As} + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{AsH}_3$	-0.54
$\text{WO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{W} + 2\text{H}_2\text{O}$	-0.12	$\text{HPbO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Pb} + 3\text{OH}^-$	-0.54
$\text{Pb}^{+2} + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg})$	-0.1205	$\text{TiCl} + \text{e}^- \rightarrow \text{Ti}(\text{Hg}) + \text{Cl}^-$	-0.555
$\text{Pb}^{+2} + 2\text{e}^- \rightarrow \text{Pb}$	-0.1263	$\text{Cr}^{+2} + 2\text{e}^- \rightarrow \text{Cr}$	-0.557
	(0.126)	$\text{Ga}^{+3} + 3\text{e}^- \rightarrow \text{Ga}$	-0.560
$\text{H}_2\text{GeO}_3 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Ge} + 3\text{H}_2\text{O}$	-0.13	$\text{Fe}(\text{OH})_3 + \text{e}^- \rightarrow \text{Fe}(\text{OH})_2 + \text{OH}^-$	-0.56
$\text{Sn}^{+2} + 2\text{e}^- \rightarrow \text{Sn}$	-0.1364	$\text{PbO} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Pb} + 2\text{OH}^-$	-0.576
$\text{O}_2 + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2\text{O}_2 \rightarrow 2\text{OH}^-$	-0.146	$2\text{SO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{S}_2\text{O}_3^{2-} + 6\text{OH}^-$	-0.58
$\text{AgI} + \text{e}^- \rightarrow \text{Ag} + \text{I}^-$	-0.1519	$\text{SbO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{SbO}_2^- + 2\text{OH}^-$	-0.59
$2\text{NO}_2^- + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{N}_2\text{O}_2^{2-} + 4\text{OH}^-$	-0.18	$\text{TiBr} + \text{e}^- \rightarrow \text{Ti}(\text{Hg}) + \text{Br}^-$	-0.606
$\text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{HCOOH}$	-0.2	$\text{U}^{+4} + \text{e}^- \rightarrow \text{U}^{+3}$	-0.61
$2\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{S}_2\text{O}_8^{2-} + 2\text{H}_2\text{O}$	-0.2	$\text{Cb}_2\text{O}_3 + 10\text{H}^+ + 10\text{e}^- \rightarrow 2\text{Cb} + 5\text{H}_2\text{O}$	-0.62
$\text{Cu}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Cu} + 2\text{OH}^-$	-0.224	$\text{U}^{+4} + \text{e}^- \rightarrow \text{U}^{+3} (1f\text{HClO}_4)$	-0.631
$\text{Ni}^{+2} + 2\text{e}^- \rightarrow \text{Ni}$	-0.23	$\text{Ni}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Ni} + 2\text{OH}^-$	-0.66
$\text{PbHPO}_4 + \text{H}^+ + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + \text{HPO}_4^{2-}$	-0.2448	$\text{SbO}_2^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Sb} + 4\text{OH}^-$	-0.66
$\text{V}(\text{OH})_4^+ + 4\text{H}^+ + 5\text{e}^- \rightarrow \text{V} + 4\text{H}_2\text{O}$	-0.25	$\text{AsO}_2^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{As} + 4\text{OH}^-$	-0.68
$\text{V}^{+3} + \text{e}^- \rightarrow \text{V}^{+2}$	-0.255	$^*\text{Te} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{Te}(\text{Ag})$	-0.69
$\text{PbCl}_2 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + 2\text{Cl}^-$	-0.262		(-0.72)
$\text{PbBr}_2 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + \text{Br}^-$	-0.275	$\text{Ag}_2\text{S} + 2\text{e}^- \rightarrow 2\text{Ag} + \text{S}^{2-}$	-0.7051
$\text{H}_3\text{PO}_4 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_3\text{PO}_3 + \text{H}_2\text{O}$	-0.276	$\text{Ta}_2\text{O}_5 + 10\text{H}^+ + 10\text{e}^- \rightarrow 2\text{Ta} + 5\text{H}_2\text{O}$	-0.71
	(-0.2)	$\text{AsO}_4^{3-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{AsO}_2^- + 4\text{OH}^-$	-0.71
$\text{Co}^{+2} + 2\text{e}^- \rightarrow \text{Co}$	-0.28	$\text{Co}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Co} + 2\text{OH}^-$	-0.73
$\text{Ti}^+ + \text{e}^- \rightarrow \text{Ti}(\text{Hg})$	-0.3338	$\text{H}_3\text{BO}_3 + 3\text{H}^+ + 3\text{e}^- \rightarrow \text{B} + 3\text{H}_2\text{O}$	-0.73
$\text{Ti}^+ + \text{e}^- \rightarrow \text{Ti}$	-0.3363	$\text{Cr}^{+3} + 3\text{e}^- \rightarrow \text{Cr}$	-0.74
$\text{In}^{+3} + 3\text{e}^- \rightarrow \text{In}$	-0.338	$\text{V}^{+5} + \text{e}^- \rightarrow \text{V}^{+4} (1f\text{NaOH})$	-0.74
$\text{PbF}_2 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + 2\text{F}^-$	-0.3444	$\text{Cd}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Cd}(\text{Hg}) + 2\text{OH}^-$	-0.761
$\text{TiOH} + \text{e}^- \rightarrow \text{Ti} + \text{OH}^-$	-0.3445		(-0.81)
$\text{SeO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Se} + 6\text{OH}^-$	-0.35	$\text{Zn}^{+2} + 2\text{e}^- \rightarrow \text{Zn}$	-0.7628
$\text{PbSO}_4 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + \text{SO}_4^{2-}$	-0.3505	$\text{Zn}^{+2} + 2\text{e}^- \rightarrow \text{Zn}(\text{Hg})$	-0.7628
$\text{Cd}^{+2} + 2\text{e}^- \rightarrow \text{Cd}(\text{Hg})$	-0.3521	$\text{TiI} + \text{e}^- \rightarrow \text{Ti}(\text{Hg}) + \text{I}^-$	-0.769
$\text{PbSO}_4 + 2\text{e}^- \rightarrow \text{Pb} + \text{SO}_4^{2-}$	-0.356	$\text{Se} + 2\text{e}^- \rightarrow \text{Se}^{2-}$	-0.78
$\text{PbI}_2 + 2\text{e}^- \rightarrow \text{Pb}(\text{Hg}) + 2\text{I}^-$	-0.358	$\text{HSnO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Sn} + 3\text{OH}^-$	-0.79
$\text{Se} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{Se}(\text{aq})$	-0.36	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Zn}(\text{Hg}) + \text{SO}_4^{2-} (\text{Sat'd ZnSO}_4)$	-0.7993
$\text{Cu}_2\text{O} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{Cu} + 2\text{OH}^-$	-0.361	$\text{RuO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Ru} + 2\text{H}_2\text{O}$	-0.8
$\text{Ti}^{+3} + \text{e}^- \rightarrow \text{Ti}^{+2}$	-0.37	$\text{ReO}_4^- + 4\text{H}_2\text{O} + 7\text{e}^- \rightarrow \text{Re} + 8\text{OH}^-$	-0.81

ELECTROCHEMICAL SERIES—TABLE II (Continued)

Reaction	Potential, volts	Reaction	Potential, volts
$\text{UO}_2^{2+} + 4\text{H}^+ + 6\text{e}^- \rightarrow \text{U} + 2\text{H}_2\text{O}$	-0.82	$\text{N}_2 + 2\text{H}_2\text{O} + 4\text{H}^+ + 2\text{e}^- \rightarrow 2\text{NH}_4\text{OH}^+$	-1.87
$2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$	-0.8277	$\text{Th}^{4+} + 4\text{e}^- \rightarrow \text{Th}$	-1.90
$\text{SiO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Si} + 2\text{H}_2\text{O}$	-0.84	$\text{Np}^{3+} + 3\text{e}^- \rightarrow \text{Np}$	-1.9
$2\text{NO}_3^- + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{N}_2\text{O}_4 + 4\text{OH}^-$	-0.85	$\text{Ti}^{3+} + \text{e}^- \rightarrow \text{Ti}^{+2}$	-2.0
$\text{TiO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Ti} + 2\text{H}_2\text{O}$	-0.86	$\text{Sc}^{3+} + 3\text{e}^- \rightarrow \text{Sc}$	-2.08
$\text{P} + 3\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{PH}_3(\text{g}) + 3\text{OH}^-$	-0.87	$1/2\text{H}_2 + \text{e}^- \rightarrow \text{H}^-$	-2.23
$\text{SO}_4^{2-} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{SO}_3^{2-} + 2\text{OH}^-$	-0.92	$\text{Nd}^{3+} + 3\text{e}^- \rightarrow \text{Nd}$	-2.246
$\text{Te} + 2\text{e}^- \rightarrow \text{Te}^{2-}$	-0.92	$\text{Be}_2\text{O}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow 2\text{Be} + 6\text{OH}^-$	-2.28
$\text{Sn}(\text{OH})_6^{2-} + 2\text{e}^- \rightarrow \text{HSnO}_2^- + 3\text{OH}^- + \text{H}_2\text{O}$	-0.96	$\text{ZrO}(\text{OH})_2 + \text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Zr} + 4\text{OH}^-$	-2.32
$\text{Mn}^{+2} + 2\text{e}^- \rightarrow \text{Mn}$	-1.029	$\text{Ce}^{+3} + 3\text{e}^- \rightarrow \text{Ce}$	-2.335
$\text{PO}_4^{3-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{HPO}_3^{2-} + 3\text{OH}^-$	-1.05	$\text{H}_2\text{AlO}_3^- + \text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Al} + 4\text{OH}^-$	-2.35
$2\text{SO}_4^{2-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{S}_2\text{O}_4^{2-} + 4\text{OH}^-$	-1.12	$\text{Y}^{+3} + 3\text{e}^- \rightarrow \text{Y}$	-2.37
$\text{CrO}_2^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Cr} + 4\text{OH}^-$	-1.2	$\text{La}^{+3} + 3\text{e}^- \rightarrow \text{La}$	-2.37
$\text{SiF}_6^{2-} + 4\text{e}^- \rightarrow \text{Si} + 6\text{F}^-$	-1.2	$\text{Mg}^{++} + 2\text{e}^- \rightarrow \text{Mg}$	-2.375
$\text{V}^{+2} + 2\text{e}^- \rightarrow \text{V}$	-1.2	$\text{H}_2\text{BO}_3^- + \text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{B} + 4\text{OH}^-$	-2.5
$\text{ZnO}_2^{2-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Zn} + 4\text{OH}^-$	-1.216	$\text{HfO}(\text{OH})_2 + \text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Hf} + 4\text{OH}^-$	-2.60
$\text{H}_2\text{GaO}_3^- + \text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{Ga} + 4\text{OH}^-$	-1.22	$\text{ThO}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Th} + 4\text{OH}^-$	-2.64
$\text{H}_2\text{BO}_3^- + 5\text{H}_2\text{O} + 8\text{e}^- \rightarrow \text{BH}_4^- + 8\text{OH}^-$	-1.24	$\text{Mg}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Mg} + 2\text{OH}^-$	-2.67
$\text{Cr}(\text{OH})_3 + 3\text{e}^- \rightarrow \text{Cr} + 3\text{OH}^-$	-1.3	$\text{Na}^+ + \text{e}^- \rightarrow \text{Na}$	-2.7109
$\text{ZrO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Zr} + 2\text{H}_2\text{O}$	-1.43		
$\text{Ce}^{+3} + 3\text{e}^- \rightarrow \text{Ce}(\text{Hg})$	-1.4373	$\text{Ca}^{+2} + 2\text{e}^- \rightarrow \text{Ca}$	(-2.712)
$\text{Mn}(\text{OH})_2 \rightarrow \text{Mn} + 2\text{OH}^-$	-1.47	$\text{La}(\text{OH})_3 + 3\text{e}^- \rightarrow \text{La} + 3\text{OH}^-$	-2.76
$\text{Ba}^{+2} + 2\text{e}^- \rightarrow \text{Ba}(\text{Hg})$	-1.570	$\text{Sr}^{+2} + 2\text{e}^- \rightarrow \text{Sr}$	-2.76
$\text{HfO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Hf} + 2\text{H}_2\text{O}$	-1.57	$\text{Ba}^{+2} + 2\text{e}^- \rightarrow \text{Ba}$	-2.89
$\text{Ti}^{+2} + 2\text{e}^- \rightarrow \text{Ti}$	-1.63	$\text{Cs}^+ + \text{e}^- \rightarrow \text{Cs}$	-2.90
$\text{HPO}_3^{2-} + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2\text{PO}_3^- + 3\text{OH}^-$	-1.65	$\text{K}^+ + \text{e}^- \rightarrow \text{K}$	-2.923
$\text{HfO}^{+2} + 2\text{H}^+ + 4\text{e}^- \rightarrow \text{Hf} + \text{H}_2\text{O}$	-1.68		-2.924
$\text{Be}^{+2} + 2\text{e}^- \rightarrow \text{Be}$	-1.70	$\text{Rb}^+ + \text{e}^- \rightarrow \text{Rb}$	(-2.923)
	(-1.85)		-2.925
$\text{Al}^{+3} + 3\text{e}^- \rightarrow \text{Al}(0.1\text{f NaOH})$	-1.706	$\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Ba} + 2\text{OH}^- + 8\text{H}_2\text{O}$	(-2.99)
$\text{HPO}_3^{2-} + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{P} + 5\text{OH}^-$	-1.71	$\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Sr} + 2\text{OH}^- + 8\text{H}_2\text{O}$	-2.97
$\text{SiO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{Si} + 6\text{OH}^-$	-1.73	$\text{Ca}(\text{OH})_2 + 2\text{e}^- \rightarrow \text{Ca} + 2\text{OH}^-$	-2.99
$\text{Sr}^{+2} + 2\text{e}^- \rightarrow \text{Sr}(\text{Hg})$	-1.793	$\text{Ca}^+ + \text{e}^- \rightarrow \text{Ca}$	-3.02
$\text{ThO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{Th} + 2\text{H}_2\text{O}$	-1.80	$\text{Li}^+ + \text{e}^- \rightarrow \text{Li}$	-3.02
$\text{U}^{+3} + 3\text{e}^- \rightarrow \text{U}$	-1.8		-3.045
$\text{H}_3\text{PO}_2^- + \text{e}^- \rightarrow \text{P} + 2\text{OH}^-$	-1.82	$3\text{N}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{HN}_3$	(-3.02)
			-3.1

APÉNDICE 5

Constantes parciales de formación

Ligando	Catión	$\log K_1$	$\log K_2$	$\log K_3$	$\log K_4$	$\log K_5$	$\log K_6$
CH ₃ COO ⁻	Ag ⁺	0,4	-0,2				
	Cd ²⁺	1,3	1,0	0,1	-0,4		
	Cu ²⁺	2,2	1,1				
	Hg ²⁺	$\log K_1 K_2 = 8,4$					
	Pb ²⁺	2,7	1,5				
NH ₃	Ag ⁺	3,3	3,8				
	Cd ²⁺	2,6	2,1	1,4	0,9	-0,3	-1,7
	Co ²⁺	2,1	1,6	1,0	0,8	0,2	-0,6
	Cu ²⁺	4,3	3,7	3,0	2,3	-0,5	
	Ni ²⁺	2,8	2,2	1,7	1,2	0,8	0,0
	Zn ²⁺	2,4	2,4	2,5	2,1		
Br ⁻	Ag ⁺	$\text{AgBr(s)} + \text{Br}^- \rightleftharpoons \text{AgBr}_2^-$			$\log K_{s2} = -4,7$		
		$\text{AgBr}_2^- + \text{Br}^- \rightleftharpoons \text{AgBr}_3^{2-}$			$\log K_3 = 0,7$		
	Hg ²⁺	9,0	8,3	1,4	1,3		
	Pb ²⁺	1,2					
Cl ⁻	Ag ⁺	$\text{AgCl(s)} + \text{Cl}^- \rightleftharpoons \text{AgCl}_2^-$			$\log K_{s2} = -4,7$		
		$\text{AgCl}_2^- + \text{Cl}^- \rightleftharpoons \text{AgCl}_3^{2-}$			$\log K_{s3} = 0,0$		
	Bi ³⁺	2,4	2,0	1,4	0,4	0,5	
	Cd ²⁺	1,5	0,4	0,4			
	Cu ⁺	$\text{Cu}^+ + 2 \text{Cl}^- \rightleftharpoons \text{CuCl}_2^-$			$\log K_1 K_2 = 4,9$		
	Fe ²⁺	0,4	0,0				
	Fe ³⁺	1,5	0,6	-1,0			
	Hg ²⁺	6,7	6,5	0,9	1,0		
	Pb ²⁺	1,6	$\text{Pb}^{2+} + 3 \text{Cl}^- \rightleftharpoons \text{PbCl}_3^-$		$\log K_1 K_2 K_3 = 1,7$		
	Sn ²⁺	1,1	0,6	0,0			
CN ⁻	Ag ⁺	$\text{Ag}^+ + 2 \text{CN}^- \rightleftharpoons \text{Ag(CN)}_2^-$			$\log K_1 K_2 = 21,1$		
	Cd ²⁺	5,5	5,1	4,6	3,6		

APÉNDICE 5 Constantes parciales de formación

Ligando	Catión	$\log K_1$	$\log K_2$	$\log K_3$	$\log K_4$	$\log K_5$	$\log K_6$
	Hg ²⁺	18,0	16,7				
	Ni ²⁺	$\text{Ni}^{2+} + 4 \text{CN}^- \rightleftharpoons \text{Ni}(\text{CN})_4^-$		3,8	3,0		
					$\log K_1 K_2 K_3 K_4 = 31$		
EDTA Ver Tabla 13-1							
F ⁻	Al ³⁺	6,1	5,0	3,8	2,7	1,6	0,5
	Fe ³⁺	5,3	4,0	2,8			
OH ⁻	Al ³⁺	8,9	$\text{Al}(\text{OH})_3(\text{s}) + \text{OH}^- \rightleftharpoons \text{Al}(\text{OH})_4^-$		$\log K_{s4} = 1,0$		
	Cd ²⁺	2,3					
	Cu ²⁺	6,5					
	Fe ²⁺	3,9					
	Fe ³⁺	11,1	10,7				
	Hg ²⁺	10,3					
	Ni ²⁺	4,6					
	Pb ²⁺	6,2	$\text{Pb}(\text{OH})_2(\text{s}) + \text{OH}^- \rightleftharpoons \text{Pb}(\text{OH})_3^-$		$\log K_{s3} = -1,3$		
	Zn ²⁺	4,4	$\text{Zn}(\text{OH})_2(\text{s}) + 2 \text{OH}^- \rightleftharpoons \text{Zn}(\text{OH})_4^{2-}$		$\log K_{s4} = -0,9$		
I ⁻	Cd ²⁺	2,4	1,6	1,0	1,1		
	Cu ⁺		$\text{CuI}(\text{s}) + \text{I}^- \rightleftharpoons \text{CuI}_2^-$		$\log K_{s2} = -3,1$		
	Hg ²⁺	12,9	11,0	3,8	2,3		
	Pb ²⁺	1,3	$\text{PbI}_2(\text{s}) + \text{I}^- \rightleftharpoons \text{PbI}_3^-$		$\log K_{s3} = -4,7$		
			$\text{PbI}_3^- + \text{I}^- \rightleftharpoons \text{PbI}_4^{2-}$		$\log K_4 = -3,8$		
C ₂ O ₄ ²⁻	Al ³⁺	$\log K_1 K_2 = 13$		3,8			
	Fe ³⁺	9,4	6,8	4,0			
	Mg ²⁺	3,4	1,0				
	Mn ²⁺	3,9	1,9				
	Pb ²⁺	$\text{Pb}^{2+} + 2 \text{C}_2\text{O}_4^{2-} \rightleftharpoons \text{Pb}(\text{C}_2\text{O}_4)_2^{2-}$		$\log K_1 K_2 = 6,5$			
SO ₄ ²⁻	Al ³⁺	3,2	1,9				
	Cd ²⁺	2,3					
	Cu ²⁺	2,4					
	Fe ³⁺	3,0	1,0				
SCN ⁻	Ag ⁺		$\text{AgSCN}(\text{s}) + \text{SCN}^- \rightleftharpoons \text{Ag}(\text{SCN})_2^-$		$\log K_{s2} = -7,2$		
	Cd ²⁺	1,0	0,7	0,6	1,0		
	Co ²⁺	2,3	0,7	-0,7	0,0		
	Cu ²⁺		$\text{CuSCN}(\text{s}) + \text{SCN}^- \rightleftharpoons \text{Cu}(\text{SCN})_2^-$		$\log K_{s2} = -3,4$		
	Fe ³⁺	2,1	1,3				
	Hg ²⁺	$\log K_1 K_2 = 17,3$		2,7	1,8		
	Ni ²⁺	1,2	0,5	0,2			

De L. Meites, *Handbook of Analytical Chemistry*, p. 1-39, New York: McGraw-Hill, 1963. Con autorización.