

# ELECTROCHEMICAL SERIES

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There are three tables for this electrochemical series. Each table lists standard reduction potentials,  $E^\circ$  values, at 298.15 K (25°C), and at a pressure of 101.325 kPa (1 atm). Table 1 is an alphabetical listing of the elements, according to the symbol of the elements. Thus, data for silver (Ag) precedes those for aluminum (Al). Table 2 lists only those reduction reactions which have  $E^\circ$  values positive in respect to the standard hydrogen electrode. In Table 2, the reactions are listed in the order of increasing positive potential, and they range from 0.0000 V to + 3.4 V. Table 3 lists only those reduction potentials which have  $E^\circ$  negative with respect to the standard hydrogen electrode. In Table 3, the reactions are listed in the order of decreasing potential and range from 0.0000 V to -4.10 V. The reliability of the potentials is not the same for all the data. Typically, the values with fewer significant figures have lower reliability. The values of reduction potentials, in particular those of less common reactions, are not definite; they are subject to occasional revisions.

*Abbreviations:* ac = acetate; bipy = 2,2'-dipyridine, or bipyridine; en = ethylenediamine; phen = 1,10-phenanthroline.

## REFERENCES

1. G. Milazzo, S. Caroli, and V. K. Sharma, *Tables of Standard Electrode Potentials*, Wiley, Chichester, 1978.
2. A. J. Bard, R. Parsons, and J. Jordan, *Standard Potentials in Aqueous Solutions*, Marcel Dekker, New York, 1985.
3. S. G. Bratsch, *J. Phys. Chem. Ref. Data*, 18, 1—21, 1989.

**TABLE 1**  
**Alphabetical Listing**

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$\text{Ac}^{3+} + 3 e \rightleftharpoons \text{Ac}$	-2.20	$\text{Al}(\text{OH})_4^- + 3 e \rightleftharpoons \text{Al} + 4 \text{OH}^-$	-2.328
$\text{Ag}^+ + e \rightleftharpoons \text{Ag}$	0.7996	$\text{H}_2\text{AlO}_3^- + \text{H}_2\text{O} + 3 e \rightleftharpoons \text{Al} + 4 \text{OH}^-$	-2.33
$\text{Ag}^{2+} + e \rightleftharpoons \text{Ag}^+$	1.980	$\text{AlF}_6^{3-} + 3 e \rightleftharpoons \text{Al} + 6 \text{F}^-$	-2.069
$\text{Ag}(\text{ac}) + e \rightleftharpoons \text{Ag} + (\text{ac})^-$	0.643	$\text{Am}^{4+} + e \rightleftharpoons \text{Am}^{3+}$	2.60
$\text{AgBr} + e \rightleftharpoons \text{Ag} + \text{Br}^-$	0.07133	$\text{Am}^{2+} + 2 e \rightleftharpoons \text{Am}$	-1.9
$\text{AgBrO}_3 + e \rightleftharpoons \text{Ag} + \text{BrO}_3^-$	0.546	$\text{Am}^{3+} + 3 e \rightleftharpoons \text{Am}$	-2.048
$\text{Ag}_2\text{C}_2\text{O}_4 + 2 e \rightleftharpoons 2 \text{Ag} + \text{C}_2\text{O}_4^{2-}$	0.4647	$\text{Am}^{3+} + e \rightleftharpoons \text{Am}^{2+}$	-2.3
$\text{AgCl} + e \rightleftharpoons \text{Ag} + \text{Cl}^-$	0.22233	$\text{As} + 3 \text{H}^+ + 3 e \rightleftharpoons \text{AsH}_3$	-0.608
$\text{AgCN} + e \rightleftharpoons \text{Ag} + \text{CN}^-$	-0.017	$\text{As}_2\text{O}_3 + 6 \text{H}^+ + 6 e \rightleftharpoons 2 \text{As} + 3 \text{H}_2\text{O}$	0.234
$\text{Ag}_2\text{CO}_3 + 2 e \rightleftharpoons 2 \text{Ag} + \text{CO}_3^{2-}$	0.47	$\text{HAsO}_2 + 3 \text{H}^+ + 3 e \rightleftharpoons \text{As} + 2 \text{H}_2\text{O}$	0.248
$\text{Ag}_2\text{CrO}_4 + 2 e \rightleftharpoons 2 \text{Ag} + \text{CrO}_4^{2-}$	0.4470	$\text{AsO}_2^- + 2 \text{H}_2\text{O} + 3 e \rightleftharpoons \text{As} + 4 \text{OH}^-$	-0.68
$\text{AgF} + e \rightleftharpoons \text{Ag} + \text{F}^-$	0.779	$\text{H}_3\text{AsO}_4 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{HAsO}_2 + 2 \text{H}_2\text{O}$	0.560
$\text{Ag}_4[\text{Fe}(\text{CN})_6] + 4 e \rightleftharpoons 4 \text{Ag} + [\text{Fe}(\text{CN})_6]^{4-}$	0.1478	$\text{AsO}_4^{3-} + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{AsO}_2^- + 4 \text{OH}^-$	-0.71
$\text{AgI} + e \rightleftharpoons \text{Ag} + \text{I}^-$	-0.15224	$\text{At}_2 + 2 e \rightleftharpoons 2 \text{At}^-$	0.3
$\text{AgIO}_3 + e \rightleftharpoons \text{Ag} + \text{IO}_3^-$	0.354	$\text{Au}^+ + e \rightleftharpoons \text{Au}$	1.692
$\text{Ag}_2\text{MoO}_4 + 2 e \rightleftharpoons 2 \text{Ag} + \text{MoO}_4^{2-}$	0.4573	$\text{Au}^{3+} + 2 e \rightleftharpoons \text{Au}^+$	1.401
$\text{AgNO}_2 + e \rightleftharpoons \text{Ag} + 2 \text{NO}_2^-$	0.564	$\text{Au}^{3+} + 3 e \rightleftharpoons \text{Au}$	1.498
$\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2 e \rightleftharpoons 2 \text{Ag} + 2 \text{OH}^-$	0.342	$\text{Au}^{2+} + e \rightleftharpoons \text{Au}^+$	1.8
$\text{Ag}_2\text{O}_3 + \text{H}_2\text{O} + 2 e \rightleftharpoons 2 \text{AgO} + 2 \text{OH}^-$	0.739	$\text{AuOH}^{2+} + \text{H}^+ + 2 e \rightleftharpoons \text{Au}^+ + \text{H}_2\text{O}$	1.32
$\text{Ag}^{3+} + 2 e \rightleftharpoons \text{Ag}^+$	1.9	$\text{AuBr}_2^- + e \rightleftharpoons \text{Au} + 2 \text{Br}^-$	0.959
$\text{Ag}^{3+} + e \rightleftharpoons \text{Ag}^{2+}$	1.8	$\text{AuBr}_4^- + 3 e \rightleftharpoons \text{Au} + 4 \text{Br}^-$	0.854
$\text{Ag}_2\text{O}_2 + 4 \text{H}^+ + e \rightleftharpoons 2 \text{Ag} + 2 \text{H}_2\text{O}$	1.802	$\text{AuCl}_4^- + 3 e \rightleftharpoons \text{Au} + 4 \text{Cl}^-$	1.002
$2 \text{AgO} + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Ag}_2\text{O} + 2 \text{OH}^-$	0.607	$\text{Au}(\text{OH})_3 + 3 \text{H}^+ + 3 e \rightleftharpoons \text{Au} + 3 \text{H}_2\text{O}$	1.45
$\text{AgOCN} + e \rightleftharpoons \text{Ag} + \text{OCN}^-$	0.41	$\text{H}_2\text{BO}_3^- + 5 \text{H}_2\text{O} + 8 e \rightleftharpoons \text{BH}_4^- + 8 \text{OH}^-$	-1.24
$\text{Ag}_2\text{S} + 2 e \rightleftharpoons 2 \text{Ag} + \text{S}^{2-}$	-0.691	$\text{H}_2\text{BO}_3^- + \text{H}_2\text{O} + 3 e \rightleftharpoons \text{B} + 4 \text{OH}^-$	-1.79
$\text{Ag}_2\text{S} + 2 \text{H}^+ + 2 e \rightleftharpoons 2 \text{Ag} + \text{H}_2\text{S}$	-0.0366	$\text{H}_3\text{BO}_3 + 3 \text{H}^+ + 3 e \rightleftharpoons \text{B} + 3 \text{H}_2\text{O}$	-0.8698
$\text{AgSCN} + e \rightleftharpoons \text{Ag} + \text{SCN}^-$	0.08951	$\text{B}(\text{OH})_3 + 7 \text{H}^+ + 8 e \rightleftharpoons \text{BH}_4^- + 3 \text{H}_2\text{O}$	-0.481
$\text{Ag}_2\text{SeO}_3 + 2 e \rightleftharpoons 2 \text{Ag} + \text{SeO}_4^{2-}$	0.3629	$\text{Ba}^{2+} + 2 e \rightleftharpoons \text{Ba}$	-2.912
$\text{Ag}_2\text{SO}_4 + 2 e \rightleftharpoons 2 \text{Ag} + \text{SO}_4^{2-}$	0.654	$\text{Ba}^{2+} + 2 e \rightleftharpoons \text{Ba}(\text{Hg})$	-1.570
$\text{Ag}_2\text{WO}_4 + 2 e \rightleftharpoons 2 \text{Ag} + \text{WO}_4^{2-}$	0.4660	$\text{Ba}(\text{OH})_2 + 2 e \rightleftharpoons \text{Ba} + 2 \text{OH}^-$	-2.99
$\text{Al}^{3+} + 3 e \rightleftharpoons \text{Al}$	-1.662	$\text{Be}^{2+} + 2 e \rightleftharpoons \text{Be}$	-1.847
$\text{Al}(\text{OH})_3 + 3 e \rightleftharpoons \text{Al} + 3 \text{OH}^-$	-2.31	$\text{Be}_2\text{O}_3^{2-} + 3 \text{H}_2\text{O} + 4 e \rightleftharpoons 2 \text{Be} + 6 \text{OH}^-$	-2.63

**ELECTROCHEMICAL SERIES (continued)**

**TABLE 1**  
**Alphabetical Listing (continued)**

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$p$ -benzoquinone + 2 H <sup>+</sup> + 2 e $\rightleftharpoons$ hydroquinone	0.6992	HClO <sub>2</sub> + 3 H <sup>+</sup> + 4 e $\rightleftharpoons$ Cl <sup>-</sup> + 2 H <sub>2</sub> O	1.570
Bi <sup>+</sup> + e $\rightleftharpoons$ Bi	0.5	ClO <sub>2</sub> <sup>-</sup> + H <sub>2</sub> O + 2 e $\rightleftharpoons$ ClO <sup>-</sup> + 2 OH <sup>-</sup>	0.66
Bi <sup>3+</sup> + 3 e $\rightleftharpoons$ Bi	0.308	ClO <sub>2</sub> <sup>-</sup> + 2 H <sub>2</sub> O + 4 e $\rightleftharpoons$ Cl <sup>-</sup> + 4 OH <sup>-</sup>	0.76
Bi <sup>3+</sup> + 2 e $\rightleftharpoons$ Bi <sup>+</sup>	0.2	ClO <sub>2</sub> (aq) + e $\rightleftharpoons$ ClO <sub>2</sub> <sup>-</sup>	0.954
Bi + 3 H <sup>+</sup> + 3 e $\rightleftharpoons$ BiH <sub>3</sub>	-0.8	ClO <sub>3</sub> <sup>-</sup> + 2 H <sup>+</sup> + e $\rightleftharpoons$ ClO <sub>2</sub> + H <sub>2</sub> O	1.152
BiCl <sub>4</sub> <sup>-</sup> + 3 e $\rightleftharpoons$ Bi + 4 Cl <sup>-</sup>	0.16	ClO <sub>3</sub> <sup>-</sup> + 3 H <sup>+</sup> + 2 e $\rightleftharpoons$ HClO <sub>2</sub> + H <sub>2</sub> O	1.214
Bi <sub>2</sub> O <sub>3</sub> + 3 H <sub>2</sub> O + 6 e $\rightleftharpoons$ 2 Bi + 6 OH <sup>-</sup>	-0.46	ClO <sub>3</sub> <sup>-</sup> + 6 H <sup>+</sup> + 5 e $\rightleftharpoons$ 1/2 Cl <sub>2</sub> + 3 H <sub>2</sub> O	1.47
Bi <sub>2</sub> O <sub>4</sub> + 4 H <sup>+</sup> + 2 e $\rightleftharpoons$ 2 BiO <sup>+</sup> + 2 H <sub>2</sub> O	1.593	ClO <sub>3</sub> <sup>-</sup> + 6 H <sup>+</sup> + 6 e $\rightleftharpoons$ Cl <sup>-</sup> + 3 H <sub>2</sub> O	1.451
BiO <sup>+</sup> + 2 H <sup>+</sup> + 3 e $\rightleftharpoons$ Bi + H <sub>2</sub> O	0.320	ClO <sub>3</sub> <sup>-</sup> + H <sub>2</sub> O + 2 e $\rightleftharpoons$ ClO <sub>2</sub> <sup>-</sup> + 2 OH <sup>-</sup>	0.33
BiOCl + 2 H <sup>+</sup> + 3 e $\rightleftharpoons$ Bi + Cl <sup>-</sup> + H <sub>2</sub> O	0.1583	ClO <sub>3</sub> <sup>-</sup> + 3 H <sub>2</sub> O + 6 e $\rightleftharpoons$ Cl <sup>-</sup> + 6 OH <sup>-</sup>	0.62
Bk <sup>4+</sup> + e $\rightleftharpoons$ Bk <sup>3+</sup>	1.67	ClO <sub>4</sub> <sup>-</sup> + 2 H <sup>+</sup> + 2 e $\rightleftharpoons$ ClO <sub>3</sub> <sup>-</sup> + H <sub>2</sub> O	1.189
Bk <sup>2+</sup> + 2 e $\rightleftharpoons$ Bk	-1.6	ClO <sub>4</sub> <sup>-</sup> + 8 H <sup>+</sup> + 7 e $\rightleftharpoons$ 1/2 Cl <sub>2</sub> + 4 H <sub>2</sub> O	1.39
Bk <sup>3+</sup> + e $\rightleftharpoons$ Bk <sup>2+</sup>	-2.8	ClO <sub>4</sub> <sup>-</sup> + 8 H <sup>+</sup> + 8 e $\rightleftharpoons$ Cl <sup>-</sup> + 4 H <sub>2</sub> O	1.389
Br <sub>2</sub> (aq) + 2 e $\rightleftharpoons$ 2 Br <sup>-</sup>	1.0873	ClO <sub>4</sub> <sup>-</sup> + H <sub>2</sub> O + 2 e $\rightleftharpoons$ ClO <sub>3</sub> <sup>-</sup> + 2 OH <sup>-</sup>	0.36
Br <sub>2</sub> (l) + 2 e $\rightleftharpoons$ 2 Br <sup>-</sup>	1.066	Cm <sup>4+</sup> + e $\rightleftharpoons$ Cm <sup>3+</sup>	3.0
HBrO + H <sup>+</sup> + 2 e $\rightleftharpoons$ Br <sup>-</sup> + H <sub>2</sub> O	1.331	Cm <sup>3+</sup> + 3 e $\rightleftharpoons$ Cm	-2.04
HBrO + H <sup>+</sup> + e $\rightleftharpoons$ 1/2 Br <sub>2</sub> (aq) + H <sub>2</sub> O	1.574	Co <sup>2+</sup> + 2 e $\rightleftharpoons$ Co	-0.28
HBrO + H <sup>+</sup> + e $\rightleftharpoons$ 1/2 Br <sub>2</sub> (l) + H <sub>2</sub> O	1.596	Co <sup>3+</sup> + e $\rightleftharpoons$ Co <sup>2+</sup>	1.92
BrO <sup>-</sup> + H <sub>2</sub> O + 2 e $\rightleftharpoons$ Br <sup>-</sup> + 2 OH <sup>-</sup>	0.761	[Co(NH <sub>3</sub> ) <sub>6</sub> ] <sup>3+</sup> + e $\rightleftharpoons$ [Co(NH <sub>3</sub> ) <sub>6</sub> ] <sup>2+</sup>	0.108
BrO <sub>3</sub> <sup>-</sup> + 6 H <sup>+</sup> + 5 e $\rightleftharpoons$ 1/2 Br <sub>2</sub> + 3 H <sub>2</sub> O	1.482	Co(OH) <sub>2</sub> + 2 e $\rightleftharpoons$ Co + 2 OH <sup>-</sup>	-0.73
BrO <sub>3</sub> <sup>-</sup> + 6 H <sup>+</sup> + 6 e $\rightleftharpoons$ Br <sup>-</sup> + 3 H <sub>2</sub> O	1.423	Co(OH) <sub>3</sub> + e $\rightleftharpoons$ Co(OH) <sub>2</sub> + OH <sup>-</sup>	0.17
BrO <sub>3</sub> <sup>-</sup> + 3 H <sub>2</sub> O + 6 e $\rightleftharpoons$ Br <sup>-</sup> + 6 OH <sup>-</sup>	0.61	Cr <sup>2+</sup> + 2 e $\rightleftharpoons$ Cr	-0.913
(CN) <sub>2</sub> + 2 H <sup>+</sup> + 2 e $\rightleftharpoons$ 2 HCN	0.373	Cr <sup>3+</sup> + e $\rightleftharpoons$ Cr <sup>2+</sup>	-0.407
2 HCNO + 2 H <sup>+</sup> + 2 e $\rightleftharpoons$ (CN) <sub>2</sub> + 2 H <sub>2</sub> O	0.330	Cr <sup>3+</sup> + 3 e $\rightleftharpoons$ Cr	-0.744
(CNS) <sub>2</sub> + 2 e $\rightleftharpoons$ 2 CNS <sup>-</sup>	0.77	Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> + 14 H <sup>+</sup> + 6 e $\rightleftharpoons$ 2 Cr <sup>3+</sup> + 7 H <sub>2</sub> O	1.232
CO <sub>2</sub> + 2 H <sup>+</sup> + 2 e $\rightleftharpoons$ HCOOH	-0.199	CrO <sub>2</sub> + 2 H <sub>2</sub> O + 3 e $\rightleftharpoons$ Cr + 4 OH <sup>-</sup>	-1.2
Ca <sup>+</sup> + e $\rightleftharpoons$ Ca	-3.80	HCrO <sub>4</sub> <sup>-</sup> + 7 H <sup>+</sup> + 3 e $\rightleftharpoons$ Cr <sup>3+</sup> + 4 H <sub>2</sub> O	1.350
Ca <sup>2+</sup> + 2 e $\rightleftharpoons$ Ca	-2.868	CrO <sub>2</sub> + 4 H <sup>+</sup> + e $\rightleftharpoons$ Cr <sup>3+</sup> + 2 H <sub>2</sub> O	1.48
Ca(OH) <sub>2</sub> + 2 e $\rightleftharpoons$ Ca + 2 OH <sup>-</sup>	-3.02	Cr(V) + e $\rightleftharpoons$ Cr(IV)	1.34
Calomel electrode, 1 molal KCl	0.2800	CrO <sub>4</sub> <sup>2-</sup> + 4 H <sub>2</sub> O + 3 e $\rightleftharpoons$ Cr(OH) <sub>3</sub> + 5 OH <sup>-</sup>	-0.13
Calomel electrode, 1 molar KCl (NCE)	0.2801	Cr(OH) <sub>3</sub> + 3 e $\rightleftharpoons$ Cr + 3 OH <sup>-</sup>	-1.48
Calomel electrode, 0.1 molar KCl	0.3337	Cs <sup>+</sup> + e $\rightleftharpoons$ Cs	-3.026
Calomel electrode, saturated KCl (SCE)	0.2412	Cu <sup>+</sup> + e $\rightleftharpoons$ Cu	0.521
Calomel electrode, saturated NaCl (SSCE)	0.2360	Cu <sup>2+</sup> + e $\rightleftharpoons$ Cu <sup>+</sup>	0.153
Cd <sup>2+</sup> + 2 e $\rightleftharpoons$ Cd	-0.4030	Cu <sup>2+</sup> + 2 e $\rightleftharpoons$ Cu	0.3419
Cd <sup>2+</sup> + 2 e $\rightleftharpoons$ Cd(Hg)	-0.3521	Cu <sup>2+</sup> + 2 e $\rightleftharpoons$ Cu(Hg)	0.345
Cd(OH) <sub>2</sub> + 2 e $\rightleftharpoons$ Cd(Hg) + 2 OH <sup>-</sup>	-0.809	Cu <sup>3+</sup> + e $\rightleftharpoons$ Cu <sup>2+</sup>	2.4
CdSO <sub>4</sub> + 2 e $\rightleftharpoons$ Cd + SO <sub>4</sub> <sup>2-</sup>	-0.246	Cu <sub>2</sub> O <sub>3</sub> + 6 H <sup>+</sup> + 2 e $\rightleftharpoons$ 2 Cu <sup>2+</sup> + 3 H <sub>2</sub> O	2.0
Cd(OH) <sub>4</sub> <sup>2-</sup> + 2 e $\rightleftharpoons$ Cd + 4 OH <sup>-</sup>	-0.658	Cu <sup>2+</sup> + 2 CN <sup>-</sup> + e $\rightleftharpoons$ [Cu(CN) <sub>2</sub> ] <sup>-</sup>	1.103
CdO + H <sub>2</sub> O + 2 e $\rightleftharpoons$ Cd + 2 OH <sup>-</sup>	-0.783	CuI <sub>2</sub> <sup>-</sup> + e $\rightleftharpoons$ Cu + 2 I <sup>-</sup>	0.00
Ce <sup>3+</sup> + 3 e $\rightleftharpoons$ Ce	-2.336	Cu <sub>2</sub> O + H <sub>2</sub> O + 2 e $\rightleftharpoons$ 2 Cu + 2 OH <sup>-</sup>	-0.360
Ce <sup>3+</sup> + 3 e $\rightleftharpoons$ Ce(Hg)	-1.4373	Cu(OH) <sub>2</sub> + 2 e $\rightleftharpoons$ Cu + 2 OH <sup>-</sup>	-0.222
Ce <sup>4+</sup> + e $\rightleftharpoons$ Ce <sup>3+</sup>	1.72	2 Cu(OH) <sub>2</sub> + 2 e $\rightleftharpoons$ Cu <sub>2</sub> O + 2 OH <sup>-</sup> + H <sub>2</sub> O	-0.080
CeOH <sup>3+</sup> + H <sup>+</sup> + e $\rightleftharpoons$ Ce <sup>3+</sup> + H <sub>2</sub> O	1.715	2 D <sup>+</sup> + 2 e $\rightleftharpoons$ D <sub>2</sub>	-0.013
Cf <sup>4+</sup> + e $\rightleftharpoons$ Cf <sup>3+</sup>	3.3	Dy <sup>2+</sup> + 2 e $\rightleftharpoons$ Dy	-2.2
Cf <sup>3+</sup> + e $\rightleftharpoons$ Cf <sup>2+</sup>	-1.6	Dy <sup>3+</sup> + 3 e $\rightleftharpoons$ Dy	-2.295
Cf <sup>3+</sup> + 3 e $\rightleftharpoons$ Cf	-1.94	Dy <sup>3+</sup> + e $\rightleftharpoons$ Dy <sup>2+</sup>	-2.6
Cf <sup>2+</sup> + 2 e $\rightleftharpoons$ Cf	-2.12	Er <sup>2+</sup> + 2 e $\rightleftharpoons$ Er	-2.0
Cl <sub>2</sub> (g) + 2 e $\rightleftharpoons$ 2 Cl <sup>-</sup>	1.35827	Er <sup>3+</sup> + 3 e $\rightleftharpoons$ Er	-2.331
HClO + H <sup>+</sup> + e $\rightleftharpoons$ 1/2 Cl <sub>2</sub> + H <sub>2</sub> O	1.611	Er <sup>3+</sup> + e $\rightleftharpoons$ Er <sup>2+</sup>	-3.0
HClO + H <sup>+</sup> + 2 e $\rightleftharpoons$ Cl <sup>-</sup> + H <sub>2</sub> O	1.482	Es <sup>3+</sup> + e $\rightleftharpoons$ Es <sup>2+</sup>	-1.3
ClO <sup>-</sup> + H <sub>2</sub> O + 2 e $\rightleftharpoons$ Cl <sup>-</sup> + 2 OH <sup>-</sup>	0.81	Es <sup>3+</sup> + 3 e $\rightleftharpoons$ Es	-1.91
ClO <sub>2</sub> + H <sup>+</sup> + e $\rightleftharpoons$ HClO <sub>2</sub>	1.277	Es <sup>2+</sup> + 2 e $\rightleftharpoons$ Es	-2.23
HClO <sub>2</sub> + 2 H <sup>+</sup> + 2 e $\rightleftharpoons$ HClO + H <sub>2</sub> O	1.645	Eu <sup>2+</sup> + 2 e $\rightleftharpoons$ Eu	-2.812
HClO <sub>2</sub> + 3 H <sup>+</sup> + 3 e $\rightleftharpoons$ 1/2 Cl <sub>2</sub> + 2 H <sub>2</sub> O	1.628	Eu <sup>3+</sup> + 3 e $\rightleftharpoons$ Eu	-1.991

ELECTROCHEMICAL SERIES (continued)

TABLE 1  
Alphabetical Listing (continued)

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$\text{Eu}^{3+} + e \rightleftharpoons \text{Eu}^{2+}$	-0.36	$\text{Ho}^{3+} + 3 e \rightleftharpoons \text{Ho}$	-2.33
$\text{F}_2 + 2 \text{H}^+ + 2 e \rightleftharpoons 2 \text{HF}$	3.053	$\text{Ho}^{3+} + e \rightleftharpoons \text{Ho}^{2+}$	-2.8
$\text{F}_2 + 2 e \rightleftharpoons 2 \text{F}^-$	2.866	$\text{I}_2 + 2 e \rightleftharpoons 2 \text{I}^-$	0.5355
$\text{F}_2\text{O} + 2 \text{H}^+ + 4 e \rightleftharpoons \text{H}_2\text{O} + 2 \text{F}^-$	2.153	$\text{I}_3^- + 2 e \rightleftharpoons 3 \text{I}^-$	0.536
$\text{Fe}^{2+} + 2 e \rightleftharpoons \text{Fe}$	-0.447	$\text{H}_3\text{IO}_6^{2-} + 2 e \rightleftharpoons \text{IO}_3^- + 3 \text{OH}^-$	0.7
$\text{Fe}^{3+} + 3 e \rightleftharpoons \text{Fe}$	-0.037	$\text{H}_3\text{IO}_6 + \text{H}^+ + 2 e \rightleftharpoons \text{IO}_3^- + 3 \text{H}_2\text{O}$	1.601
$\text{Fe}^{3+} + e \rightleftharpoons \text{Fe}^{2+}$	0.771	$2 \text{HIO} + 2 \text{H}^+ + 2 e \rightleftharpoons \text{I}_2 + 2 \text{H}_2\text{O}$	1.439
$2 \text{HFeO}_4^- + 8 \text{H}^+ + 6 e \rightleftharpoons \text{Fe}_2\text{O}_3 + 5 \text{H}_2\text{O}$	2.09	$\text{HIO} + \text{H}^+ + 2 e \rightleftharpoons \text{I}^- + \text{H}_2\text{O}$	0.987
$\text{HFeO}_4^- + 4 \text{H}^+ + 3 e \rightleftharpoons \text{FeOOH} + 2 \text{H}_2\text{O}$	2.08	$\text{IO}^- + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{I}^- + 2 \text{OH}^-$	0.485
$\text{HFeO}_4^- + 7 \text{H}^+ + 3 e \rightleftharpoons \text{Fe}^{3+} + 4 \text{H}_2\text{O}$	2.07	$2 \text{IO}_3^- + 12 \text{H}^+ + 10 e \rightleftharpoons \text{I}_2 + 6 \text{H}_2\text{O}$	1.195
$\text{Fe}_2\text{O}_3 + 4 \text{H}^+ + 2 e \rightleftharpoons 2 \text{FeOH}^+ + \text{H}_2\text{O}$	0.16	$\text{IO}_3^- + 6 \text{H}^+ + 6 e \rightleftharpoons \text{I}^- + 3 \text{H}_2\text{O}$	1.085
$[\text{Fe}(\text{CN})_6]^{3-} + e \rightleftharpoons [\text{Fe}(\text{CN})_6]^{4-}$	0.358	$\text{IO}_3^- + 2 \text{H}_2\text{O} + 4 e \rightleftharpoons \text{IO}^- + 4 \text{OH}^-$	0.15
$\text{FeO}_4^{2-} + 8 \text{H}^+ + 3 e \rightleftharpoons \text{Fe}^{3+} + 4 \text{H}_2\text{O}$	2.20	$\text{IO}_3^- + 3 \text{H}_2\text{O} + 6 e \rightleftharpoons \text{IO}^- + 6 \text{OH}^-$	0.26
$[\text{Fe}(\text{bipy})_2]^{3+} + e \rightleftharpoons [\text{Fe}(\text{bipy})_2]^{2+}$	0.78	$\text{In}^+ + e \rightleftharpoons \text{In}$	-0.14
$[\text{Fe}(\text{bipy})_3]^{3+} + e \rightleftharpoons [\text{Fe}(\text{bipy})_3]^{2+}$	1.03	$\text{In}^{2+} + e \rightleftharpoons \text{In}^+$	-0.40
$\text{Fe}(\text{OH})_3 + e \rightleftharpoons \text{Fe}(\text{OH})_2 + \text{OH}^-$	-0.56	$\text{In}^{3+} + e \rightleftharpoons \text{In}^{2+}$	-0.49
$[\text{Fe}(\text{phen})_3]^{3+} + e \rightleftharpoons [\text{Fe}(\text{phen})_3]^{2+}$	1.147	$\text{In}^{3+} + 2 e \rightleftharpoons \text{In}^+$	-0.443
$[\text{Fe}(\text{phen})_3]^{3+} + e \rightleftharpoons [\text{Fe}(\text{phen})_3]^{2+}$ (1 molar $\text{H}_2\text{SO}_4$ )	1.06	$\text{In}^{3+} + 3 e \rightleftharpoons \text{In}$	-0.3382
$[\text{Ferrocenium}]^+ + e \rightleftharpoons \text{ferrocene}$	0.400	$\text{In}(\text{OH})_3 + 3 e \rightleftharpoons \text{In} + 3 \text{OH}^-$	-0.99
$\text{Fm}^{3+} + e \rightleftharpoons \text{Fm}^{2+}$	-1.1	$\text{In}(\text{OH})_4^- + 3 e \rightleftharpoons \text{In} + 4 \text{OH}^-$	-1.007
$\text{Fm}^{3+} + 3 e \rightleftharpoons \text{Fm}$	-1.89	$\text{In}_2\text{O}_3 + 3 \text{H}_2\text{O} + 6 e \rightleftharpoons 2 \text{In} + 6 \text{OH}^-$	-1.034
$\text{Fm}^{2+} + 2 e \rightleftharpoons \text{Fm}$	-2.30	$\text{Ir}^{3+} + 3 e \rightleftharpoons \text{Ir}$	1.156
$\text{Fr}^+ + e \rightleftharpoons \text{Fr}$	-2.9	$[\text{IrCl}_6]^{2-} + e \rightleftharpoons [\text{IrCl}_6]^{3-}$	0.8665
$\text{Ga}^{3+} + 3 e \rightleftharpoons \text{Ga}$	-0.549	$[\text{IrCl}_6]^{3-} + 3 e \rightleftharpoons \text{Ir} + 6 \text{Cl}^-$	0.77
$\text{Ga}^+ + e \rightleftharpoons \text{Ga}$	-0.2	$\text{Ir}_2\text{O}_3 + 3 \text{H}_2\text{O} + 6 e \rightleftharpoons 2 \text{Ir} + 6 \text{OH}^-$	0.098
$\text{GaOH}^{2+} + \text{H}^+ + 3 e \rightleftharpoons \text{Ga} + \text{H}_2\text{O}$	-0.498	$\text{K}^+ + e \rightleftharpoons \text{K}$	-2.931
$\text{H}_2\text{GaO}_3 + \text{H}_2\text{O} + 3 e \rightleftharpoons \text{Ga} + 4 \text{OH}^-$	-1.219	$\text{La}^{3+} + 3 e \rightleftharpoons \text{La}$	-2.379
$\text{Gd}^{3+} + 3 e \rightleftharpoons \text{Gd}$	-2.279	$\text{La}(\text{OH})_3 + 3 e \rightleftharpoons \text{La} + 3 \text{OH}^-$	-2.90
$\text{Ge}^{2+} + 2 e \rightleftharpoons \text{Ge}$	0.24	$\text{Li}^+ + e \rightleftharpoons \text{Li}$	-3.0401
$\text{Ge}^{4+} + 4 e \rightleftharpoons \text{Ge}$	0.124	$\text{Lr}^{3+} + 3 e \rightleftharpoons \text{Lr}$	-1.96
$\text{Ge}^{4+} + 2 e \rightleftharpoons \text{Ge}^{2+}$	0.00	$\text{Lu}^{3+} + 3 e \rightleftharpoons \text{Lu}$	-2.28
$\text{GeO}_2 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{GeO} + \text{H}_2\text{O}$	-0.118	$\text{Md}^{3+} + e \rightleftharpoons \text{Md}^{2+}$	-0.1
$\text{H}_2\text{GeO}_3 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Ge} + 3 \text{H}_2\text{O}$	-0.182	$\text{Md}^{3+} + 3 e \rightleftharpoons \text{Md}$	-1.65
$2 \text{H}^+ + 2 e \rightleftharpoons \text{H}_2$	0.00000	$\text{Md}^{2+} + 2 e \rightleftharpoons \text{Md}$	-2.40
$\text{H}_2 + 2 e \rightleftharpoons 2 \text{H}^-$	-2.23	$\text{Mg}^+ + e \rightleftharpoons \text{Mg}$	-2.70
$\text{HO}_2 + \text{H}^+ + e \rightleftharpoons \text{H}_2\text{O}_2$	1.495	$\text{Mg}^{2+} + 2 e \rightleftharpoons \text{Mg}$	-2.372
$2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{H}_2 + 2 \text{OH}^-$	-0.8277	$\text{Mg}(\text{OH})_2 + 2 e \rightleftharpoons \text{Mg} + 2 \text{OH}^-$	-2.690
$\text{H}_2\text{O}_2 + 2 \text{H}^+ + 2 e \rightleftharpoons 2 \text{H}_2\text{O}$	1.776	$\text{Mn}^{2+} + 2 e \rightleftharpoons \text{Mn}$	-1.185
$\text{Hf}^{4+} + 4 e \rightleftharpoons \text{Hf}$	-1.55	$\text{Mn}^{3+} + 3 e \rightleftharpoons \text{Mn}^{2+}$	1.5415
$\text{HfO}^{2+} + 2 \text{H}^+ + 4 e \rightleftharpoons \text{Hf} + \text{H}_2\text{O}$	-1.724	$\text{MnO}_2 + 4 \text{H}^+ + 2 e \rightleftharpoons \text{Mn}^{2+} + 2 \text{H}_2\text{O}$	1.224
$\text{HfO}_2 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Hf} + 2 \text{H}_2\text{O}$	-1.505	$\text{MnO}_4^- + e \rightleftharpoons \text{MnO}_4^{2-}$	0.558
$\text{HfO}(\text{OH})_2 + \text{H}_2\text{O} + 4 e \rightleftharpoons \text{Hf} + 4 \text{OH}^-$	-2.50	$\text{MnO}_4^- + 4 \text{H}^+ + 3 e \rightleftharpoons \text{MnO}_2 + 2 \text{H}_2\text{O}$	1.679
$\text{Hg}^{2+} + 2 e \rightleftharpoons \text{Hg}$	0.851	$\text{MnO}_4^- + 8 \text{H}^+ + 5 e \rightleftharpoons \text{Mn}^{2+} + 4 \text{H}_2\text{O}$	1.507
$2 \text{Hg}^{2+} + 2 e \rightleftharpoons \text{Hg}_2^{2+}$	0.920	$\text{MnO}_4^- + 2 \text{H}_2\text{O} + 3 e \rightleftharpoons \text{MnO}_2 + 4 \text{OH}^-$	0.595
$\text{Hg}_2^{2+} + 2 e \rightleftharpoons 2 \text{Hg}$	0.7973	$\text{MnO}_4^{2-} + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{MnO}_2 + 4 \text{OH}^-$	0.60
$\text{Hg}_2(\text{ac})_2 + 2 e \rightleftharpoons 2 \text{Hg} + 2(\text{ac})^-$	0.51163	$\text{Mn}(\text{OH})_2 + 2 e \rightleftharpoons \text{Mn} + 2 \text{OH}^-$	-1.56
$\text{Hg}_2\text{Br}_2 + 2 e \rightleftharpoons 2 \text{Hg} + 2 \text{Br}^-$	0.13923	$\text{Mn}(\text{OH})_3 + e \rightleftharpoons \text{Mn}(\text{OH})_2 + \text{OH}^-$	0.15
$\text{Hg}_2\text{Cl}_2 + 2 e \rightleftharpoons 2 \text{Hg} + 2 \text{Cl}^-$	0.26808	$\text{Mn}_2\text{O}_3 + 6 \text{H}^+ + e \rightleftharpoons 2 \text{Mn}^{2+} + 3 \text{H}_2\text{O}$	1.485
$\text{Hg}_2\text{HPO}_4 + 2 e \rightleftharpoons 2 \text{Hg} + \text{HPO}_4^{2-}$	0.6359	$\text{Mo}^{3+} + 3 e \rightleftharpoons \text{Mo}$	-0.200
$\text{Hg}_2\text{I}_2 + 2 e \rightleftharpoons 2 \text{Hg} + 2 \text{I}^-$	-0.0405	$\text{MoO}_2 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Mo} + 4 \text{H}_2\text{O}$	-0.152
$\text{Hg}_2\text{O} + \text{H}_2\text{O} + 2 e \rightleftharpoons 2 \text{Hg} + 2 \text{OH}^-$	0.123	$\text{H}_3\text{Mo}_7\text{O}_{24}^{3-} + 45 \text{H}^+ + 42 e \rightleftharpoons 7 \text{Mo} + 24 \text{H}_2\text{O}$	0.082
$\text{HgO} + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Hg} + 2 \text{OH}^-$	0.0977	$\text{MoO}_3 + 6 \text{H}^+ + 6 e \rightleftharpoons \text{Mo} + 3 \text{H}_2\text{O}$	0.075
$\text{Hg}(\text{OH})_2 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{Hg} + 2 \text{H}_2\text{O}$	1.034	$\text{N}_2 + 2 \text{H}_2\text{O} + 6 \text{H}^+ + 6 e \rightleftharpoons 2 \text{NH}_4\text{OH}$	0.092
$\text{Hg}_2\text{SO}_4 + 2 e \rightleftharpoons 2 \text{Hg} + \text{SO}_4^{2-}$	0.6125	$3 \text{N}_2 + 2 \text{H}^+ + 2 e \rightleftharpoons 2 \text{HN}_3$	-3.09
$\text{Ho}^{2+} + 2 e \rightleftharpoons \text{Ho}$	-2.1	$\text{N}_5^+ + 3 \text{H}^+ + 2 e \rightleftharpoons 2 \text{NH}_4^+$	1.275

**ELECTROCHEMICAL SERIES (continued)**

**TABLE 1**  
**Alphabetical Listing (continued)**

Reaction	<i>E</i> <sup>o</sup> / <i>V</i>	Reaction	<i>E</i> <sup>o</sup> / <i>V</i>
N <sub>2</sub> O + 2 H <sup>+</sup> + 2 e ⇌ N <sub>2</sub> + H <sub>2</sub> O	1.766	H <sub>2</sub> P <sub>2</sub> <sup>-</sup> + e ⇌ P + 2 OH <sup>-</sup>	-1.82
H <sub>2</sub> N <sub>2</sub> O <sub>2</sub> + 2 H <sup>+</sup> + 2 e ⇌ N <sub>2</sub> + 2 H <sub>2</sub> O	2.65	H <sub>3</sub> PO <sub>2</sub> + H <sup>+</sup> + e ⇌ P + 2 H <sub>2</sub> O	-0.508
N <sub>2</sub> O <sub>4</sub> + 2 e ⇌ 2 NO <sub>2</sub> <sup>-</sup>	0.867	H <sub>3</sub> PO <sub>3</sub> + 2 H <sup>+</sup> + 2 e ⇌ H <sub>3</sub> PO <sub>2</sub> + H <sub>2</sub> O	-0.499
N <sub>2</sub> O <sub>4</sub> + 2 H <sup>+</sup> + 2 e ⇌ 2 NHO <sub>2</sub>	1.065	H <sub>3</sub> PO <sub>3</sub> + 3 H <sup>+</sup> + 3 e ⇌ P + 3 H <sub>2</sub> O	-0.454
N <sub>2</sub> O <sub>4</sub> + 4 H <sup>+</sup> + 4 e ⇌ 2 NO + 2 H <sub>2</sub> O	1.035	HPO <sub>3</sub> <sup>2-</sup> + 2 H <sub>2</sub> O + 2 e ⇌ H <sub>2</sub> PO <sub>2</sub> <sup>-</sup> + 3 OH <sup>-</sup>	-1.65
2 NH <sub>3</sub> OH <sup>+</sup> + H <sup>+</sup> + 2 e ⇌ N <sub>2</sub> H <sub>5</sub> <sup>+</sup> + 2 H <sub>2</sub> O	1.42	HPO <sub>3</sub> <sup>2-</sup> + 2 H <sub>2</sub> O + 3 e ⇌ P + 5 OH <sup>-</sup>	-1.71
2 NO + 2 H <sup>+</sup> + 2 e ⇌ N <sub>2</sub> O + H <sub>2</sub> O	1.591	H <sub>3</sub> PO <sub>4</sub> + 2 H <sup>+</sup> + 2 e ⇌ H <sub>3</sub> PO <sub>3</sub> + H <sub>2</sub> O	-0.276
2 NO + H <sub>2</sub> O + 2 e ⇌ N <sub>2</sub> O + 2 OH <sup>-</sup>	0.76	PO <sub>3</sub> <sup>3-</sup> + 2 H <sub>2</sub> O + 2 e ⇌ HPO <sub>3</sub> <sup>2-</sup> + 3 OH <sup>-</sup>	-1.05
HNO <sub>2</sub> + H <sup>+</sup> + e ⇌ NO + H <sub>2</sub> O	0.983	Pa <sup>3+</sup> + 3 e ⇌ Pa	-1.34
2 HNO <sub>2</sub> + 4 H <sup>+</sup> + 4 e ⇌ H <sub>2</sub> N <sub>2</sub> O <sub>2</sub> + 2 H <sub>2</sub> O	0.86	Pa <sup>4+</sup> + 4 e ⇌ Pa	-1.49
2 HNO <sub>2</sub> + 4 H <sup>+</sup> + 4 e ⇌ N <sub>2</sub> O + 3 H <sub>2</sub> O	1.297	Pa <sup>4+</sup> + e ⇌ Pa <sup>3+</sup>	-1.9
NO <sub>2</sub> <sup>-</sup> + H <sub>2</sub> O + e ⇌ NO + 2 OH <sup>-</sup>	-0.46	Pb <sup>2+</sup> + 2 e ⇌ Pb	-0.1262
2 NO <sub>2</sub> <sup>-</sup> + 2 H <sub>2</sub> O + 4 e ⇌ N <sub>2</sub> O <sub>2</sub> <sup>2-</sup> + 4 OH <sup>-</sup>	-0.18	Pb <sup>2+</sup> + 2 e ⇌ Pb(Hg)	-0.1205
2 NO <sub>2</sub> <sup>-</sup> + 3 H <sub>2</sub> O + 4 e ⇌ N <sub>2</sub> O + 6 OH <sup>-</sup>	0.15	PbBr <sub>2</sub> + 2 e ⇌ Pb + 2 Br <sup>-</sup>	-0.284
NO <sub>3</sub> <sup>-</sup> + 3 H <sup>+</sup> + 2 e ⇌ HNO <sub>2</sub> + H <sub>2</sub> O	0.934	PbCl <sub>2</sub> + 2 e ⇌ Pb + 2 Cl <sup>-</sup>	-0.2675
NO <sub>3</sub> <sup>-</sup> + 4 H <sup>+</sup> + 3 e ⇌ NO + 2 H <sub>2</sub> O	0.957	PbF <sub>2</sub> + 2 e ⇌ Pb + 2 F <sup>-</sup>	-0.3444
2 NO <sub>3</sub> <sup>-</sup> + 4 H <sup>+</sup> + 2 e ⇌ N <sub>2</sub> O <sub>4</sub> + 2 H <sub>2</sub> O	0.803	PbHPO <sub>4</sub> + 2 e ⇌ Pb + HPO <sub>4</sub> <sup>2-</sup>	-0.465
NO <sub>3</sub> <sup>-</sup> + H <sub>2</sub> O + 2 e ⇌ NO <sub>2</sub> <sup>-</sup> + 2 OH <sup>-</sup>	0.01	PbI <sub>2</sub> + 2 e ⇌ Pb + 2 I <sup>-</sup>	-0.365
2 NO <sub>3</sub> <sup>-</sup> + 2 H <sub>2</sub> O + 2 e ⇌ N <sub>2</sub> O <sub>4</sub> + 4 OH <sup>-</sup>	-0.85	PbO + H <sub>2</sub> O + 2 e ⇌ Pb + 2 OH <sup>-</sup>	-0.580
Na <sup>+</sup> + e ⇌ Na	-2.71	PbO <sub>2</sub> + 4 H <sup>+</sup> + 2 e ⇌ Pb <sup>2+</sup> + 2 H <sub>2</sub> O	1.455
Nb <sup>3+</sup> + 3 e ⇌ Nb	-1.099	HPbO <sub>2</sub> <sup>-</sup> + H <sub>2</sub> O + 2 e ⇌ Pb + 3 OH <sup>-</sup>	-0.537
NbO <sub>2</sub> + 2 H <sup>+</sup> + 2 e ⇌ NbO + H <sub>2</sub> O	-0.646	PbO <sub>2</sub> + H <sub>2</sub> O + 2 e ⇌ PbO + 2 OH <sup>-</sup>	0.247
NbO <sub>2</sub> + 4 H <sup>+</sup> + 4 e ⇌ Nb + 2 H <sub>2</sub> O	-0.690	PbO <sub>2</sub> + SO <sub>4</sub> <sup>2-</sup> + 4 H <sup>+</sup> + 2 e ⇌ PbSO <sub>4</sub> + 2 H <sub>2</sub> O	1.6913
NbO + 2 H <sup>+</sup> + 2 e ⇌ Nb + H <sub>2</sub> O	-0.733	PbSO <sub>4</sub> + 2 e ⇌ Pb + SO <sub>4</sub> <sup>2-</sup>	-0.3588
Nb <sub>2</sub> O <sub>5</sub> + 10 H <sup>+</sup> + 10 e ⇌ 2 Nb + 5 H <sub>2</sub> O	-0.644	PbSO <sub>4</sub> + 2 e ⇌ Pb(Hg) + SO <sub>4</sub> <sup>2-</sup>	-0.3505
Nd <sup>3+</sup> + 3 e ⇌ Nd	-2.323	Pd <sup>2+</sup> + 2 e ⇌ Pd	0.951
Nd <sup>2+</sup> + 2 e ⇌ Nd	-2.1	[PdCl <sub>4</sub> ] <sup>2-</sup> + 2 e ⇌ Pd + 4 Cl <sup>-</sup>	0.591
Nd <sup>3+</sup> + e ⇌ Nd <sup>2+</sup>	-2.7	[PdCl <sub>6</sub> ] <sup>2-</sup> + 2 e ⇌ [PdCl <sub>4</sub> ] <sup>2-</sup> + 2 Cl <sup>-</sup>	1.288
Ni <sup>2+</sup> + 2 e ⇌ Ni	-0.257	Pd(OH) <sub>2</sub> + 2 e ⇌ Pd + 2 OH <sup>-</sup>	0.07
Ni(OH) <sub>2</sub> + 2 e ⇌ Ni + 2 OH <sup>-</sup>	-0.72	Pm <sup>2+</sup> + 2 e ⇌ Pm	-2.2
NiO <sub>2</sub> + 4 H <sup>+</sup> + 2 e ⇌ Ni <sup>2+</sup> + 2 H <sub>2</sub> O	1.678	Pm <sup>3+</sup> + 3 e ⇌ Pm	-2.30
NiO <sub>2</sub> + 2 H <sub>2</sub> O + 2 e ⇌ Ni(OH) <sub>2</sub> + 2 OH <sup>-</sup>	-0.490	Pm <sup>3+</sup> + e ⇌ Pm <sup>2+</sup>	-2.6
No <sup>3+</sup> + e ⇌ No <sup>2+</sup>	1.4	Po <sup>4+</sup> + 2 e ⇌ Po <sup>2+</sup>	0.9
No <sup>3+</sup> + 3 e ⇌ No	-1.20	Po <sup>4+</sup> + 4 e ⇌ Po	0.76
No <sup>2+</sup> + 2 e ⇌ No	-2.50	Pr <sup>4+</sup> + e ⇌ Pr <sup>3+</sup>	3.2
Np <sup>3+</sup> + 3 e ⇌ Np	-1.856	Pr <sup>2+</sup> + 2 e ⇌ Pr	-2.0
Np <sup>4+</sup> + e ⇌ Np <sup>3+</sup>	0.147	Pr <sup>3+</sup> + 3 e ⇌ Pr	-2.353
NpO <sub>2</sub> + H <sub>2</sub> O + H <sup>+</sup> + e ⇌ Np(OH) <sub>3</sub>	-0.962	Pr <sup>3+</sup> + e ⇌ Pr <sup>2+</sup>	-3.1
O <sub>2</sub> + 2 H <sup>+</sup> + 2 e ⇌ H <sub>2</sub> O <sub>2</sub>	0.695	Pt <sup>2+</sup> + 2 e ⇌ Pt	1.18
O <sub>2</sub> + 4 H <sup>+</sup> + 4 e ⇌ 2 H <sub>2</sub> O	1.229	[PtCl <sub>4</sub> ] <sup>2-</sup> + 2 e ⇌ Pt + 4 Cl <sup>-</sup>	0.755
O <sub>2</sub> + H <sub>2</sub> O + 2 e ⇌ HO <sub>2</sub> <sup>-</sup> + OH <sup>-</sup>	-0.076	[PtCl <sub>6</sub> ] <sup>2-</sup> + 2 e ⇌ [PtCl <sub>4</sub> ] <sup>2-</sup> + 2 Cl <sup>-</sup>	0.68
O <sub>2</sub> + 2 H <sub>2</sub> O + 2 e ⇌ H <sub>2</sub> O <sub>2</sub> + 2 OH <sup>-</sup>	-0.146	Pt(OH) <sub>2</sub> + 2 e ⇌ Pt + 2 OH <sup>-</sup>	0.14
O <sub>2</sub> + 2 H <sub>2</sub> O + 4 e ⇌ 4 OH <sup>-</sup>	0.401	PtO <sub>3</sub> + 2 H <sup>+</sup> + 2 e ⇌ PtO <sub>2</sub> + H <sub>2</sub> O	1.7
O <sub>3</sub> + 2 H <sup>+</sup> + 2 e ⇌ O <sub>2</sub> + H <sub>2</sub> O	2.076	PtO <sub>3</sub> + 4 H <sup>+</sup> + 2 e ⇌ Pt(OH) <sub>2</sub> <sup>2+</sup> + H <sub>2</sub> O	1.5
O <sub>3</sub> + H <sub>2</sub> O + 2 e ⇌ O <sub>2</sub> + 2 OH <sup>-</sup>	1.24	PtOH <sup>+</sup> + H <sup>+</sup> + 2 e ⇌ Pt + H <sub>2</sub> O	1.2
O(g) + 2 H <sup>+</sup> + 2 e ⇌ H <sub>2</sub> O	2.421	PtO <sub>2</sub> + 2 H <sup>+</sup> + 2 e ⇌ PtO + H <sub>2</sub> O	1.01
OH + e ⇌ OH <sup>-</sup>	2.02	PtO <sub>2</sub> + 4 H <sup>+</sup> + 4 e ⇌ Pt + 2 H <sub>2</sub> O	1.00
HO <sub>2</sub> <sup>-</sup> + H <sub>2</sub> O + 2 e ⇌ 3 OH <sup>-</sup>	0.878	Pu <sup>3+</sup> + 3 e ⇌ Pu	-2.031
OsO <sub>4</sub> + 8 H <sup>+</sup> + 8 e ⇌ Os + 4 H <sub>2</sub> O	0.838	Pu <sup>4+</sup> + e ⇌ Pu <sup>3+</sup>	1.006
OsO <sub>4</sub> + 4 H <sup>+</sup> + 4 e ⇌ OsO <sub>2</sub> + 2 H <sub>2</sub> O	1.02	Pu <sup>5+</sup> + e ⇌ Pu <sup>4+</sup>	1.099
[Os(bipy) <sub>2</sub> ] <sup>3+</sup> + e ⇌ [Os(bipy) <sub>2</sub> ] <sup>2+</sup>	0.81	PuO <sub>2</sub> (OH) <sub>2</sub> + 2 H <sup>+</sup> + 2 e ⇌ Pu(OH) <sub>4</sub>	1.325
[Os(bipy) <sub>3</sub> ] <sup>3+</sup> + e ⇌ [Os(bipy) <sub>3</sub> ] <sup>2+</sup>	0.80	PuO <sub>2</sub> (OH) <sub>2</sub> + H <sup>+</sup> + e ⇌ PuO <sub>2</sub> OH + H <sub>2</sub> O	1.062
P(red) + 3 H <sup>+</sup> + 3 e ⇌ PH <sub>3</sub> (g)	-0.111	Ra <sup>2+</sup> + 2 e ⇌ Ra	-2.8
P(white) + 3 H <sup>+</sup> + 3 e ⇌ PH <sub>3</sub> (g)	-0.063	Rb <sup>+</sup> + e ⇌ Rb	-2.98
P + 3 H <sub>2</sub> O + 3 e ⇌ PH <sub>3</sub> (g) + 3 OH <sup>-</sup>	-0.87	Re <sup>3+</sup> + 3 e ⇌ Re	0.300

ELECTROCHEMICAL SERIES (continued)

TABLE 1  
Alphabetical Listing (continued)

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$\text{ReO}_4^- + 4 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{ReO}_2 + 2 \text{H}_2\text{O}$	0.510	$\text{SiO}_2 \text{ (quartz)} + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Si} + 2 \text{H}_2\text{O}$	0.857
$\text{ReO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Re} + 2 \text{H}_2\text{O}$	0.2513	$\text{SiO}_3^{2-} + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Si} + 6 \text{OH}^-$	-1.697
$\text{ReO}_4^- + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{ReO}_3 + \text{H}_2\text{O}$	0.768	$\text{Sm}^{3+} + \text{e} \rightleftharpoons \text{Sm}^{2+}$	-1.55
$\text{ReO}_4^- + 4 \text{H}_2\text{O} + 7 \text{e} \rightleftharpoons \text{Re} + 8 \text{OH}^-$	-0.584	$\text{Sm}^{3+} + 3 \text{e} \rightleftharpoons \text{Sm}$	-2.304
$\text{ReO}_4^- + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons \text{Re} + 4 \text{H}_2\text{O}$	0.368	$\text{Sm}^{2+} + 2 \text{e} \rightleftharpoons \text{Sm}$	-2.68
$\text{Rh}^+ + \text{e} \rightleftharpoons \text{Rh}$	0.600	$\text{Sn}^{2+} + 2 \text{e} \rightleftharpoons \text{Sn}$	-0.1375
$\text{Rh}^+ + 2 \text{e} \rightleftharpoons \text{Rh}$	0.600	$\text{Sn}^{4+} + 2 \text{e} \rightleftharpoons \text{Sn}^{2+}$	0.151
$\text{Rh}^{3+} + 3 \text{e} \rightleftharpoons \text{Rh}$	0.758	$\text{Sn(OH)}_3^+ + 3 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Sn}^{2+} + 3 \text{H}_2\text{O}$	0.142
$[\text{RhCl}_6]^{3-} + 3 \text{e} \rightleftharpoons \text{Rh} + 6 \text{Cl}^-$	0.431	$\text{SnO}_2 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Sn}^{2+} + 2 \text{H}_2\text{O}$	-0.094
$\text{RhOH}^{2+} + \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Rh} + \text{H}_2\text{O}$	0.83	$\text{SnO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Sn} + 2 \text{H}_2\text{O}$	-0.117
$\text{Ru}^{2+} + 2 \text{e} \rightleftharpoons \text{Ru}$	0.455	$\text{SnO}_2 + 3 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{SnOH}^+ + \text{H}_2\text{O}$	-0.194
$\text{Ru}^{3+} + \text{e} \rightleftharpoons \text{Ru}^{2+}$	0.2487	$\text{SnO}_2 + 2 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Sn} + 4 \text{OH}^-$	-0.945
$\text{RuO}_2 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Ru}^{2+} + 2 \text{H}_2\text{O}$	1.120	$\text{HSnO}_2^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Sn} + 3 \text{OH}^-$	-0.909
$\text{RuO}_4^- + \text{e} \rightleftharpoons \text{RuO}_4^{2-}$	0.59	$\text{Sn(OH)}_6^{2-} + 2 \text{e} \rightleftharpoons \text{HSnO}_2^- + 3 \text{OH}^- + \text{H}_2\text{O}$	-0.93
$\text{RuO}_4 + \text{e} \rightleftharpoons \text{RuO}_4^-$	1.00	$\text{Sr}^+ + \text{e} \rightleftharpoons \text{Sr}$	-4.10
$\text{RuO}_4 + 6 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Ru(OH)}_2^{2+} + 2 \text{H}_2\text{O}$	1.40	$\text{Sr}^{2+} + 2 \text{e} \rightleftharpoons \text{Sr}$	-2.899
$\text{RuO}_4 + 8 \text{H}^+ + 8 \text{e} \rightleftharpoons \text{Ru} + 4 \text{H}_2\text{O}$	1.038	$\text{Sr}^{2+} + 2 \text{e} \rightleftharpoons \text{Sr(Hg)}$	-1.793
$[\text{Ru(bipy)}_3]^{3+} + \text{e}^- \rightleftharpoons [\text{Ru(bipy)}_3]^{2+}$	1.24	$\text{Sr(OH)}_2 + 2 \text{e} \rightleftharpoons \text{Sr} + 2 \text{OH}^-$	-2.88
$[\text{Ru(H}_2\text{O)}_6]^{3+} + \text{e}^- \rightleftharpoons [\text{Ru(H}_2\text{O)}_6]^{2+}$	0.23	$\text{Ta}_2\text{O}_5 + 10 \text{H}^+ + 10 \text{e} \rightleftharpoons 2 \text{Ta} + 5 \text{H}_2\text{O}$	-0.750
$[\text{Ru(NH}_3)_6]^{3+} + \text{e}^- \rightleftharpoons [\text{Ru(NH}_3)_6]^{2+}$	0.10	$\text{Ta}^{3+} + 3 \text{e} \rightleftharpoons \text{Ta}$	-0.6
$[\text{Ru(en)}_3]^{3+} + \text{e}^- \rightleftharpoons [\text{Ru(en)}_3]^{2+}$	0.210	$\text{Tc}^{2+} + 2 \text{e} \rightleftharpoons \text{Tc}$	0.400
$[\text{Ru(CN)}_6]^{3-} + \text{e}^- \rightleftharpoons [\text{Ru(CN)}_6]^{4-}$	0.86	$\text{TcO}_4^- + 4 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{TcO}_2 + 2 \text{H}_2\text{O}$	0.782
$\text{S} + 2 \text{e} \rightleftharpoons \text{S}^{2-}$	-0.47627	$\text{Tc}^{3+} + \text{e} \rightleftharpoons \text{Tc}^{2+}$	0.3
$\text{S} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{S(aq)}$	0.142	$\text{TcO}_4^- + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons \text{Tc} + 4 \text{H}_2\text{O}$	0.472
$\text{S} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{SH}^- + \text{OH}^-$	-0.478	$\text{Tb}^{4+} + \text{e} \rightleftharpoons \text{Tb}^{3+}$	3.1
$2 \text{S} + 2 \text{e} \rightleftharpoons \text{S}_2^{2-}$	-0.42836	$\text{Tb}^{3+} + 3 \text{e} \rightleftharpoons \text{Tb}$	-2.28
$\text{S}_2\text{O}_6^{2-} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{H}_2\text{SO}_3$	0.564	$\text{Te} + 2 \text{e} \rightleftharpoons \text{Te}^{2-}$	-1.143
$\text{S}_2\text{O}_8^{2-} + 2 \text{e} \rightleftharpoons 2 \text{SO}_4^{2-}$	2.010	$\text{Te} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{Te}$	-0.793
$\text{S}_2\text{O}_8^{2-} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{HSO}_4^-$	2.123	$\text{Te}^{4+} + 4 \text{e} \rightleftharpoons \text{Te}$	0.568
$\text{S}_4\text{O}_6^{2-} + 2 \text{e} \rightleftharpoons 2 \text{S}_2\text{O}_3^{2-}$	0.08	$\text{TeO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Te} + 2 \text{H}_2\text{O}$	0.593
$2 \text{H}_2\text{SO}_3 + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{HS}_2\text{O}_4^- + 2 \text{H}_2\text{O}$	-0.056	$\text{TeO}_3^{2-} + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Te} + 6 \text{OH}^-$	-0.57
$\text{H}_2\text{SO}_3 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{S} + 3 \text{H}_2\text{O}$	0.449	$\text{TeO}_4^- + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons \text{Te} + 4 \text{H}_2\text{O}$	0.472
$2 \text{SO}_3^{2-} + 2 \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{S}_2\text{O}_4^{2-} + 4 \text{OH}^-$	-1.12	$\text{H}_6\text{TeO}_6 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{TeO}_2 + 4 \text{H}_2\text{O}$	1.02
$2 \text{SO}_3^{2-} + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{S}_2\text{O}_3^{2-} + 6 \text{OH}^-$	-0.571	$\text{Th}^{4+} + 4 \text{e} \rightleftharpoons \text{Th}$	-1.899
$\text{SO}_4^{2-} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{SO}_3 + \text{H}_2\text{O}$	0.172	$\text{ThO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Th} + 2 \text{H}_2\text{O}$	-1.789
$2 \text{SO}_4^{2-} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{S}_2\text{O}_6^{2-} + \text{H}_2\text{O}$	-0.22	$\text{Th(OH)}_4 + 4 \text{e} \rightleftharpoons \text{Th} + 4 \text{OH}^-$	-2.48
$\text{SO}_4^{2-} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{SO}_3^{2-} + 2 \text{OH}^-$	-0.93	$\text{Ti}^{2+} + 2 \text{e} \rightleftharpoons \text{Ti}$	-1.630
$\text{Sb} + 3 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{SbH}_3$	-0.510	$\text{Ti}^{3+} + \text{e} \rightleftharpoons \text{Ti}^{2+}$	-0.9
$\text{Sb}_2\text{O}_3 + 6 \text{H}^+ + 6 \text{e} \rightleftharpoons 2 \text{Sb} + 3 \text{H}_2\text{O}$	0.152	$\text{TiO}_2 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Ti}^{2+} + 2 \text{H}_2\text{O}$	-0.502
$\text{Sb}_2\text{O}_5 \text{ (senarmontite)} + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Sb}_2\text{O}_3 + 2 \text{H}_2\text{O}$	0.671	$\text{Ti}^{3+} + 3 \text{e} \rightleftharpoons \text{Ti}$	-1.37
$\text{Sb}_2\text{O}_5 \text{ (valentinite)} + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Sb}_2\text{O}_3 + 2 \text{H}_2\text{O}$	0.649	$\text{TiOH}^{3+} + \text{H}^+ + \text{e} \rightleftharpoons \text{Ti}^{3+} + \text{H}_2\text{O}$	-0.055
$\text{Sb}_2\text{O}_5 + 6 \text{H}^+ + 4 \text{e} \rightleftharpoons 2 \text{SbO}^+ + 3 \text{H}_2\text{O}$	0.581	$\text{Ti}^+ + \text{e} \rightleftharpoons \text{Ti}$	-0.336
$\text{SbO}^+ + 2 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Sb} + 2 \text{H}_2\text{O}$	0.212	$\text{Ti}^+ + \text{e} \rightleftharpoons \text{Ti(Hg)}$	-0.3338
$\text{SbO}_2^- + 2 \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{Sb} + 4 \text{OH}^-$	-0.66	$\text{Ti}^{3+} + 2 \text{e} \rightleftharpoons \text{Ti}^+$	1.252
$\text{SbO}_3^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{SbO}_2^- + 2 \text{OH}^-$	-0.59	$\text{Ti}^{3+} + 3 \text{e} \rightleftharpoons \text{Ti}$	0.741
$\text{Sc}^{3+} + 3 \text{e} \rightleftharpoons \text{Sc}$	-2.077	$\text{TlBr} + \text{e} \rightleftharpoons \text{Tl} + \text{Br}^-$	-0.658
$\text{Se} + 2 \text{e} \rightleftharpoons \text{Se}^{2-}$	-0.924	$\text{TlCl} + \text{e} \rightleftharpoons \text{Tl} + \text{Cl}^-$	-0.5568
$\text{Se} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{Se(aq)}$	-0.399	$\text{TlI} + \text{e} \rightleftharpoons \text{Tl} + \text{I}^-$	-0.752
$\text{H}_2\text{SeO}_3 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Se} + 3 \text{H}_2\text{O}$	0.74	$\text{Ti}_2\text{O}_3 + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons 2 \text{Ti}^+ + 6 \text{OH}^-$	0.02
$\text{Se} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{Se}$	-0.082	$\text{TlOH} + \text{e} \rightleftharpoons \text{Tl} + \text{OH}^-$	-0.34
$\text{SeO}_3^{2-} + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Se} + 6 \text{OH}^-$	-0.366	$\text{Ti(OH)}_3 + 2 \text{e} \rightleftharpoons \text{TlOH} + 2 \text{OH}^-$	-0.05
$\text{SeO}_4^{2-} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{SeO}_3 + \text{H}_2\text{O}$	1.151	$\text{Ti}_2\text{SO}_4 + 2 \text{e} \rightleftharpoons \text{Ti} + \text{SO}_4^{2-}$	-0.4360
$\text{SeO}_4^{2-} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{SeO}_3^{2-} + 2 \text{OH}^-$	0.05	$\text{Tm}^{3+} + \text{e} \rightleftharpoons \text{Tm}^{2+}$	-2.2
$\text{SiF}_6^{2-} + 4 \text{e} \rightleftharpoons \text{Si} + 6 \text{F}^-$	-1.24	$\text{Tm}^{3+} + 3 \text{e} \rightleftharpoons \text{Tm}$	-2.319
$\text{SiO} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Si} + \text{H}_2\text{O}$	-0.8	$\text{Tm}^{2+} + 2 \text{e} \rightleftharpoons \text{Tm}$	-2.4

**ELECTROCHEMICAL SERIES (continued)**

**TABLE 1**  
**Alphabetical Listing (continued)**

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$U^{3+} + 3 e \rightleftharpoons U$	-1.798	$2 WO_3 + 2 H^+ + 2 e \rightleftharpoons W_2O_5 + H_2O$	-0.029
$U^{4+} + e \rightleftharpoons U^{3+}$	-0.607	$H_4XeO_6 + 2 H^+ + 2 e \rightleftharpoons XeO_3 + 3 H_2O$	2.42
$UO_2^{2+} + 4 H^+ + e \rightleftharpoons U^{4+} + 2 H_2O$	0.612	$XeO_3 + 6 H^+ + 6 e \rightleftharpoons Xe + 3 H_2O$	2.10
$UO_2^{2+} + e \rightleftharpoons UO_2^+$	0.062	$XeF + e \rightleftharpoons Xe + F^-$	3.4
$UO_2^{2+} + 4 H^+ + 2 e \rightleftharpoons U^{4+} + 2 H_2O$	0.327	$Y^{3+} + 3 e \rightleftharpoons Y$	-2.372
$UO_2^{2+} + 4 H^+ + 6 e \rightleftharpoons U + 2 H_2O$	-1.444	$Yb^{3+} + e \rightleftharpoons Yb^{2+}$	-1.05
$V^{2+} + 2 e \rightleftharpoons V$	-1.175	$Yb^{3+} + 3 e \rightleftharpoons Yb$	-2.19
$V^{3+} + e \rightleftharpoons V^{2+}$	-0.255	$Yb^{2+} + 2 e \rightleftharpoons Yb$	-2.76
$VO^{2+} + 2 H^+ + e \rightleftharpoons V^{3+} + H_2O$	0.337	$Zn^{2+} + 2 e \rightleftharpoons Zn$	-0.7618
$VO_2^+ + 2 H^+ + e \rightleftharpoons VO^{2+} + H_2O$	0.991	$Zn^{2+} + 2 e \rightleftharpoons Zn(Hg)$	-0.7628
$V_2O_5 + 6 H^+ + 2 e \rightleftharpoons 2 VO^{2+} + 3 H_2O$	0.957	$ZnO_2^{2-} + 2 H_2O + 2 e \rightleftharpoons Zn + 4 OH^-$	-1.215
$V_2O_5 + 10 H^+ + 10 e \rightleftharpoons 2 V + 5 H_2O$	-0.242	$ZnSO_4 \cdot 7 H_2O + 2 e \rightleftharpoons Zn(Hg) + SO_4^{2-} + 7 H_2O$	-0.7993
$V(OH)_4^+ + 2 H^+ + e \rightleftharpoons VO^{2+} + 3 H_2O$	1.00	(Saturated ZnSO <sub>4</sub> )	
$V(OH)_4^+ + 4 H^+ + 5 e \rightleftharpoons V + 4 H_2O$	-0.254	$ZnOH^+ + H^+ + 2 e \rightleftharpoons Zn + H_2O$	-0.497
$[V(phen)_3]^{3+} + e \rightleftharpoons [V(phen)_3]^{2+}$	0.14	$Zn(OH)_4^{2-} + 2 e \rightleftharpoons Zn + 4 OH^-$	-1.199
$W^{3+} + 3 e \rightleftharpoons W$	0.1	$Zn(OH)_2 + 2 e \rightleftharpoons Zn + 2 OH^-$	-1.249
$W_2O_5 + 2 H^+ + 2 e \rightleftharpoons 2 WO_2 + H_2O$	-0.031	$ZnO + H_2O + 2 e \rightleftharpoons Zn + 2 OH^-$	-1.260
$WO_2 + 4 H^+ + 4 e \rightleftharpoons W + 2 H_2O$	-0.119	$ZrO_2 + 4 H^+ + 4 e \rightleftharpoons Zr + 2 H_2O$	-1.553
$WO_3 + 6 H^+ + 6 e \rightleftharpoons W + 3 H_2O$	-0.090	$ZrO(OH)_2 + H_2O + 4 e \rightleftharpoons Zr + 4 OH^-$	-2.36
$WO_3 + 2 H^+ + 2 e \rightleftharpoons WO_2 + H_2O$	0.036	$Zr^{4+} + 4 e \rightleftharpoons Zr$	-1.45

**TABLE 2**  
**Reduction Reactions Having  $E^\circ$  Values More Positive than that of the Standard Hydrogen Electrode**

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$2 H^+ + 2 e \rightleftharpoons H_2$	0.00000	$Sn(OH)_3^+ + 3 H^+ + 2 e \rightleftharpoons Sn^{2+} + 3 H_2O$	0.142
$CuI_2^- + e \rightleftharpoons Cu + 2 I^-$	0.00	$Np^{4+} + e \rightleftharpoons Np^{3+}$	0.147
$Ge^{4+} + 2 e \rightleftharpoons Ge^{2+}$	0.00	$Ag_4[Fe(CN)_6] + 4 e \rightleftharpoons 4 Ag + [Fe(CN)_6]^{4-}$	0.1478
$NO_3^- + H_2O + 2 e \rightleftharpoons NO_2^- + 2 OH^-$	0.01	$IO_3^- + 2 H_2O + 4 e \rightleftharpoons IO^- + 4 OH^-$	0.15
$Tl_2O_3 + 3 H_2O + 4 e \rightleftharpoons 2 Tl^+ + 6 OH^-$	0.02	$Mn(OH)_3 + e \rightleftharpoons Mn(OH)_2 + OH^-$	0.15
$SeO_4^{2-} + H_2O + 2 e \rightleftharpoons SeO_3^{2-} + 2 OH^-$	0.05	$2 NO_2^- + 3 H_2O + 4 e \rightleftharpoons N_2O + 6 OH^-$	0.15
$WO_3 + 2 H^+ + 2 e \rightleftharpoons WO_2 + H_2O$	0.036	$Sn^{4+} + 2 e \rightleftharpoons Sn^{2+}$	0.151
$UO_2^{2+} + e \rightleftharpoons UO_2^+$	0.062	$Sb_2O_3 + 6 H^+ + 6 e \rightleftharpoons 2 Sb + 3 H_2O$	0.152
$Pd(OH)_2 + 2 e \rightleftharpoons Pd + 2 OH^-$	0.07	$Cu^{2+} + e \rightleftharpoons Cu^+$	0.153
$AgBr + e \rightleftharpoons Ag + Br^-$	0.07133	$BiOCl + 2 H^+ + 3 e \rightleftharpoons Bi + Cl^- + H_2O$	0.1583
$MoO_3 + 6 H^+ + 6 e \rightleftharpoons Mo + 3 H_2O$	0.075	$BiCl_4^- + 3 e \rightleftharpoons Bi + 4 Cl^-$	0.16
$S_4O_6^{2-} + 2 e \rightleftharpoons 2 S_2O_3^{2-}$	0.08	$Fe_2O_3 + 4 H^+ + 2 e \rightleftharpoons 2 FeOH^+ + H_2O$	0.16
$H_3Mo_7O_{24}^{3-} + 45 H^+ + 42 e \rightleftharpoons 7 Mo + 24 H_2O$	0.082	$Co(OH)_3 + e \rightleftharpoons Co(OH)_2 + OH^-$	0.17
$AgSCN + e \rightleftharpoons Ag + SCN^-$	0.8951	$SO_4^{2-} + 4 H^+ + 2 e \rightleftharpoons H_2SO_3 + H_2O$	0.172
$N_2 + 2 H_2O + 6 H^+ + 6 e \rightleftharpoons 2 NH_4OH$	0.092	$Bi^{3+} + 2 e \rightleftharpoons Bi^+$	0.2
$HgO + H_2O + 2 e \rightleftharpoons Hg + 2 OH^-$	0.0977	$[Ru(en)_3]^{3+} + e \rightleftharpoons [Ru(en)_3]^{2+}$	0.210
$Ir_2O_3 + 3 H_2O + 6 e \rightleftharpoons 2 Ir + 6 OH^-$	0.098	$SbO^+ + 2 H^+ + 3 e \rightleftharpoons Sb + 2 H_2O$	0.212
$2 NO + 2 e \rightleftharpoons N_2O_2^{2-}$	0.10	$AgCl + e \rightleftharpoons Ag + Cl^-$	0.22233
$[Ru(NH_3)_6]^{3+} + e \rightleftharpoons [Ru(NH_3)_6]^{2+}$	0.10	$[Ru(H_2O)_6]^{3+} + e \rightleftharpoons [Ru(H_2O)_6]^{2+}$	0.23
$W^{3+} + 3 e \rightleftharpoons W$	0.1	$As_2O_3 + 6 H^+ + 6 e \rightleftharpoons 2 As + 3 H_2O$	0.234
$[Co(NH_3)_6]^{3+} + e \rightleftharpoons [Co(NH_3)_6]^{2+}$	0.108	Calomel electrode, saturated NaCl (SSCE)	0.2360
$Hg_2O + H_2O + 2 e \rightleftharpoons 2 Hg + 2 OH^-$	0.123	$Ge^{2+} + 2 e \rightleftharpoons Ge$	0.24
$Ge^{4+} + 4 e \rightleftharpoons Ge$	0.124	$Ru^{3+} + e \rightleftharpoons Ru^{2+}$	0.24
$Hg_2Br_2 + 2 e \rightleftharpoons 2 Hg + 2 Br^-$	0.13923	Calomel electrode, saturated KCl	0.2412
$Pt(OH)_2 + 2 e \rightleftharpoons Pt + 2 OH^-$	0.14	$PbO_2 + H_2O + 2 e \rightleftharpoons PbO + 2 OH^-$	0.247
$[V(phen)_3]^{3+} + e \rightleftharpoons [V(phen)_3]^{2+}$	0.14	$HAsO_2 + 3 H^+ + 3 e \rightleftharpoons As + 2 H_2O$	0.248
$S + 2 H^+ + 2 e \rightleftharpoons H_2S(aq)$	0.142	$Ru^{3+} + e \rightleftharpoons Ru^{2+}$	0.2487

**ELECTROCHEMICAL SERIES (continued)**

**TABLE 2**  
**Reduction Reactions Having  $E^\circ$  Values More Positive than that of the Standard Hydrogen Electrode (continued)**

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$\text{ReO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Re} + 2 \text{H}_2\text{O}$	0.2513	$[\text{PdCl}_4]^{2-} + 2 \text{e} \rightleftharpoons \text{Pd} + 4 \text{Cl}^-$	0.591
$\text{IO}_3^- + 3 \text{H}_2\text{O} + 6 \text{e} \rightleftharpoons \text{I}^- + 6 \text{OH}^-$	0.26	$\text{TeO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Te} + 2 \text{H}_2\text{O}$	0.593
$\text{Hg}_2\text{Cl}_2 + 2 \text{e} \rightleftharpoons 2 \text{Hg} + 2 \text{Cl}^-$	0.26808	$\text{MnO}_4^- + 2 \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{MnO}_2 + 4 \text{OH}^-$	0.595
Calomel electrode, 1 molal KCl	0.2800	$\text{Rh}^{2+} + 2 \text{e} \rightleftharpoons \text{Rh}$	0.600
Calomel electrode, 1 molar KCl (NCE)	0.2801	$\text{Rh}^+ + \text{e} \rightleftharpoons \text{Rh}$	0.600
$\text{At}_2 + 2 \text{e} \rightleftharpoons 2 \text{At}^-$	0.3	$\text{MnO}_4^{2-} + 2 \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{MnO}_2 + 4 \text{OH}^-$	0.60
$\text{Re}^{3+} + 3 \text{e} \rightleftharpoons \text{Re}$	0.300	$2 \text{AgO} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Ag}_2\text{O} + 2 \text{OH}^-$	0.607
$\text{Tc}^{3+} + \text{e} \rightleftharpoons \text{Tc}^{2+}$	0.3	$\text{BrO}_3^- + 3 \text{H}_2\text{O} + 6 \text{e} \rightleftharpoons \text{Br}^- + 6 \text{OH}^-$	0.61
$\text{Bi}^{3+} + 3 \text{e} \rightleftharpoons \text{Bi}$	0.308	$\text{UO}_2^{2+} + 4 \text{H}^+ + \text{e} \rightleftharpoons \text{U}^{4+} + 2 \text{H}_2\text{O}$	0.612
$\text{BiO}^+ + 2 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Bi} + \text{H}_2\text{O}$	0.320	$\text{Hg}_2\text{SO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Hg} + \text{SO}_4^{2-}$	0.6125
$\text{UO}_2^{2+} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{U}^{4+} + 2 \text{H}_2\text{O}$	0.327	$\text{ClO}_3^- + 3 \text{H}_2\text{O} + 6 \text{e} \rightleftharpoons \text{Cl}^- + 6 \text{OH}^-$	0.62
$\text{ClO}_3^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{ClO}_2^- + 2 \text{OH}^-$	0.33	$\text{Hg}_2\text{HPO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Hg} + \text{HPO}_4^{2-}$	0.6359
$2 \text{HCNO} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons (\text{CN})_2 + 2 \text{H}_2\text{O}$	0.330	$\text{Ag}(\text{ac}) + \text{e} \rightleftharpoons \text{Ag} + (\text{ac})^-$	0.643
Calomel electrode, 0.1 molar KCl	0.3337	$\text{Sb}_2\text{O}_5(\text{valentinite}) + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Sb}_2\text{O}_3 + 2 \text{H}_2\text{O}$	0.649
$\text{VO}^{2+} + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{V}^{3+} + \text{H}_2\text{O}$	0.337	$\text{Ag}_2\text{SO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{SO}_4^{2-}$	0.654
$\text{Cu}^{2+} + 2 \text{e} \rightleftharpoons \text{Cu}$	0.3419	$\text{ClO}_2^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{ClO}^- + 2 \text{OH}^-$	0.66
$\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons 2 \text{Ag} + 2 \text{OH}^-$	0.342	$\text{Sb}_2\text{O}_5(\text{senarmontite}) + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Sb}_2\text{O}_3 + 2 \text{H}_2\text{O}$	0.671
$\text{Cu}^{2+} + 2 \text{e} \rightleftharpoons \text{Cu}(\text{Hg})$	0.345	$[\text{PtCl}_6]^{2-} + 2 \text{e} \rightleftharpoons [\text{PtCl}_4]^{2-} + 2 \text{Cl}^-$	0.68
$\text{AgIO}_3 + \text{e} \rightleftharpoons \text{Ag} + \text{IO}_3^-$	0.354	$\text{O}_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{O}_2$	0.695
$[\text{Fe}(\text{CN})_6]^{3-} + \text{e} \rightleftharpoons [\text{Fe}(\text{CN})_6]^{4-}$	0.358	<i>p</i> -benzoquinone + 2 $\text{H}^+$ + 2 $\text{e} \rightleftharpoons$ hydroquinone	0.6992
$\text{ClO}_4^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{ClO}_3^- + 2 \text{OH}^-$	0.36	$\text{H}_3\text{IO}_6^{2-} + 2 \text{e} \rightleftharpoons \text{IO}_3^- + 3 \text{OH}^-$	0.7
$\text{Ag}_2\text{SeO}_3 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{SeO}_3^{2-}$	0.3629	$\text{Ag}_2\text{O}_3 + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons 2 \text{AgO} + 2 \text{OH}^-$	0.739
$\text{ReO}_4^- + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons \text{Re} + 4 \text{H}_2\text{O}$	0.368	$\text{Ti}^{3+} + 3 \text{e} \rightleftharpoons \text{Ti}$	0.741
$(\text{CN})_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{HCN}$	0.373	$[\text{PtCl}_4]^{2-} + 2 \text{e} \rightleftharpoons \text{Pt} + 4 \text{Cl}^-$	0.755
[Ferricinium] $^+$ + $\text{e} \rightleftharpoons$ ferrocene	0.400	$\text{Rh}^{3+} + 3 \text{e} \rightleftharpoons \text{Rh}$	0.758
$\text{Tc}^{2+} + 2 \text{e} \rightleftharpoons \text{Tc}$	0.400	$\text{ClO}_2 + 2 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Cl}^- + 4 \text{OH}^-$	0.76
$\text{O}_2 + 2 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons 4 \text{OH}^-$	0.401	$2 \text{NO} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{N}_2\text{O} + 2 \text{OH}^-$	0.76
$\text{AgOCN} + \text{e} \rightleftharpoons \text{Ag} + \text{OCN}^-$	0.41	$\text{Po}^{4+} + 4 \text{e} \rightleftharpoons \text{Po}$	0.76
$[\text{RhCl}_6]^{3-} + 3 \text{e} \rightleftharpoons \text{Rh} + 6 \text{Cl}^-$	0.431	$\text{BrO}^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Br}^- + 2 \text{OH}^-$	0.761
$\text{Ag}_2\text{CrO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{CrO}_4^{2-}$	0.4470	$\text{ReO}_4^- + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{ReO}_3 + \text{H}_2\text{O}$	0.768
$\text{H}_2\text{SO}_3 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{S} + 3 \text{H}_2\text{O}$	0.449	$(\text{CNS})_2 + 2 \text{e} \rightleftharpoons 2 \text{CNS}^-$	0.77
$\text{Ru}^{2+} + 2 \text{e} \rightleftharpoons \text{Ru}$	0.455	$[\text{IrCl}_6]^{3-} + 3 \text{e} \rightleftharpoons \text{Ir} + 6 \text{Cl}^-$	0.77
$\text{Ag}_2\text{MoO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{MoO}_4^{2-}$	0.4573	$\text{Fe}^{3+} + \text{e} \rightleftharpoons \text{Fe}^{2+}$	0.771
$\text{Ag}_2\text{C}_2\text{O}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{C}_2\text{O}_4^{2-}$	0.4647	$\text{AgF} + \text{e} \rightleftharpoons \text{Ag} + \text{F}^-$	0.779
$\text{Ag}_2\text{WO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{WO}_4^{2-}$	0.4660	$[\text{Fe}(\text{bipy})_2]^{3+} + \text{e} \rightleftharpoons [\text{Fe}(\text{bipy})_2]^{2+}$	0.78
$\text{Ag}_2\text{CO}_3 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{CO}_3^{2-}$	0.47	$\text{TcO}_4^- + 4 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{TcO}_2 + 2 \text{H}_2\text{O}$	0.782
$\text{TcO}_4^- + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons \text{Tc} + 4 \text{H}_2\text{O}$	0.472	$\text{Hg}_2^{2+} + 2 \text{e} \rightleftharpoons 2 \text{Hg}$	0.7973
$\text{TeO}_4^{2-} + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons \text{Te} + 4 \text{H}_2\text{O}$	0.472	$\text{Ag}^+ + \text{e} \rightleftharpoons \text{Ag}$	0.7996
$\text{IO}^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{I}^- + 2 \text{OH}^-$	0.485	$[\text{Os}(\text{bipy})_3]^{3+} + \text{e} \rightleftharpoons [\text{Os}(\text{bipy})_3]^{2+}$	0.80
$\text{NiO}_2 + 2 \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Ni}(\text{OH})_2 + 2 \text{OH}^-$	0.490	$2 \text{NO}_3^- + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{N}_2\text{O}_4 + 2 \text{H}_2\text{O}$	0.803
$\text{Bi}^+ + \text{e} \rightleftharpoons \text{Bi}$	0.5	$[\text{Os}(\text{bipy})_2]^{3+} + \text{e} \rightleftharpoons [\text{Os}(\text{bipy})_2]^{2+}$	0.81
$\text{ReO}_4^- + 4 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{ReO}_2 + 2 \text{H}_2\text{O}$	0.510	$\text{RhOH}^{2+} + \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Rh} + \text{H}_2\text{O}$	0.83
$\text{Hg}_2(\text{ac})_2 + 2 \text{e} \rightleftharpoons 2 \text{Hg} + 2(\text{ac})^-$	0.51163	$\text{OsO}_4 + 8 \text{H}^+ + 8 \text{e} \rightleftharpoons \text{Os} + 4 \text{H}_2\text{O}$	0.838
$\text{Cu}^+ + \text{e} \rightleftharpoons \text{Cu}$	0.521	$\text{ClO}^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Cl}^- + 2 \text{OH}^-$	0.841
$\text{I}_2 + 2 \text{e} \rightleftharpoons 2 \text{I}^-$	0.5355	$\text{Hg}^{2+} + 2 \text{e} \rightleftharpoons \text{Hg}$	0.851
$\text{I}_3^- + 2 \text{e} \rightleftharpoons 3 \text{I}^-$	0.536	$\text{AuBr}_4^- + 3 \text{e} \rightleftharpoons \text{Au} + 4 \text{Br}^-$	0.854
$\text{AgBrO}_3 + \text{e} \rightleftharpoons \text{Ag} + \text{BrO}_3^-$	0.546	$\text{SiO}_2(\text{quartz}) + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Si} + 2 \text{H}_2\text{O}$	0.857
$\text{MnO}_4^- + \text{e} \rightleftharpoons \text{MnO}_2^-$	0.558	$2 \text{HNO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{H}_2\text{N}_2\text{O}_2 + \text{H}_2\text{O}$	0.86
$\text{H}_3\text{AsO}_4 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{HASO}_2 + 2 \text{H}_2\text{O}$	0.560	$[\text{Ru}(\text{CN})_6]^{3-} + \text{e}^- \rightleftharpoons [\text{Ru}(\text{CN})_6]^{4-}$	0.86
$\text{S}_2\text{O}_6^{2-} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{H}_2\text{SO}_3$	0.564	$[\text{IrCl}_6]^{2-} + \text{e} \rightleftharpoons [\text{IrCl}_6]^{3-}$	0.8665
$\text{AgNO}_2 + \text{e} \rightleftharpoons \text{Ag} + \text{NO}_2^-$	0.564	$\text{N}_2\text{O}_4 + 2 \text{e} \rightleftharpoons 2 \text{NO}_2^-$	0.867
$\text{Te}^{4+} + 4 \text{e} \rightleftharpoons \text{Te}$	0.568	$\text{HO}_2^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons 3 \text{OH}^-$	0.878
$\text{Sb}_2\text{O}_5 + 6 \text{H}^+ + 4 \text{e} \rightleftharpoons 2 \text{SbO}^+ + 3 \text{H}_2\text{O}$	0.581	$\text{Po}^{4+} + 2 \text{e} \rightleftharpoons \text{Po}^{2+}$	0.9
$\text{RuO}_4^- + \text{e} \rightleftharpoons \text{RuO}_4^{2-}$	0.59	$2 \text{Hg}^+ + 2 \text{e} \rightleftharpoons \text{Hg}_2^{2+}$	0.920

**ELECTROCHEMICAL SERIES (continued)**

**TABLE 2**  
**Reduction Reactions Having  $E^\circ$  Values More Positive than that of the Standard Hydrogen Electrode**  
**(continued)**

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$\text{NO}_3^- + 3 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{HNO}_2 + \text{H}_2\text{O}$	0.934	$\text{Cl}_2(\text{g}) + 2 \text{e} \rightleftharpoons 2 \text{Cl}^-$	1.35827
$\text{Pd}^{2+} + 2 \text{e} \rightleftharpoons \text{Pd}$	0.951	$\text{ClO}_4^- + 8 \text{H}^+ + 8 \text{e} \rightleftharpoons \text{Cl}^- + 4 \text{H}_2\text{O}$	1.389
$\text{ClO}_2(\text{aq}) + \text{e} \rightleftharpoons \text{ClO}_2^-$	0.954	$\text{ClO}_4^- + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons 1/2 \text{Cl}_2 + 4 \text{H}_2\text{O}$	1.39
$\text{NO}_3^- + 4 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{NO} + 2 \text{H}_2\text{O}$	0.957	$\text{No}^{3+} + \text{e} \rightleftharpoons \text{No}^{2+}$	1.4
$\text{V}_2\text{O}_5 + 6 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{VO}^{2+} + 3 \text{H}_2\text{O}$	0.957	$\text{RuO}_4 + 6 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Ru}(\text{OH})_2^{2+} + 2 \text{H}_2\text{O}$	1.40
$\text{AuBr}_2^- + \text{e} \rightleftharpoons \text{Au} + 2 \text{Br}^-$	0.959	$\text{Au}^{3+} + 2 \text{e} \rightleftharpoons \text{Au}^+$	1.401
$\text{HNO}_2 + \text{H}^+ + \text{e} \rightleftharpoons \text{NO} + \text{H}_2\text{O}$	0.983	$2 \text{NH}_3\text{OH}^+ + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{N}_2\text{H}_5^+ + 2 \text{H}_2\text{O}$	1.42
$\text{HIO} + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{I}^- + \text{H}_2\text{O}$	0.987	$\text{BrO}_3^- + 6 \text{H}^+ + 6 \text{e} \rightleftharpoons \text{Br}^- + 3 \text{H}_2\text{O}$	1.423
$\text{VO}_2^+ + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{VO}^{2+} + \text{H}_2\text{O}$	0.991	$2 \text{HIO} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{I}_2 + 2 \text{H}_2\text{O}$	1.439
$\text{PtO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Pt} + 2 \text{H}_2\text{O}$	1.00	$\text{Au}(\text{OH})_3 + 3 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Au}^- + 3 \text{H}_2\text{O}$	1.45
$\text{RuO}_4 + \text{e} \rightleftharpoons \text{RuO}_4^-$	1.00	$3\text{IO}_3^- + 6 \text{H}^+ + 6 \text{e} \rightleftharpoons \text{Cl}^- + 3 \text{H}_2\text{O}$	1.451
$\text{V}(\text{OH})_4^+ + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{VO}^{2+} + 3 \text{H}_2\text{O}$	1.00	$\text{PbO}_2 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Pb}^{2+} + 2 \text{H}_2\text{O}$	1.455
$\text{AuCl}_4^- + 3 \text{e} \rightleftharpoons \text{Au} + 4 \text{Cl}^-$	1.002	$\text{ClO}_3^- + 6 \text{H}^+ + 5 \text{e} \rightleftharpoons 1/2 \text{Cl}_2 + 3 \text{H}_2\text{O}$	1.47
$\text{Pu}^{4+} + \text{e} \rightleftharpoons \text{Pu}^{3+}$	1.006	$\text{CrO}_2 + 4 \text{H}^+ + \text{e} \rightleftharpoons \text{Cr}^{3+} + 2 \text{H}_2\text{O}$	1.48
$\text{PtO}_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{PtO} + \text{H}_2\text{O}$	1.01	$\text{BrO}_3^- + 6 \text{H}^+ + 5 \text{e} \rightleftharpoons 1/2 \text{Br}_2 + 3 \text{H}_2\text{O}$	1.482
$\text{OsO}_4 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{OsO}_2 + 2 \text{H}_2\text{O}$	1.02	$\text{HClO} + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Cl}^- + \text{H}_2\text{O}$	1.482
$\text{H}_6\text{TeO}_6 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{TeO}_2 + 4 \text{H}_2\text{O}$	1.02	$\text{Mn}_2\text{O}_3 + 6 \text{H}^+ + \text{e} \rightleftharpoons 2 \text{Mn}^{2+} + 3 \text{H}_2\text{O}$	1.485
$[\text{Fe}(\text{bipy})_3]^{3+} + \text{e} \rightleftharpoons [\text{Fe}(\text{bipy})_3]^{2+}$	1.03	$\text{HO}_2 + \text{H}^+ + \text{e} \rightleftharpoons \text{H}_2\text{O}_2$	1.495
$\text{Hg}(\text{OH})_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Hg} + 2 \text{H}_2\text{O}$	1.034	$\text{Au}^{3+} + 3 \text{e} \rightleftharpoons \text{Au}$	1.498
$\text{N}_2\text{O}_4 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons 2 \text{NO} + 2 \text{H}_2\text{O}$	1.035	$\text{PtO}_3 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Pt}(\text{OH})_2^{2+} + \text{H}_2\text{O}$	1.5
$\text{RuO}_4 + 8 \text{H}^+ + 8 \text{e} \rightleftharpoons \text{Ru} + 4 \text{H}_2\text{O}$	1.038	$\text{MnO}_4^- + 8 \text{H}^+ + 5 \text{e} \rightleftharpoons \text{Mn}^{2+} + 4 \text{H}_2\text{O}$	1.507
$[\text{Fe}(\text{phen})_3]^{3+} + \text{e} \rightleftharpoons [\text{Fe}(\text{phen})_3]^{2+}$ (1 molar $\text{H}_2\text{SO}_4$ )	1.06	$\text{Mn}^{3+} + \text{e} \rightleftharpoons \text{Mn}^{2+}$	1.5415
$\text{PuO}_2(\text{OH})_2 + \text{H}^+ + \text{e} \rightleftharpoons \text{PuO}_2\text{OH} + \text{H}_2\text{O}$	1.062	$\text{HClO}_2 + 3 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Cl}^- + 2 \text{H}_2\text{O}$	1.570
$\text{N}_2\text{O}_4 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{HNO}_2$	1.065	$\text{HBrO} + \text{H}^+ + \text{e} \rightleftharpoons 1/2 \text{Br}_2(\text{aq}) + \text{H}_2\text{O}$	1.574
$\text{Br}_2(\text{l}) + 2 \text{e} \rightleftharpoons 2 \text{Br}^-$	1.066	$2 \text{NO} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{N}_2\text{O} + \text{H}_2\text{O}$	1.591
$\text{IO}_3^- + 6 \text{H}^+ + 6 \text{e} \rightleftharpoons \text{I}^- + 3 \text{H}_2\text{O}$	1.085	$\text{Bi}_2\text{O}_3 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{BiO}^+ + 2 \text{H}_2\text{O}$	1.593
$\text{Br}_2(\text{aq}) + 2 \text{e} \rightleftharpoons 2 \text{Br}^-$	1.0873	$\text{HBrO} + \text{H}^+ + \text{e} \rightleftharpoons 1/2 \text{Br}_2(\text{l}) + \text{H}_2\text{O}$	1.596
$\text{Pu}^{5+} + \text{e} \rightleftharpoons \text{Pu}^{4+}$	1.099	$\text{H}_5\text{IO}_6 + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{IO}_3^- + 3 \text{H}_2\text{O}$	1.601
$\text{Cu}^{2+} + 2 \text{CN}^- + \text{e} \rightleftharpoons [\text{Cu}(\text{CN})_2]^-$	1.103	$\text{HClO} + \text{H}^+ + \text{e} \rightleftharpoons 1/2 \text{Cl}_2 + \text{H}_2\text{O}$	1.611
$\text{RuO}_2 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Ru}^{2+} + 2 \text{H}_2\text{O}$	1.120	$\text{HClO}_2 + 3 \text{H}^+ + 3 \text{e} \rightleftharpoons 1/2 \text{Cl}_2 + 2 \text{H}_2\text{O}$	1.628
$[\text{Fe}(\text{phen})_3]^{3+} + \text{e} \rightleftharpoons [\text{Fe}(\text{phen})_3]^{2+}$	1.147	$\text{HClO}_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{HClO} + \text{H}_2\text{O}$	1.645
$\text{SeO}_4^{2-} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{SeO}_3 + \text{H}_2\text{O}$	1.151	$\text{Bk}^{4+} + \text{e} \rightleftharpoons \text{Bk}^{3+}$	1.67
$\text{ClO}_3^- + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{ClO}_2 + \text{H}_2\text{O}$	1.152	$\text{NiO}_2 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Ni}^{2+} + 2 \text{H}_2\text{O}$	1.678
$\text{Ir}^{3+} + 3 \text{e} \rightleftharpoons \text{Ir}$	1.156	$\text{MnO}_4^- + 4 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{MnO}_2 + 2 \text{H}_2\text{O}$	1.679
$\text{Pt}^{2+} + 2 \text{e} \rightleftharpoons \text{Pt}$	1.18	$\text{PbO}_2 + \text{SO}_4^{2-} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{PbSO}_4 + 2 \text{H}_2\text{O}$	1.6913
$\text{ClO}_4^- + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{ClO}_3^- + \text{H}_2\text{O}$	1.189	$\text{Au}^+ + \text{e} \rightleftharpoons \text{Au}$	1.692
$2 \text{IO}_3^- + 12 \text{H}^+ + 10 \text{e} \rightleftharpoons \text{I}_2 + 6 \text{H}_2\text{O}$	1.195	$\text{PtO}_3 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{PtO}_2 + \text{H}_2\text{O}$	1.7
$\text{PtOH}^+ + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Pt} + \text{H}_2\text{O}$	1.2	$\text{CeOH}^{3+} + \text{H}^+ + \text{e} \rightleftharpoons \text{Ce}^{3+} + \text{H}_2\text{O}$	1.715
$\text{ClO}_3^- + 3 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{HClO}_2 + \text{H}_2\text{O}$	1.214	$\text{Ce}^{4+} + \text{e} \rightleftharpoons \text{Ce}^{3+}$	1.72
$\text{MnO}_2 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Mn}^{2+} + 2 \text{H}_2\text{O}$	1.224	$\text{N}_2\text{O} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{N}_2 + \text{H}_2\text{O}$	1.766
$\text{O}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons 2 \text{H}_2\text{O}$	1.229	$\text{H}_2\text{O}_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{H}_2\text{O}$	1.776
$\text{Cr}_2\text{O}_7^{2-} + 14 \text{H}^+ + 6 \text{e} \rightleftharpoons 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O}$	1.232	$\text{Ag}^{3+} + \text{e} \rightleftharpoons \text{Ag}^{2+}$	1.8
$\text{O}_3 + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{O}_2 + 2 \text{OH}^-$	1.24	$\text{Au}^{2+} + \text{e}^- \rightleftharpoons \text{Au}^+$	1.8
$[\text{Ru}(\text{bipy})_3]^{3+} + \text{e} \rightleftharpoons [\text{Ru}(\text{bipy})_3]^{2+}$	1.24	$\text{Ag}_2\text{O}_2 + 4 \text{H}^+ + \text{e} \rightleftharpoons 2 \text{Ag} + 2 \text{H}_2\text{O}$	1.802
$\text{Ti}^{3+} + 2 \text{e} \rightleftharpoons \text{Ti}^+$	1.252	$\text{Co}^{3+} + \text{e} \rightleftharpoons \text{Co}^{2+}$ (2 molar $\text{H}_2\text{SO}_4$ )	1.83
$\text{N}_2\text{H}_5^+ + 3 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{NH}_4^+$	1.275	$\text{Ag}^{3+} + 2 \text{e} \rightleftharpoons \text{Ag}^+$	1.9
$\text{ClO}_2 + \text{H}^+ + \text{e} \rightleftharpoons \text{HClO}_2$	1.277	$\text{Co}^{3+} + \text{e} \rightleftharpoons \text{Co}^{2+}$	1.92
$[\text{PdCl}_6]^{2-} + 2 \text{e} \rightleftharpoons [\text{PdCl}_4]^{2-} + 2 \text{Cl}^-$	1.288	$\text{Ag}^{2+} + \text{e} \rightleftharpoons \text{Ag}^+$	1.980
$2 \text{HNO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{N}_2\text{O} + 3 \text{H}_2\text{O}$	1.297	$\text{Cu}_2\text{O}_3 + 6 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{Cu}^{2+} + 3 \text{H}_2\text{O}$	2.0
$\text{AuOH}^{2+} + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Au}^+ + \text{H}_2\text{O}$	1.32	$\text{S}_2\text{O}_8^{2-} + 2 \text{e} \rightleftharpoons 2 \text{SO}_4^{2-}$	2.010
$\text{PuO}_2(\text{OH})_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Pu}(\text{OH})_4$	1.325	$\text{OH}^- + \text{e} \rightleftharpoons \text{OH}^{2-}$	2.02
$\text{HBrO} + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Br}^- + \text{H}_2\text{O}$	1.331	$\text{HFeO}_4^- + 7 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Fe}^{3+} + 4 \text{H}_2\text{O}$	2.07
$\text{Cr}(\text{V}) + \text{e} \rightleftharpoons \text{Cr}(\text{IV})$	1.34	$\text{O}_3 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{O}_2 + \text{H}_2\text{O}$	2.076
$\text{HCrO}_4^- + 7 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Cr}^{3+} + 4 \text{H}_2\text{O}$	1.350	$\text{HFeO}_4^- + 4 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{FeOOH} + 2 \text{H}_2\text{O}$	2.08



**ELECTROCHEMICAL SERIES (continued)**

**TABLE 2**  
**Reduction Reactions Having  $E^\circ$  Values More Positive than that of the Standard Hydrogen Electrode**  
**(continued)**

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$2\text{HFeO}_4^- + 8\text{H}^+ + 6\text{e} \rightleftharpoons \text{Fe}_2\text{O}_3 + 5\text{H}_2\text{O}$	2.09	$\text{H}_2\text{N}_2\text{O}_2 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{N}_2 + 2\text{H}_2\text{O}$	2.65
$\text{XeO}_3 + 6\text{H}^+ + 6\text{e} \rightleftharpoons \text{Xe} + 3\text{H}_2\text{O}$	2.10	$\text{F}_2 + 2\text{e} \rightleftharpoons 2\text{F}^-$	2.866
$\text{S}_2\text{O}_8^{2-} + 2\text{H}^+ + 2\text{e} \rightleftharpoons 2\text{HSO}_4^-$	2.123	$\text{Cm}^{4+} + \text{e} \rightleftharpoons \text{Cm}^{3+}$	3.0
$\text{F}_2\text{O} + 2\text{H}^+ + 4\text{e} \rightleftharpoons \text{H}_2\text{O} + 2\text{F}^-$	2.153	$\text{F}_2 + 2\text{H}^+ + 2\text{e} \rightleftharpoons 2\text{HF}$	3.053
$\text{FeO}_4^{2-} + 8\text{H}^+ + 3\text{e} \rightleftharpoons \text{Fe}^{3+} + 4\text{H}_2\text{O}$	2.20	$\text{Tb}^{4+} + \text{e} \rightleftharpoons \text{Tb}^{3+}$	3.1
$\text{Cu}^{3+} + \text{e} \rightleftharpoons \text{Cu}^{2+}$	2.4	$\text{Pr}^{4+} + \text{e} \rightleftharpoons \text{Pr}^{3+}$	3.2
$\text{H}_4\text{XeO}_6 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{XeO}_3 + 3\text{H}_2\text{O}$	2.42	$\text{Cf}^{4+} + \text{e} \rightleftharpoons \text{Cf}^{3+}$	3.3
$\text{O}(\text{g}) + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_2\text{O}$	2.421	$\text{XeF} + \text{e} \rightleftharpoons \text{Xe} + \text{F}^-$	3.4
$\text{Am}^{4+} + \text{e} \rightleftharpoons \text{Am}^{3+}$	2.60		

**TABLE 3**  
**Reduction Reactions Having  $E^\circ$  Values More Negative than that of the Standard Hydrogen Electrode**

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_2$	0.00000	$\text{Cu}(\text{OH})_2 + 2\text{e} \rightleftharpoons \text{Cu} + 2\text{OH}^-$	-0.222
$2\text{D}^+ + 2\text{e} \rightleftharpoons \text{D}_2$	-0.013	$\text{V}_2\text{O}_5 + 10\text{H}^+ + 10\text{e} \rightleftharpoons 2\text{V} + 5\text{H}_2\text{O}$	-0.242
$\text{AgCN} + \text{e} \rightleftharpoons \text{Ag} + \text{CN}^-$	-0.017	$\text{CdSO}_4 + 2\text{e} \rightleftharpoons \text{Cd} + \text{SO}_4^{2-}$	-0.246
$2\text{WO}_3 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{W}_2\text{O}_5 + \text{H}_2\text{O}$	-0.029	$\text{V}(\text{OH})_4^+ + 4\text{H}^+ + 5\text{e} \rightleftharpoons \text{V} + 4\text{H}_2\text{O}$	-0.254
$\text{W}_2\text{O}_5 + 2\text{H}^+ + 2\text{e} \rightleftharpoons 2\text{WO}_2 + \text{H}_2\text{O}$	-0.031	$\text{V}^{3+} + \text{e} \rightleftharpoons \text{V}^{2+}$	-0.255
$\text{Ag}_2\text{S} + 2\text{H}^+ + 2\text{e} \rightleftharpoons 2\text{Ag} + \text{H}_2\text{S}$	-0.0366	$\text{Ni}^{2+} + 2\text{e} \rightleftharpoons \text{Ni}$	-0.257
$\text{Fe}^{3+} + 3\text{e} \rightleftharpoons \text{Fe}$	-0.037	$\text{PbCl}_2 + 2\text{e} \rightleftharpoons \text{Pb} + 2\text{Cl}^-$	-0.2675
$\text{Hg}_2\text{I}_2 + 2\text{e} \rightleftharpoons 2\text{Hg} + 2\text{I}^-$	-0.0405	$\text{H}_3\text{PO}_4 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_3\text{PO}_3 + \text{H}_2\text{O}$	-0.276
$\text{Tl}(\text{OH})_3 + 2\text{e} \rightleftharpoons \text{TlOH} + 2\text{OH}^-$	-0.05	$\text{Co}^{2+} + 2\text{e} \rightleftharpoons \text{Co}$	-0.28
$\text{TiOH}^{3+} + \text{H}^+ + \text{e} \rightleftharpoons \text{Ti}^{3+} + \text{H}_2\text{O}$	-0.055	$\text{PbBr}_2 + 2\text{e} \rightleftharpoons \text{Pb} + 2\text{Br}^-$	-0.284
$2\text{H}_2\text{SO}_3 + \text{H}^+ + 2\text{e} \rightleftharpoons \text{HS}_2\text{O}_4^- + 2\text{H}_2\text{O}$	-0.056	$\text{Tl}^+ + \text{e} \rightleftharpoons \text{Tl}(\text{Hg})$	-0.3338
$\text{P}(\text{white}) + 3\text{H}^+ + 3\text{e} \rightleftharpoons \text{PH}_3(\text{g})$	-0.063	$\text{Tl}^+ + \text{e} \rightleftharpoons \text{Tl}$	-0.336
$\text{O}_2 + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{HO}_2^- + \text{OH}^-$	-0.076	$\text{In}^{3+} + 3\text{e} \rightleftharpoons \text{In}$	-0.3382
$2\text{Cu}(\text{OH})_2 + 2\text{e} \rightleftharpoons \text{Cu}_2\text{O} + 2\text{OH}^- + \text{H}_2\text{O}$	-0.080	$\text{TlOH} + \text{e} \rightleftharpoons \text{Tl} + \text{OH}^-$	-0.34
$\text{Se} + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_2\text{Se}$	-0.082	$\text{PbF}_2 + 2\text{e} \rightleftharpoons \text{Pb} + 2\text{F}^-$	-0.3444
$\text{WO}_3 + 6\text{H}^+ + 6\text{e} \rightleftharpoons \text{W} + 3\text{H}_2\text{O}$	-0.090	$\text{PbSO}_4 + 2\text{e} \rightleftharpoons \text{Pb}(\text{Hg}) + \text{SO}_4^{2-}$	-0.3505
$\text{SnO}_2 + 4\text{H}^+ + 2\text{e} \rightleftharpoons \text{Sn}^{2+} + 2\text{H}_2\text{O}$	-0.094	$\text{Cd}^{2+} + 2\text{e} \rightleftharpoons \text{Cd}(\text{Hg})$	-0.3521
$\text{Md}^{3+} + \text{e} \rightleftharpoons \text{Md}^{2+}$	-0.1	$\text{PbSO}_4 + 2\text{e} \rightleftharpoons \text{Pb} + \text{SO}_4^{2-}$	-0.3588
$\text{P}(\text{red}) + 3\text{H}^+ + 3\text{e} \rightleftharpoons \text{PH}_3(\text{g})$	-0.111	$\text{Cu}_2\text{O} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons 2\text{Cu} + 2\text{OH}^-$	-0.360
$\text{SnO}_2 + 4\text{H}^+ + 4\text{e} \rightleftharpoons \text{Sn} + 2\text{H}_2\text{O}$	-0.117	$\text{Eu}^{3+} + \text{e} \rightleftharpoons \text{Eu}^{2+}$	-0.36
$\text{GeO}_2 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{GeO} + \text{H}_2\text{O}$	-0.118	$\text{PbI}_2 + 2\text{e} \rightleftharpoons \text{Pb} + 2\text{I}^-$	-0.365
$\text{WO}_2 + 4\text{H}^+ + 4\text{e} \rightleftharpoons \text{W} + 2\text{H}_2\text{O}$	-0.119	$\text{SeO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e} \rightleftharpoons \text{Se} + 6\text{OH}^-$	-0.366
$\text{Pb}^{2+} + 2\text{e} \rightleftharpoons \text{Pb}(\text{Hg})$	-0.1205	$\text{Se} + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_2\text{Se}(\text{aq})$	-0.399
$\text{Pb}^{2+} + 2\text{e} \rightleftharpoons \text{Pb}$	-0.1262	$\text{In}^{2+} + \text{e} \rightleftharpoons \text{In}^+$	-0.40
$\text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3\text{e} \rightleftharpoons \text{Cr}(\text{OH})_3 + 5\text{OH}^-$	-0.13	$\text{Cd}^{2+} + 2\text{e} \rightleftharpoons \text{Cd}$	-0.4030
$\text{Sn}^{2+} + 2\text{e} \rightleftharpoons \text{Sn}$	-0.1375	$\text{Cr}^{3+} + \text{e} \rightleftharpoons \text{Cr}^{2+}$	-0.407
$\text{In}^+ + \text{e} \rightleftharpoons \text{In}$	-0.14	$2\text{S} + 2\text{e} \rightleftharpoons \text{S}_2^{2-}$	-0.42836
$\text{O}_2 + 2\text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{H}_2\text{O}_2 + 2\text{OH}^-$	-0.146	$\text{Tl}_2\text{SO}_4 + 2\text{e} \rightleftharpoons \text{Tl} + \text{SO}_4^{2-}$	-0.4360
$\text{MoO}_2 + 4\text{H}^+ + 4\text{e} \rightleftharpoons \text{Mo} + 4\text{H}_2\text{O}$	-0.152	$\text{In}^{3+} + 2\text{e} \rightleftharpoons \text{In}^+$	-0.443
$\text{AgI} + \text{e} \rightleftharpoons \text{Ag} + \text{I}^-$	-0.15224	$\text{Fe}^{2+} + 2\text{e} \rightleftharpoons \text{Fe}$	-0.447
$2\text{NO}_2^- + 2\text{H}_2\text{O} + 4\text{e} \rightleftharpoons \text{N}_2\text{O}_2^{2-} + 4\text{OH}^-$	-0.18	$\text{H}_3\text{PO}_3 + 3\text{H}^+ + 3\text{e} \rightleftharpoons \text{P} + 3\text{H}_2\text{O}$	-0.454
$\text{H}_2\text{GeO}_3 + 4\text{H}^+ + 4\text{e} \rightleftharpoons \text{Ge} + 3\text{H}_2\text{O}$	-0.182	$\text{Bi}_2\text{O}_3 + 3\text{H}_2\text{O} + 6\text{e} \rightleftharpoons 2\text{Bi} + 6\text{OH}^-$	-0.46
$\text{SnO}_2 + 3\text{H}^+ + 2\text{e} \rightleftharpoons \text{SnOH}^+ + \text{H}_2\text{O}$	-0.194	$\text{NO}_2^- + \text{H}_2\text{O} + \text{e} \rightleftharpoons \text{NO} + 2\text{OH}^-$	-0.46
$\text{CO}_2 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{HCOOH}$	-0.199	$\text{PbHPO}_4 + 2\text{e} \rightleftharpoons \text{Pb} + \text{HPO}_4^{2-}$	-0.465
$\text{Mo}^{3+} + 3\text{e} \rightleftharpoons \text{Mo}$	-0.200	$\text{S} + 2\text{e} \rightleftharpoons \text{S}^{2-}$	-0.47627
$\text{Ga}^+ + \text{e} \rightleftharpoons \text{Ga}$	-0.2	$\text{S} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{HS}^- + \text{OH}^-$	-0.478
$2\text{SO}_2^{2-} + 4\text{H}^+ + 2\text{e} \rightleftharpoons \text{S}_2\text{O}_6^{2-} + \text{H}_2\text{O}$	-0.22	$\text{B}(\text{OH})_3 + 7\text{H}^+ + 8\text{e} \rightleftharpoons \text{BH}_4^- + 3\text{H}_2\text{O}$	-0.481

ELECTROCHEMICAL SERIES (continued)

TABLE 3  
Reduction Reactions Having  $E^\circ$  Values More Negative than that of the Standard Hydrogen Electrode (continued)

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$\text{In}^{3+} + e \rightleftharpoons \text{In}^{2+}$	-0.49	$\text{SnO}_2 + 2 \text{H}_2\text{O} + 4 e \rightleftharpoons \text{Sn} + 4 \text{OH}^-$	-0.945
$\text{ZnOH}^+ + \text{H}^+ + 2 e \rightleftharpoons \text{Zn} + \text{H}_2\text{O}$	-0.497	$\text{In}(\text{OH})_3 + 3 e \rightleftharpoons \text{In} + 3 \text{OH}^-$	-0.99
$\text{GaOH}^{2+} + \text{H}^+ + 3 e \rightleftharpoons \text{Ga} + \text{H}_2\text{O}$	-0.498	$\text{NpO}_2 + \text{H}_2\text{O} + \text{H}^+ + e \rightleftharpoons \text{Np}(\text{OH})_3$	-0.962
$\text{H}_3\text{PO}_3 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{H}_3\text{PO}_2 + \text{H}_2\text{O}$	-0.499	$\text{In}(\text{OH})_4^- + 3 e \rightleftharpoons \text{In} + 4 \text{OH}^-$	-1.007
$\text{TiO}_2 + 4 \text{H}^+ + 2 e \rightleftharpoons \text{Ti}^{2+} + 2 \text{H}_2\text{O}$	-0.502	$\text{In}_2\text{O}_3 + 3 \text{H}_2\text{O} + 6 e \rightleftharpoons 2 \text{In} + 6 \text{OH}^-$	-1.034
$\text{H}_3\text{PO}_2 + \text{H}^+ + e \rightleftharpoons \text{P} + 2 \text{H}_2\text{O}$	-0.508	$\text{PO}_4^{3-} + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{HPO}_3^{2-} + 3 \text{OH}^-$	-1.05
$\text{Sb} + 3 \text{H}^+ + 3 e \rightleftharpoons \text{SbH}_3$	-0.510	$\text{Yb}^{3+} + e \rightleftharpoons \text{Yb}^{2+}$	-1.05
$\text{HPbO}_2^- + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Pb} + 3 \text{OH}^-$	-0.537	$\text{Nb}^{3+} + 3 e \rightleftharpoons \text{Nb}$	-1.099
$\text{Ga}^{3+} + 3 e \rightleftharpoons \text{Ga}$	-0.549	$\text{Fm}^{3+} + e \rightleftharpoons \text{Fm}^{2+}$	-1.1
$\text{TlCl} + e \rightleftharpoons \text{Tl} + \text{Cl}^-$	-0.5568	$2 \text{SO}_3^{2-} + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{S}_2\text{O}_4^{2-} + 4 \text{OH}^-$	-1.12
$\text{Fe}(\text{OH})_3 + e \rightleftharpoons \text{Fe}(\text{OH})_2 + \text{OH}^-$	-0.56	$\text{Te} + 2 e \rightleftharpoons \text{Te}^{2-}$	-1.143
$\text{TeO}_3^{2-} + 3 \text{H}_2\text{O} + 4 e \rightleftharpoons \text{Te} + 6 \text{OH}^-$	-0.57	$\text{V}^{2+} + 2 e \rightleftharpoons \text{V}$	-1.175
$2 \text{SO}_3^{2-} + 3 \text{H}_2\text{O} + 4 e \rightleftharpoons \text{S}_2\text{O}_3^{2-} + 6 \text{OH}^-$	-0.571	$\text{Mn}^{2+} + 2 e \rightleftharpoons \text{Mn}$	-1.185
$\text{PbO} + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Pb} + 2 \text{OH}^-$	-0.580	$\text{Zn}(\text{OH})_4^{2-} + 2 e \rightleftharpoons \text{Zn} + 4 \text{OH}^-$	-1.199
$\text{ReO}_2 + 4 \text{H}_2\text{O} + 7 e \rightleftharpoons \text{Re} + 8 \text{OH}^-$	-0.584	$\text{CrO}_2 + 2 \text{H}_2\text{O} + 3 e \rightleftharpoons \text{Cr} + 4 \text{OH}^-$	-1.2
$\text{SbO}_3^- + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{SbO}_2^- + 2 \text{OH}^-$	-0.59	$\text{No}^{3+} + 3 e \rightleftharpoons \text{No}$	-1.20
$\text{Ta}^{3+} + 3 e \rightleftharpoons \text{Ta}$	-0.6	$\text{ZnO}_2^- + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Zn} + 4 \text{OH}^-$	-1.215
$\text{U}^{4+} + e \rightleftharpoons \text{U}^{3+}$	-0.607	$\text{H}_2\text{GaO}_3^- + \text{H}_2\text{O} + 3 e \rightleftharpoons \text{Ga} + 4 \text{OH}^-$	-1.219
$\text{As} + 3 \text{H}^+ + 3 e \rightleftharpoons \text{AsH}_3$	-0.608	$\text{H}_2\text{BO}_3^- + 5 \text{H}_2\text{O} + 8 e \rightleftharpoons \text{BH}_4^- + 8 \text{OH}^-$	-1.24
$\text{Nb}_2\text{O}_5 + 10 \text{H}^+ + 10 e \rightleftharpoons 2 \text{Nb} + 5 \text{H}_2\text{O}$	-0.644	$\text{SiF}_6^{2-} + 4 e \rightleftharpoons \text{Si} + 6 \text{F}^-$	-1.24
$\text{NbO}_2 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{NbO} + \text{H}_2\text{O}$	-0.646	$\text{Zn}(\text{OH})_2 + 2 e \rightleftharpoons \text{Zn} + 2 \text{OH}^-$	-1.249
$\text{Cd}(\text{OH})_4^{2-} + 2 e \rightleftharpoons \text{Cd} + 4 \text{OH}^-$	-0.658	$\text{ZnO} + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Zn} + 2 \text{OH}^-$	-1.260
$\text{TlBr} + e \rightleftharpoons \text{Tl} + \text{Br}^-$	-0.658	$\text{Es}^{3+} + e \rightleftharpoons \text{Es}^{2+}$	-1.3
$\text{SbO}_2^- + 2 \text{H}_2\text{O} + 3 e \rightleftharpoons \text{Sb} + 4 \text{OH}^-$	-0.66	$\text{Pa}^{3+} + 3 e \rightleftharpoons \text{Pa}$	-1.34
$\text{AsO}_2^- + 2 \text{H}_2\text{O} + 3 e \rightleftharpoons \text{As} + 4 \text{OH}^-$	-0.68	$\text{Ti}^{3+} + 3 e \rightleftharpoons \text{Ti}$	-1.37
$\text{NbO}_2 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Nb} + 2 \text{H}_2\text{O}$	-0.690	$\text{Ce}^{3+} + 3 e \rightleftharpoons \text{Ce}(\text{Hg})$	-1.4373
$\text{Ag}_2\text{S} + 2 e \rightleftharpoons 2 \text{Ag} + \text{S}^{2-}$	-0.691	$\text{UO}_2^{2+} + 4 \text{H}^+ + 6 e \rightleftharpoons \text{U} + 2 \text{H}_2\text{O}$	-1.444
$\text{AsO}_4^{3-} + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{AsO}_2^- + 4 \text{OH}^-$	-0.71	$\text{Zr}^{4+} + 4 e \rightleftharpoons \text{Zr}$	-1.45
$\text{Ni}(\text{OH})_2 + 2 e \rightleftharpoons \text{Ni} + 2 \text{OH}^-$	-0.72	$\text{Cr}(\text{OH})_3 + 3 e \rightleftharpoons \text{Cr} + 3 \text{OH}^-$	-1.48
$\text{Co}(\text{OH})_2 + 2 e \rightleftharpoons \text{Co} + 2 \text{OH}^-$	-0.73	$\text{Pa}^{4+} + 4 e \rightleftharpoons \text{Pa}$	-1.49
$\text{NbO} + 2 \text{H}^+ + 2 e \rightleftharpoons \text{Nb} + \text{H}_2\text{O}$	-0.733	$\text{HfO}_2 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Hf} + 2 \text{H}_2\text{O}$	-1.505
$\text{H}_2\text{SeO}_3 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Se} + 3 \text{H}_2\text{O}$	-0.74	$\text{Hf}^{4+} + 4 e \rightleftharpoons \text{Hf}$	-1.55
$\text{Cr}^{3+} + 3 e \rightleftharpoons \text{Cr}$	-0.744	$\text{Sm}^{3+} + e \rightleftharpoons \text{Sm}^{2+}$	-1.55
$\text{Ta}_2\text{O}_5 + 10 \text{H}^+ + 10 e \rightleftharpoons 2 \text{Ta} + 5 \text{H}_2\text{O}$	-0.750	$\text{ZrO}_2 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Zr} + 2 \text{H}_2\text{O}$	-1.553
$\text{TlI} + e \rightleftharpoons \text{Tl} + \text{I}^-$	-0.752	$\text{Mn}(\text{OH})_2 + 2 e \rightleftharpoons \text{Mn} + 2 \text{OH}^-$	-1.56
$\text{Zn}^{2+} + 2 e \rightleftharpoons \text{Zn}$	-0.7618	$\text{Ba}^{2+} + 2 e \rightleftharpoons \text{Ba}(\text{Hg})$	-1.570
$\text{Zn}^{2+} + 2 e \rightleftharpoons \text{Zn}(\text{Hg})$	-0.7628	$\text{Bk}^{2+} + 2 e \rightleftharpoons \text{Bk}$	-1.6
$\text{CdO} + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Cd} + 2 \text{OH}^-$	-0.783	$\text{Cf}^{3+} + e \rightleftharpoons \text{Cf}^{2+}$	-1.6
$\text{Te} + 2 \text{H}^+ + 2 e \rightleftharpoons \text{H}_2\text{Te}$	-0.793	$\text{Ti}^{2+} + 2 e \rightleftharpoons \text{Ti}$	-1.630
$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O} + 2 e \rightleftharpoons \text{Zn}(\text{Hg}) + \text{SO}_4^{2-} + 7 \text{H}_2\text{O}$ (Saturated $\text{ZnSO}_4$ )	-0.7993	$\text{Md}^{3+} + 3 e \rightleftharpoons \text{Md}$	-1.65
$\text{Bi} + 3 \text{H}^+ + 3 e \rightleftharpoons \text{BiH}_3$	-0.8	$\text{HPO}_3^{2-} + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{H}_2\text{PO}_2^- + 3 \text{OH}^-$	-1.65
$\text{SiO} + 2 \text{H}^+ + 2 e \rightleftharpoons \text{Si} + \text{H}_2\text{O}$	-0.8	$\text{Al}^{3+} + 3 e \rightleftharpoons \text{Al}$	-1.662
$\text{Cd}(\text{OH})_2 + 2 e \rightleftharpoons \text{Cd}(\text{Hg}) + 2 \text{OH}^-$	-0.809	$\text{SiO}_3^{2-} + \text{H}_2\text{O} + 4 e \rightleftharpoons \text{Si} + 6 \text{OH}^-$	-1.697
$2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{H}_2 + 2 \text{OH}^-$	-0.8277	$\text{HPO}_3^{2-} + 2 \text{H}_2\text{O} + 3 e \rightleftharpoons \text{P} + 5 \text{OH}^-$	-1.71
$2 \text{NO}_3^- + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{N}_2\text{O}_4 + 4 \text{OH}^-$	-0.85	$\text{HfO}^{2+} + 2 \text{H}^+ + 4 e \rightleftharpoons \text{Hf} + \text{H}_2\text{O}$	-1.724
$\text{H}_3\text{BO}_3 + 3 \text{H}^+ + 3 e \rightleftharpoons \text{B} + 3 \text{H}_2\text{O}$	-0.8698	$\text{ThO}_2 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Th} + 2 \text{H}_2\text{O}$	-1.789
$\text{P} + 3 \text{H}_2\text{O} + 3 e \rightleftharpoons \text{PH}_3(\text{g}) + 3 \text{OH}^-$	-0.87	$\text{H}_2\text{BO}_3^- + \text{H}_2\text{O} + 3 e \rightleftharpoons \text{B} + 4 \text{OH}^-$	-1.79
$\text{Ti}^{3+} + e \rightleftharpoons \text{Ti}^{2+}$	-0.9	$\text{Sr}^{2+} + 2 e \rightleftharpoons \text{Sr}(\text{Hg})$	-1.793
$\text{HSnO}_2^- + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Sn} + 3 \text{OH}^-$	-0.909	$\text{U}^{3+} + 3 e \rightleftharpoons \text{U}$	-1.798
$\text{Cr}^{2+} + 2 e \rightleftharpoons \text{Cr}$	-0.913	$\text{H}_2\text{PO}_2^- + e \rightleftharpoons \text{P} + 2 \text{OH}^-$	-1.82
$\text{Se} + 2 e \rightleftharpoons \text{Se}^{2-}$	-0.924	$\text{Be}^{2+} + 2 e \rightleftharpoons \text{Be}$	-1.847
$\text{SO}_4^{2-} + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{SO}_3^{2-} + 2 \text{OH}^-$	-0.93	$\text{Np}^{3+} + 3 e \rightleftharpoons \text{Np}$	-1.856
$\text{Sn}(\text{OH})_6^{2-} + 2 e \rightleftharpoons \text{HSnO}_2^- + 3 \text{OH}^- + \text{H}_2\text{O}$	-0.93	$\text{Fm}^{3+} + 3 e \rightleftharpoons \text{Fm}$	-1.89
		$\text{Th}^{4+} + 4 e \rightleftharpoons \text{Th}$	-1.899

ELECTROCHEMICAL SERIES (continued)

TABLE 3  
Reduction Reactions Having  $E^\circ$  Values More Negative than that of the Standard Hydrogen Electrode  
(continued)

Reaction	$E^\circ/V$	Reaction	$E^\circ/V$
$\text{Am}^{2+} + 2 e \rightleftharpoons \text{Am}$	-1.9	$\text{ZrO}(\text{OH})_2 + \text{H}_2\text{O} + 4 e \rightleftharpoons \text{Zr} + 4 \text{OH}^-$	-2.36
$\text{Pa}^{4+} + e \rightleftharpoons \text{Pa}^{3+}$	-1.9	$\text{Mg}^{2+} + 2 e \rightleftharpoons \text{Mg}$	-2.372
$\text{Es}^{3+} + 3 e \rightleftharpoons \text{Es}$	-1.91	$\text{Y}^{3+} + 3 e \rightleftharpoons \text{Y}$	-2.372
$\text{Cf}^{3+} + 3 e \rightleftharpoons \text{Cf}$	-1.94	$\text{La}^{3+} + 3 e \rightleftharpoons \text{La}$	-2.379
$\text{Lr}^{3+} + 3 e \rightleftharpoons \text{Lr}$	-1.96	$\text{Tm}^{2+} + 2 e \rightleftharpoons \text{Tm}$	-2.4
$\text{Eu}^{3+} + 3 e \rightleftharpoons \text{Eu}$	-1.991	$\text{Md}^{2+} + 2 e \rightleftharpoons \text{Md}$	-2.40
$\text{Er}^{2+} + 2 e \rightleftharpoons \text{Er}$	-2.0	$\text{Th}(\text{OH})_4 + 4 e \rightleftharpoons \text{Th} + 4 \text{OH}^-$	-2.48
$\text{Pr}^{2+} + 2 e \rightleftharpoons \text{Pr}$	-2.0	$\text{HfO}(\text{OH})_2 + \text{H}_2\text{O} + 4 e \rightleftharpoons \text{Hf} + 4 \text{OH}^-$	-2.50
$\text{Pu}^{3+} + 3 e \rightleftharpoons \text{Pu}$	-2.031	$\text{No}^{2+} + 2 e \rightleftharpoons \text{No}$	-2.50
$\text{Cm}^{3+} + 3 e \rightleftharpoons \text{Cm}$	-2.04	$\text{Dy}^{3+} + e \rightleftharpoons \text{Dy}^{2+}$	-2.6
$\text{Am}^{3+} + 3 e \rightleftharpoons \text{Am}$	-2.048	$\text{Pm}^{3+} + e \rightleftharpoons \text{Pm}^{2+}$	-2.6
$\text{AlF}_6^{3-} + 3 e \rightleftharpoons \text{Al} + 6 \text{F}^-$	-2.069	$\text{Be}_2\text{O}_3^{2-} + 3 \text{H}_2\text{O} + 4 e \rightleftharpoons 2 \text{Be} + 6 \text{OH}^-$	-2.63
$\text{Sc}^{3+} + 3 e \rightleftharpoons \text{Sc}$	-2.077	$\text{Sm}^{2+} + 2 e \rightleftharpoons \text{Sm}$	-2.68
$\text{Ho}^{2+} + 2 e \rightleftharpoons \text{Ho}$	-2.1	$\text{Mg}(\text{OH})_2 + 2 e \rightleftharpoons \text{Mg} + 2 \text{OH}^-$	-2.690
$\text{Nd}^{2+} + 2 e \rightleftharpoons \text{Nd}$	-2.1	$\text{Nd}^{3+} + e \rightleftharpoons \text{Nd}^{2+}$	-2.7
$\text{Cf}^{2+} + 2 e \rightleftharpoons \text{Cf}$	-2.12	$\text{Mg}^+ + e \rightleftharpoons \text{Mg}$	-2.70
$\text{Yb}^{3+} + 3 e \rightleftharpoons \text{Yb}$	-2.19	$\text{Na}^+ + e \rightleftharpoons \text{Na}$	-2.71
$\text{Ac}^{3+} + 3 e \rightleftharpoons \text{Ac}$	-2.20	$\text{Yb}^{2+} + 2 e \rightleftharpoons \text{Yb}$	-2.76
$\text{Dy}^{2+} + 2 e \rightleftharpoons \text{Dy}$	-2.2	$\text{Bk}^{3+} + e \rightleftharpoons \text{Bk}^{2+}$	-2.8
$\text{Tm}^{3+} + e \rightleftharpoons \text{Tm}^{2+}$	-2.2	$\text{Ho}^{3+} + e \rightleftharpoons \text{Ho}^{2+}$	-2.8
$\text{Pm}^{2+} + 2 e \rightleftharpoons \text{Pm}$	-2.2	$\text{Ra}^{2+} + 2 e \rightleftharpoons \text{Ra}$	-2.8
$\text{Es}^{2+} + 2 e \rightleftharpoons \text{Es}$	-2.23	$\text{Eu}^{2+} + 2 e \rightleftharpoons \text{Eu}$	-2.812
$\text{H}_2 + 2 e \rightleftharpoons 2 \text{H}^-$	-2.23	$\text{Ca}^{2+} + 2 e \rightleftharpoons \text{Ca}$	-2.868
$\text{Gd}^{3+} + 3 e \rightleftharpoons \text{Gd}$	-2.279	$\text{Sr}(\text{OH})_2 + 2 e \rightleftharpoons \text{Sr} + 2 \text{OH}^-$	-2.88
$\text{Tb}^{3+} + 3 e \rightleftharpoons \text{Tb}$	-2.28	$\text{Sr}^{2+} + 2 e \rightleftharpoons \text{Sr}$	-2.89
$\text{Lu}^{3+} + 3 e \rightleftharpoons \text{Lu}$	-2.28	$\text{Fr}^+ + e \rightleftharpoons \text{Fr}$	-2.9
$\text{Dy}^{3+} + 3 e \rightleftharpoons \text{Dy}$	-2.295	$\text{La}(\text{OH})_3 + 3 e \rightleftharpoons \text{La} + 3 \text{OH}^-$	-2.90
$\text{Am}^{3+} + e \rightleftharpoons \text{Am}^{2+}$	-2.3	$\text{Ba}^{2+} + 2 e \rightleftharpoons \text{Ba}$	-2.912
$\text{Fm}^{2+} + 2 e \rightleftharpoons \text{Fm}$	-2.30	$\text{K}^+ + e \rightleftharpoons \text{K}$	-2.931
$\text{Pm}^{3+} + 3 e \rightleftharpoons \text{Pm}$	-2.30	$\text{Rb}^+ + e \rightleftharpoons \text{Rb}$	-2.98
$\text{Sm}^{3+} + 3 e \rightleftharpoons \text{Sm}$	-2.304	$\text{Ba}(\text{OH})_2 + 2 e \rightleftharpoons \text{Ba} + 2 \text{OH}^-$	-2.99
$\text{Al}(\text{OH})_3 + 3 e \rightleftharpoons \text{Al} + 3 \text{OH}^-$	-2.31	$\text{Er}^{3+} + e \rightleftharpoons \text{Er}^{2+}$	-3.0
$\text{Tm}^{3+} + 3 e \rightleftharpoons \text{Tm}$	-2.319	$\text{Ca}(\text{OH})_2 + 2 e \rightleftharpoons \text{Ca} + 2 \text{OH}^-$	-3.02
$\text{Nd}^{3+} + 3 e \rightleftharpoons \text{Nd}$	-2.323	$\text{Cs}^+ + e \rightleftharpoons \text{Cs}$	-3.026
$\text{Al}(\text{OH})^- + 3 e \rightleftharpoons \text{Al} + 4 \text{OH}^-$	-2.328	$\text{Li}^+ + e \rightleftharpoons \text{Li}$	-3.0401
$\text{H}_2\text{AlO}_3^- + \text{H}_2\text{O} + 3 e \rightleftharpoons \text{Al} + 4 \text{OH}^-$	-2.33	$3 \text{N}_2 + 2 \text{H}^+ + 2 e \rightleftharpoons 2 \text{HN}_3$	-3.09
$\text{Ho}^{3+} + 3 e \rightleftharpoons \text{Ho}$	-2.33	$\text{Pr}^{3+} + e \rightleftharpoons \text{Pr}^{2+}$	-3.1
$\text{Er}^{3+} + 3 e \rightleftharpoons \text{Er}$	-2.331	$\text{Ca}^+ + e \rightleftharpoons \text{Ca}$	-3.80
$\text{Ce}^{3+} + 3 e \rightleftharpoons \text{Ce}$	-2.336	$\text{Sr}^+ + e \rightleftharpoons \text{Sr}$	-4.10
$\text{Pr}^{3+} + 3 e \rightleftharpoons \text{Pr}$	-2.353		

## REDUCTION AND OXIDATION POTENTIALS FOR CERTAIN ION RADICALS

Petr Vanýsek

There are two tables for ion radicals. The first table lists reduction potentials for organic compounds which produce anion radicals during reduction, a process described as  $A + e^- \rightleftharpoons A^-$ . The second table lists oxidation potentials for organic compounds which produce cation radicals during oxidation, a process described as  $A \rightleftharpoons A^+ + e^-$ . To obtain reduction potential for a reverse reaction, the sign for the potential is changed.

Unlike the table of the Electrochemical Series, which lists *standard* potentials, values for radicals are experimental values with experimental conditions given in the second column. Since the measurements leading to potentials for ion radicals are very dependent on conditions, an attempt to report standard potentials for radicals would serve no useful purpose. For the same reason, the potentials are also reported as experimental values, usually a half-wave potential ( $E_{1/2}$  in polarography) or a peak potential ( $E_p$  in cyclic voltammetry). Unless otherwise stated, the values are reported vs. SCE (saturated calomel electrode). To obtain a value vs. normal hydrogen electrode, 0.241 V has to be added to the SCE values. All the ion radicals chosen for inclusion in the tables result from electrochemically reversible reactions. More detailed data on ion radicals can be found in the *Encyclopedia of Electrochemistry of Elements*, (A. J. Bard, Ed.), Vol. XI and XII in particular, Marcel Dekker, New York, 1978.

Abbreviations are: CV — cyclic voltammetry; DMF — *N,N*-Dimethylformamide; *E* swp — potential sweep;  $E^\circ$  — standard potential;  $E_p$  — peak potential;  $E_{p/2}$  — half-peak potential;  $E_{1/2}$  — half wave potential; *M* — mol/L; MeCN — acetonitrile; pol — polarography; rot Pt disk — rotated Pt disk; SCE — saturated calomel electrode; TBABF<sub>4</sub> — tetrabutylammonium tetrafluoroborate; TBAI — tetrabutylammonium iodide; TBAP — tetrabutylammonium perchlorate; TEABr — tetraethylammonium bromide; TEAP — tetraethylammonium perchlorate; THF — tetrahydrofuran; TPACF<sub>3</sub>SO<sub>3</sub> — tetrapropylammonium trifluoromethanesulfite; TPAP — tetrapropylammonium perchlorate; and wr — wire.

### Reduction Potentials (Products are Anion Radicals)

Substance	Conditions/electrode/technique	Potential V (vs. SCE)
Acetone	DMF, 0.1 <i>M</i> TEABr/Hg/pol	$E_{1/2} = -2.84$
1-Naphthylphenylacetylene	DMF, 0.03 <i>M</i> TBAI/Hg/pol	$E_{1/2} = -1.91$
1-Naphthalenecarboxyaldehyde	-/Hg/pol	$E_{1/2} = -0.91$
2-Naphthalenecarboxyaldehyde	-/Hg/pol	$E_{1/2} = -0.96$
2-Phenanthrenecarboxyaldehyde	-/Hg/pol	$E_{1/2} = -1.00$
3-Phenanthrenecarboxyaldehyde	-/Hg/pol	$E_{1/2} = -0.94$
9-Phenanthrenecarboxyaldehyde	-/Hg/pol	$E_{1/2} = -0.83$
1-Anthracenecarboxyaldehyde	-/Hg/pol	$E_{1/2} = -0.75$
1-Pyrenecarboxyaldehyde	-/Hg/pol	$E_{1/2} = -0.76$
2-Pyrenecarboxyaldehyde	-/Hg/pol	$E_{1/2} = -1.00$
Anthracene	DMF, 0.1 <i>M</i> TBAP/Pt disk/CV	$E_p = -2.00$
	DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -1.93$
	MeCN, 0.1 <i>M</i> TEAP/Hg/CV	$E_{1/2} = -2.07$
	DMF, 0.1 <i>M</i> TBAI/Hg/pol	$E_{1/2} = -1.92$
9,10-Dimethylantracene	DMF, 0.1 <i>M</i> TBAP/Pt/CV	$E_p = -2.08$
	MeCN, 0.1 <i>M</i> TBAP/Pt/CV	$E_p = -2.10$
1-Phenylantracene	DMF, 0.5 <i>M</i> TBABF <sub>2</sub> /Hg/CV	$E_{1/2} = -1.91$
	DMF, 0.1 <i>M</i> TBAI/Hg/pol	$E_{1/2} = -1.878$
2-Phenylantracene	DMF, 0.1 <i>M</i> TBAI/Hg/pol	$E_{1/2} = -1.875$
8-Phenylantracene	DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -1.91$
9-Phenylantracene	DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -1.93$
	DMF, 0.1 <i>M</i> TBAI/Hg/pol	$E_{1/2} = -1.863$
1,8-Diphenylantracene	DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -1.88$
1,9-Diphenylantracene	DMF, 0.1 <i>M</i> TBAI/Hg/pol	$E_{1/2} = -1.846$
1,10-Diphenylantracene	DMF, 0.1 <i>M</i> TBAI/Hg/pol	$E_{1/2} = -1.786$
8,9-Diphenylantracene	DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -1.90$
9,10-Diphenylantracene	MeCN, 0.1 <i>M</i> TBAP/rot Pt/E swp	$E_{1/2} = -1.83$
	DMF, 0.1 <i>M</i> TBAI/Hg/pol	$E_{1/2} = -1.835$
1,8,9-Triphenylantracene	DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -1.85$
1,8,10-Triphenylantracene	DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -1.81$
9,10-Dibiphenylantracene	MeCN, 0.1 <i>M</i> TBAP/rot Pt/E swp	$E_{1/2} = -1.94$
Benz(a)anthracene	MeCN, 0.1 <i>M</i> TEAP/Hg/CV	$E_{1/2} = -2.11$
	MeCN, 0.1 <i>M</i> TEAP/Hg/pol	$E_{1/2} = -2.40^a$
Azulene	DMF, 0.1 <i>M</i> TBAI/Hg/pol	$E_{1/2} = -1.10^c$
Annulene	DMF, 0.5 <i>M</i> TBAP 0°C/Hg/pol	$E_{1/2} = -1.23$
Benzaldehyde	DMF, 0.1 <i>M</i> TBAP/Hg/pol	$E_{1/2} = -1.67$
Benzil	DMSO, 0.1 <i>M</i> TBAP/Hg/pol	$E_{1/2} = -1.04$

REDUCTION AND OXIDATION POTENTIALS FOR CERTAIN ION RADICALS (continued)

Reduction Potentials (Products are Anion Radicals) (continued)

Substance	Conditions/electrode/technique	Potential V (vs. SCE)
Benzophenone	-/Hg/pol	$E_{1/2} = -1.80$
	DMF/Pt dsk/CV	$E^{\circ} = -1.72$
Chrysene	MeCN, 0.1 M TEAP/Hg/pol	$E_{1/2} = -2.73^a$
Fluoranthrene	DMF, 0.1 M TBAP/Pt dsk/CV	$E_p = -1.76$
Cyclohexanone	DMF, 0.1 M TEABr/Hg/pol	$E_{1/2} = -2.79$
5,5-Dimethyl-3-phenyl-2-cyclohexen-1-one	DMF, 0.5 M/Hg/pol	$E_{1/2} = -1.71$
1,2,3-Indanetrione hydrate (ninhydrin)	DMF, 0.2 M NaNO <sub>3</sub> /Hg/pol	$E_{1/2} = -0.039$
Naphthacene	DMF, 0.1 M TBAI/Hg/pol	$E_{1/2} = -1.53$
Naphthalene	DMF, 0.1 M TBAP/Pt dsk/CV	$E_p = -2.55$
	DMF, 0.5 M TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -2.56$
	DMF, MeCN, 0.1 M TEAP/Hg/CV	$E_{1/2} = -2.63$
	DMF, 0.1 M TBAI/Hg/pol	$E_{1/2} = -2.50$
1-Phenylnaphthalene	DMF, 0.5 M TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -2.36$
1,2-Diphenylnaphthalene	DMF, 0.5 M TBABF <sub>4</sub> /Hg/CV	$E_{1/2} = -2.25$
Cyclopentanone	DMF, 0.1 M TEABr/Hg/pol	$E_{1/2} = -2.82$
Phenanthrene	MeCN, 0.1 M TBAP/Pt wr/CV	$E_{1/2} = -2.47$
	MeCN, 0.1 M TEAP/Hg/pol	$E_{1/2} = -2.88^a$
Pentacene	THF, 0.1 M TBAP/rot Pt dsk/E swp	$E_{1/2} = -1.40$
Perylene	MeCN, 0.1 M TEAP/Hg/CV	$E_{1/2} = -1.73$
1,3-Diphenyl-1,3-propanedione	DMSO, 0.2 M TBAP/Hg/CV	$E_{1/2} = -1.42$
2,2-Dimethyl-1,3-diphenyl-1,3 propanedione	DMSO, TBAP/Hg/CV	$E_{1/2} = -1.80$
Pyrene	DMF, 0.1 M TBAP/Pt/CV	$E_p = -2.14$
	MeCN, 0.1 M TEAP/Hg/pol	$E_{1/2} = -2.49^a$
Diphenylsulfone	DMF, TEABr	$E_{1/2} = -2.16$
Triphenylene	MeCN, 0.1 M TEAP/Hg/pol	$E_{1/2} = -2.87^a$
9,10-Anthraquinone	DMF, 0.5 M TBAP, 20°/Pt dsk/CV	$E_{1/2} = -1.01$
1,4-Benzoquinone	MeCN, 0.1 M TEAP/Pt/CV	$E_p = -0.54$
1,4-Naphthohydroquinone, dipotassium salt	DMF, 0.5 M TBAP, 20°/Pt dsk/CV	$E_{1/2} = -1.55$
Rubrene	DMF, 0.1 M TBAP/Pt dsk/CV	$E_p = -1.48$
	DMF, 0.1 M TBAI/Hg/pol	$E_{1/2} = -1.410$
Benzocyclooctatetraene	THF, 0.1 M TBAP/Hg/pol	$E_{1/2} = -2.13$
<i>sym</i> -Dibenzocyclooctatetraene	THF, 0.1 M TBAP/Hg/pol	$E_{1/2} = -2.29$
Ubiquinone-6	MeCN, 0.1 M TEAP/Pt/CV	$E_p = -1.05^e$
(9-Phenyl-fluorenyl) <sup>+</sup>	10.2 M H <sub>2</sub> SO <sub>4</sub> /Hg/CV	$E_p = -0.01^b$
(Triphenylcyclopropenyl) <sup>+</sup>	MeCN, 0.1 M TEAP/Hg/CV	$E_p = -1.87$
(Triphenylmethyl) <sup>+</sup>	MeCN, 0.1 M TBAP/Hg/pol	$E_{1/2} = 0.27$
	H <sub>2</sub> SO <sub>4</sub> , 10.2 M/Hg/CV	$E_p = -0.58^b$
(Tribiphenylmethyl) <sup>+</sup>	MeCN, 0.1 M TBAP/Hg/pol	$E_{1/2} = 0.19$
(Tri-4- <i>t</i> -butyl-5-phenylmethyl) <sup>+</sup>	MeCN, 0.1 M TBAP/Hg/pol	$E_{1/2} = 0.13$
(Tri-4-isopropylphenylmethyl) <sup>+</sup>	MeCN, 0.1 M TBAP/Hg/pol	$E_{1/2} = 0.07$
(Tri-4-methylphenylmethyl) <sup>+</sup>	MeCN, 0.1 M TBAP/Hg/pol	$E_{1/2} = 0.05$
(Tri-4-cyclopropylphenylmethyl) <sup>+</sup>	MeCN, 0.1 M TBAP/Hg/pol	$E_{1/2} = 0.01$
(Tropylium) <sup>+</sup>	MeCN, 0.1 M TBAP/Hg/pol	$E_{1/2} = -0.17$
	DMF, 0.15 M TBAI/Hg/pol	$E_{1/2} = -1.55$
	DMF, 0.15 M TBAP/Hg/pol	$E_{1/2} = -1.55$
	DMF, 0.15 M TBAI/Hg/pol	$E_{1/2} = -1.57$
	DMF, 0.15 M TBAP/Hg/pol	$E_{1/2} = -1.60$
	DMF, 0.15 M TBAI/Hg/pol	$E_{1/2} = -1.87$
	DMF, 0.15 M TBAP/Hg/pol	$E_{1/2} = -1.96$
	DMF, 0.15 M TBAI/Hg/pol	$E_{1/2} = -2.05$

REDUCTION AND OXIDATION POTENTIALS FOR CERTAIN ION RADICALS (continued)

Oxidation Potentials (Products are Cation Radicals)

Substance	Conditions/electrode/technique	Potential V (vs. SCE)
Anthracene	CH <sub>2</sub> Cl <sub>2</sub> , 0.2 M TBABF <sub>4</sub> , -70°C/Pt dsk/CV	$E_p = +0.73^d$
9,10-Dimethylantracene	MeCN, 0.1 M LiClO <sub>4</sub> /Pt wr/CV	$E_p = +1.0$
9,10-Dipropylantracene	MeCN, 0.1 M TEAP/Pt/CV	$E_p = +1.08$
1,8-Diphenylantracene	CH <sub>2</sub> Cl <sub>2</sub> , 0.2 M TPrACF <sub>3</sub> SO <sub>3</sub> /rot Pt wr/E swp	$E_{1/2} = +1.34$
8,9-Diphenylantracene	CH <sub>2</sub> Cl <sub>2</sub> , 0.2 M TPrACF <sub>3</sub> SO <sub>3</sub> /rot Pt wr/E swp	$E_{1/2} = +1.30$
9,10-Diphenylantracene	MeCN/Pt/CV	$E_p = +1.22$
Perylene	MeCN, 0.1 M TBAP/Pt/CV	$E_p = +1.34$
Pyrene	DMF, 0.1 M TBAP/Pt dsk/CV	$E_p = +1.25$
Rubrene	DMF, 0.1 M TBAP/Pt dsk/CV	$E_p = +1.10$
Tetracene	CH <sub>2</sub> Cl <sub>2</sub> , 0.2 M TBABF <sub>4</sub> , -70°C/Pt wr/CV	$E_p = +0.35^d$
1,4-Dithiabenzene	MeCN, 0.1 M TEAP/Pt dsk/rot	$E_{1/2} = +0.69$
1,4-Dithianaphthalene	MeCN, 0.1 M TEAP/Pt dsk/rot	$E_{1/2} = +0.80$
Thianthrene	0.1 M TPAP/Pt/CV	$E_{1/2} = +1.28$

<sup>a</sup> vs 0.01 M Ag/AgClO<sub>4</sub>

<sup>b</sup> vs. Hg/Hg<sub>2</sub>SO<sub>4</sub>, 17 M H<sub>2</sub>SO<sub>4</sub>

<sup>c</sup> vs Hg pool

<sup>d</sup> vs Ag/saturated AgNO<sub>3</sub>

<sup>e</sup> vs Ag/0.01 M Ag<sup>+</sup>