Spring 1998 | Thursday, June 25, 1998

Time: 90 minutes | Prof. Ayssar Nahlé

Quantitative Analysis

Chem. 206

Final Exam

Name: ....
Family First name

ID. number: ....

Section: 1 2 3 4
(Please circle)

Grades

I.	....	/ 16
II.	....	/ 16
III.	....	/ 16
IV.	....	/ 16
V.	....	/ 20
VI.	....	/ 16
Total	....	/ 100

Good luck

I. A solution known to contain both ferrocyanide [$Fe(CN)_6^{4-}$] and ferricyanide [$Fe(CN)_6^{3-}$] ions was examined spectrophotometrically at a wavelength of 420 nm, where only ferricyanide absorbs. A portion of the solution was placed into a 1-cm cell and found to have a transmittance of 0.118. The molar absorptivity of ferricyanide at 420 nm is 505 liter mole^{-1} cm^{-1}. A platinum indicator electrode was inserted into the solution of ferricyanide and ferrocyanide, and its potential was observed to be +0.337 V versus the normal hydrogen electrode. Calculate the concentrations of ferricyanide and ferrocyanide in the original solution.

[$Fe(CN)_6^{4-}$] = ... M

[$Fe(CN)_6^{3-}$] = ... M

II. Calculate the absolute and the relative standard deviations (S_y and $\frac{S_y}{y}$ respectively), and round the result to the appropriate number of significant figures. the numbers in parentheses are absolute standard deviations.

a) $$y = \frac{7.9(\pm 0.3) \times \log_{10}[15.7(\pm 0.5) - 3.12(\pm 0.06)]}{0.721(\pm 0.004) - [2.15(\pm 0.02)]^2} = 1.626107.........$$

S_y =..................................

$\frac{S_y}{y}$ =..................................

y =..............................±..........................

b) $$y = \{2.25(\pm 0.05) - \log_{10}[4.6(\pm 0.2)]^2\}^3 = 0.790130219..............$$

S_y =..................................

$\frac{S_y}{y}$ =..................................

y =..............................±..........................

III. Copper in salt water near the discharge of a sewage treatment plant is determined by first separating and concentrating it by solvent extraction of its dithizone at pH 3 into methylene chloride and then evaporating the solvent, ashing (ash is the powder remained after burning) the chelate to destroy the organic portion, and titrating the copper with EDTA. Three 1-L portions of the sample are each extracted with 25-mL portions of methylene chloride and the extracts are combined in a 100-mL volumetric flask and diluted to volume. A 50-mL aliquot is evaporated, ashed, and titrated. If EDTA solution has a $CaCO_3$ titer of 2.69 mg/mL and 2.67 mL is required for titration of the copper, what is the concentration of copper in the sea water in parts per million?

Concentration = ... ppm

IV. A sample that might be a sodium carbonate-bicarbonate or sodium carbonate-hydroxide mixture was titrated using the two indicator method. A 1.000-g sample required 31.64 mL of 0.2000-M HCl to reach the phenolphthalein end point and an additional 14.36 mL to reach the methyl orange end point. Identify the mixture and calculate the percentage of each component. (Fill the results in the table).

Components	**Percentage**

V. Given that the galvanic cell

Pt | Fe^{2+}(0.250 M), Fe^{3+}(0.00300 M) || MnO_4^-(0.0400 M), Mn^{2+}(0.0100 M), H^+(1.00 M) | Pt

contains equal volumes of solutions in the two half-cells, calculate:

a) the emf of the cell,

emf = ... V

b) the potentials of the half-cells and the concentrations of the various ions at the equilibrium state.

Potential of the left-hand half-cell = ... V

Potential of the right-hand half-cell = ... V

[MnO_4^-] = ... M

[Fe^{2+}] = ... M

[H^+] = ... M

[Mn^{2+}] = ... M

[Fe^{3+}] = ... M

VI. X mg of $Na_2SO_4.nH_2O$ is dissolved in water and the solution is diluted to 1000 mL (solution A). 2X mg of anhydrous Na_2SO_4 is dissolved and diluted to 1000 mL of solution B. The potential of a sodium-selective electrode against a suitable reference electrode is +0.1286 V in solution A and + 0.1675 V in solution B. Calculate the number of water molecules n. in the salt $Na_2SO_4.nH_2O$ (assume activity equals concentration).

n = ...

Dissociation constants for acids.

Acid	Equilibrium equation	K_a	pK_a
Acetic	$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$	1.8×10^{-5}	4.74
Aluminum hydroxide	$Al(OH)_3 \rightleftharpoons H^+ + AlO_2^- + H_2O$	4×10^{-13}	12.4
Aluminum ion	$[Al(H_2O)_6]^{3+} \rightleftharpoons H^+ + [Al(H_2O)_5(OH)]^{2+}$	1.1×10^{-5}	4.96
Ammonium ion	$NH_4^+ \rightleftharpoons H^+ + NH_3$	5.6×10^{-10}	9.25
Antimony(III) hydroxide	$Sb(OH)_3 \rightleftharpoons H^+ + SbO_2^- + H_2O$	1×10^{-11}	11.0
Arsenic	$H_3AsO_4 \rightleftharpoons H^+ + H_2AsO_4^-$	6.0×10^{-3} (K_{a_1})	2.22
	$H_2AsO_4^- \rightleftharpoons H^+ + HAsO_4^{2-}$	1×10^{-7} (K_{a_2})	7.0
	$HAsO_4^{2-} \rightleftharpoons H^+ + AsO_4^{3-}$	3×10^{-12} (K_{a_3})	11.5
Benzoic	$C_6H_5COOH \rightleftharpoons H^+ + C_6H_5COO^-$	6.6×10^{-5}	4.18
Boric	$H_3BO_3 \rightleftharpoons H^+ + H_2BO_3^-$	6.0×10^{-10}	9.22
Carbonic	$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$	4.2×10^{-7} (K_{a_1})	6.38
	$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$	4.8×10^{-11} (K_{a_2})	10.32
Chloroacetic	$ClCH_2COOH \rightleftharpoons H^+ + ClCH_2COO^-$	1.4×10^{-3}	2.85
Chromic	$H_2CrO_4 \rightleftharpoons H^+ + HCrO_4^-$	$\simeq 10^{-1}$ (K_{a_1})	1.0
	$HCrO_4^- \rightleftharpoons H^+ + CrO_4^{2-}$	3.2×10^{-7} (K_{a_2})	6.49
Copper(II) hydroxide	$Cu(OH)_2 \rightleftharpoons H^+ + HCuO_2^-$	1.5×10^{-16} (K_{a_1})	15.82
	$HCuO_2^- \rightleftharpoons H^+ + CuO_2^{2-}$	8×10^{-14} (K_{a_2})	13.1
Dichloroacetic	$Cl_2CHCOOH \rightleftharpoons H^+ + Cl_2CHCOO^-$	5.5×10^{-2}	1.26
Formic	$HCOOH \rightleftharpoons H^+ + HCOO^-$	2.1×10^{-4}	3.68
Hydrocyanic	$HCN \rightleftharpoons H^+ + CN^-$	4×10^{-10}	9.4
Hydrofluoric	$HF \rightleftharpoons H^+ + F^-$	6.9×10^{-4}	3.16
Hydrogen peroxide	$H_2O_2 \rightleftharpoons H^+ + HO_2^-$	2.4×10^{-12}	11.62
Hydrogen sulfide	$H_2S \rightleftharpoons H^+ + HS^-$	$1.0 \times 10^{-7}(K_{a_1})$	7.00
	$HS^- \rightleftharpoons H^+ + S^{2-}$	$1.0 \times 10^{-14}(K_{a_2})$	14.00
Hypochlorous	$HClO \rightleftharpoons H^+ + ClO^-$	3.2×10^{-8}	7.49
Iron(III) ion	$[Fe(H_2O)_6]^{3+} \rightleftharpoons H^+ + [Fe(H_2O)_5(OH)]^{2+}$	8.9×10^{-4}	3.05
Lead(II) hydroxide	$Pb(OH)_2 \rightleftharpoons H^+ + HPbO_2^-$	2×10^{-16}	15.7
Nitrous	$HNO_2 \rightleftharpoons H^+ + NO_2^-$	4.5×10^{-4}	3.35
Oxalic	$H_2C_2O_4 \rightleftharpoons H^+ + HC_2O_4^-$	$3.8 \times 10^{-2}(K_{a_1})$	1.42
	$HC_2O_4^- \rightleftharpoons H^+ + C_2O_4^{2-}$	$5.0 \times 10^{-5}(K_{a_2})$	4.30
Periodic	$HIO_4 \rightleftharpoons H^+ + IO_4^-$	2.3×10^{-2}	1.64
Phenol	$C_6H_5OH \rightleftharpoons H^+ + C_6H_5O^-$	1×10^{-10}	10.0
Phosphoric	$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$	$7.5 \times 10^{-3}(K_{a_1})$	2.12
	$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$	$6.2 \times 10^{-8}(K_{a_2})$	7.21
	$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$	$1 \times 10^{-12}(K_{a_3})$	12.0
Phosphorous	$H_3PO_3 \rightleftharpoons H^+ + H_2PO_3^-$	$1.6 \times 10^{-2}(K_{a_1})$	1.80
	$H_2PO_3^- \rightleftharpoons H^+ + HPO_3^{2-}$	$7 \times 10^{-7}(K_{a_2})$	6.2
Silicic (meta)	$H_2SiO_3 \rightleftharpoons H^+ + HSiO_3^-$	$3.2 \times 10^{-10}(K_{a_1})$	9.49
	$HSiO_3^- \rightleftharpoons H^+ + SiO_3^{2-}$	$6.3 \times 10^{-12}(K_{a_2})$	11.80
Sulfamic	$HNH_2SO_3 \rightleftharpoons H^+ + NH_2SO_3^-$	1.1×10^{-1}	0.96
Sulfuric	$H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$	$1.0 \times 10^{2}(K_{a_1})$	−2.00
	$HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$	$1.2 \times 10^{-2}(K_{a_2})$	1.92
Sulfurous	$H_2SO_3 \rightleftharpoons H^+ + HSO_3^-$	$1.72 \times 10^{-2}(K_{a_1})$	
	$HSO_3^- \rightleftharpoons H^+ + SO_3^{2-}$	$6.43 \times 10^{-8}(K_{a_2})$	
Tartaric	$H_2C_4H_4O_6 \rightleftharpoons H^+ + HC_4H_4O_6^-$	$1.1 \times 10^{-3}(K_{a_1})$	2.96
	$HC_4H_4O_6^- \rightleftharpoons H^+ + C_4H_4O_6^{2-}$	$6.9 \times 10^{-5}(K_{a_2})$	4.16
Thiocyanic	$HSCN \rightleftharpoons H^+ + SCN^-$	1.4×10^{-1}	0.85
Thiosulfuric	$H_2S_2O_3 \rightleftharpoons H^+ + HS_2O_3^-$	$2.0 \times 10^{-2}(K_{a_1})$	1.70
	$HS_2O_3^- \rightleftharpoons H^+ + S_2O_3^{2-}$	$3.2 \times 10^{-3}(K_{a_2})$	2.49
Tin(II) hydroxide	$Sn(OH)_2 \rightleftharpoons H^+ + HSnO_2^-$	4×10^{-15}	14.4
Trichloroacetic	$Cl_3CCOOH \rightleftharpoons H^+ + Cl_3CCOO^-$	1.3×10^{-1}	0.89
Zinc hydroxide	$Zn(OH)_2 \rightleftharpoons H^+ + HZnO_2^-$	$1 \times 10^{-17}(K_{a_1})$	17.0
	$HZnO_2^- \rightleftharpoons H^+ + ZnO_2^{2-}$	$2 \times 10^{-13}(K_{a_2})$	12.7
Zinc ion	$[Zn(H_2O)_4]^{2+} \rightleftharpoons H^+ + [Zn(H_2O)_3(OH)]^+$	2.5×10^{-10}	9.60

Half-Reaction	E^0, V*	Formal Potential, V†
Aluminum		
$Al^{3+} + 3e^- \rightleftharpoons Al(s)$	-1.662	
Antimony		
$Sb_2O_5(s) + 6H^+ + 4e^- \rightleftharpoons 2SbO^+ + 3H_2O$	$+0.581$	
Arsenic		
$H_3AsO_4 + 2H^+ + 2e^- \rightleftharpoons H_3AsO_3 + H_2O$	$+0.559$	0.577 in 1 M HCl, $HClO_4$
Barium		
$Ba^{2+} + 2e^- \rightleftharpoons Ba(s)$	-2.906	
Bismuth		
$BiO^+ + 2H^+ + 3e^- \rightleftharpoons Bi(s) + H_2O$	$+0.320$	
$BiCl_4^- + 3e^- \rightleftharpoons Bi(s) + 4Cl^-$	$+0.16$	
Bromine		
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-$	$+1.065$	1.05 in 4 M HCl
$Br_2(aq) + 2e^- \rightleftharpoons 2Br^-$	$+1.087$‡	
$BrO_3^- + 6H^+ + 5e^- \rightleftharpoons \frac{1}{2}Br_2(l) + 3H_2O$	$+1.52$	
$BrO_3^- + 6H^+ + 6e^- \rightleftharpoons Br^- + 3H_2O$	$+1.44$	
Cadmium		
$Cd^{2+} + 2e^- \rightleftharpoons Cd(s)$	-0.403	
Calcium		
$Ca^{2+} + 2e^- \rightleftharpoons Ca(s)$	-2.866	
Carbon		
$C_6H_4O_2$ (quinone) $+ 2H^+ + 2e^- \rightleftharpoons C_6H_4(OH)_2$	$+0.699$	0.696 in 1 M HCl, $HClO_4$, H_2SO_4
$2CO_2(g) + 2H^+ + 2e^- \rightleftharpoons H_2C_2O_4$	-0.49	
Cerium		
$Ce^{4+} + e^- \rightleftharpoons Ce^{3+}$		+1.70 in 1 M $HClO_4$; +1.61 in 1 M HNO_3; +1.44 in 1 M H_2SO_4
Chlorine		
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$	$+1.359$	
$HClO + H^+ + e^- \rightleftharpoons \frac{1}{2}Cl_2(g) + H_2O$	$+1.63$	
$ClO_3^- + 6H^+ + 5e^- \rightleftharpoons \frac{1}{2}Cl_2(g) + 3H_2O$	$+1.47$	
Chromium		
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	-0.408	
$Cr^{3+} + 3e^- \rightleftharpoons Cr(s)$	-0.744	
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	$+1.33$	
Cobalt		
$Co^{2+} + 2e^- \rightleftharpoons Co(s)$	-0.277	
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	$+1.808$	
Copper		
$Cu^{2+} + 2e^- \rightleftharpoons Cu(s)$	$+0.337$	
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	$+0.153$	
$Cu^+ + e^- \rightleftharpoons Cu(s)$	$+0.521$	
$Cu^{2+} + I^- + e^- \rightleftharpoons CuI(s)$	$+0.86$	
$CuI(s) + e^- \rightleftharpoons Cu(s) + I^-$	-0.185	
Fluorine		
$F_2(g) + 2H^+ + 2e^- \rightleftharpoons 2HF(aq)$	$+3.06$	
Hydrogen		
$2H^+ + 2e^- \rightleftharpoons H_2(g)$	0.000	-0.005 in 1 M HCl, $HClO_4$
Iodine		
$I_2(s) + 2e^- \rightleftharpoons 2I^-$	$+0.5355$	
$I_2(aq) + 2e^- \rightleftharpoons 2I^-$	$+0.615$‡	
$I_3^- + 2e^- \rightleftharpoons 3I^-$	$+0.536$	
$ICl_2^- + e^- \rightleftharpoons \frac{1}{2}I_2(s) + 2Cl^-$	$+1.056$	
$IO_3^- + 6H^+ + 5e^- \rightleftharpoons \frac{1}{2}I_2(s) + 3H_2O$	$+1.196$	
$IO_3^- + 6H^+ + 5e^- \rightleftharpoons \frac{1}{2}I_2(aq) + 3H_2O$	$+1.178$‡	
$IO_3^- + 2Cl^- + 6H^+ + 4e^- \rightleftharpoons ICl_2^- + 3H_2O$	$+1.24$	
$H_5IO_6 + H^+ + 2e^- \rightleftharpoons IO_3^- + 3H_2O$	$+1.601$	

Half-Reaction	E^0, V*	Formal Potential, V†
Iron		
$Fe^{2+} + 2e^- \rightleftharpoons Fe(s)$	−0.440	
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.771	0.700 in 1 M HCl; 0.732 in 1 M $HClO_4$; 0.68 in 1 M H_2SO_4
$Fe(CN)_6^{3-} + e^- \rightleftharpoons Fe(CN)_6^{4-}$	+0.36	0.71 in 1 M HCl; 0.72 in 1 M $HClO_4$, H_2SO_4
Lead		
$Pb^{2+} + 2e^- \rightleftharpoons Pb(s)$	−0.126	−0.14 in 1 M $HClO_4$; −0.29 in 1 M H_2SO_4
$PbO_2(s) + 4H^+ + 2e^- \rightleftharpoons Pb^{2+} + 2H_2O$	+1.455	
$PbSO_4(s) + 2e^- \rightleftharpoons Pb(s) + SO_4^{2-}$	−0.350	
Lithium		
$Li^+ + e^- \rightleftharpoons Li(s)$	−3.045	
Magnesium		
$Mg^{2+} + 2e^- \rightleftharpoons Mg(s)$	−2.363	
Manganese		
$Mn^{2+} + 2e^- \rightleftharpoons Mn(s)$	−1.180	
$Mn^{3+} + e^- \rightleftharpoons Mn^{2+}$		1.51 in 7.5 M H_2SO_4
$MnO_2(s) + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+1.23	
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.51	
$MnO_4^- + 4H^+ + 3e^- \rightleftharpoons MnO_2(s) + 2H_2O$	+1.695	
$MnO_4^- + e^- \rightleftharpoons MnO_4^{2-}$	+0.564	
Mercury		
$Hg_2^{2+} + 2e^- \rightleftharpoons Hg(l)$	+0.788	0.274 in 1 M HCl; 0.776 in 1 M $HClO_4$; 0.674 in 1 M H_2SO_4
$2Hg^{2+} + 2e^- \rightleftharpoons Hg_2^{2+}$	+0.920	0.907 in 1 M $HClO_4$
$Hg^{2+} + 2e^- \rightleftharpoons 2Hg(l)$	+0.854	
$Hg_2Cl_2(s) + 2e^- \rightleftharpoons 2Hg(l) + 2Cl^-$	+0.268	0.244 in sat'd KCl; 0.282 in 1 M KCl; 0.334 in 0.1 M KCl
$Hg_2SO_4(s) + 2e^- \rightleftharpoons 2Hg(l) + SO_4^{2-}$	+0.615	
Nickel		
$Ni^{2+} + 2e^- \rightleftharpoons Ni(s)$	−0.250	
Nitrogen		
$N_2(g) + 5H^+ + 4e^- \rightleftharpoons N_2H_5^+$	−0.23	
$HNO_2 + H^+ + e^- \rightleftharpoons NO(g) + H_2O$	+1.00	
$NO_3^- + 3H^+ + 2e^- \rightleftharpoons HNO_2 + H_2O$	+0.94	0.92 in 1 M HNO_3
Oxygen		
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.776	
$HO_2^- + H_2O + 2e^- \rightleftharpoons 3OH^-$	+0.88	
$O_2(g) + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.229	
$O_2(g) + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+0.682	
$O_3(g) + 2H^+ + 2e^- \rightleftharpoons O_2(g) + H_2O$	+2.07	
Palladium		
$Pd^{2+} + 2e^- \rightleftharpoons Pd(s)$	+0.987	
Platinum		
$PtCl_4^{2-} + 2e^- \rightleftharpoons Pt(s) + 4Cl^-$	+0.73	
$PtCl_6^{2-} + 2e^- \rightleftharpoons PtCl_4^{2-} + 2Cl^-$	+0.68	
Potassium		
$K^+ + e^- \rightleftharpoons K(s)$	−2.925	
Selenium		
$H_2SeO_3 + 4H^+ + 2e^- \rightleftharpoons Se(s) + 3H_2O$	+0.740	
$SeO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons H_2SeO_3 + H_2O$	+1.15	

Half-Reaction	E^0, V*	Formal Potential, V†
Silver		
$Ag^+ + e^- \rightleftharpoons Ag(s)$	+0.799	0.228 in 1 M HCl; 0.792 in 1 M $HClO_4$; 0.77 in 1 M H_2SO_4
$AgBr(s) + e^- \rightleftharpoons Ag(s) + Br^-$	+0.073	
$AgCl(s) + e^- \rightleftharpoons Ag(s) + Cl^-$	+0.222	0.228 in 1 M KCl
$Ag(CN)_2^- + e^- \rightleftharpoons Ag(s) + 2\,CN^-$	−0.31	
$Ag_2CrO_4(s) + 2\,e^- \rightleftharpoons 2\,Ag(s) + CrO_4^{2-}$	+0.446	
$AgI(s) + e^- \rightleftharpoons Ag(s) + I^-$	−0.151	
$Ag(S_2O_3)_2^{3-} + e^- \rightleftharpoons Ag(s) + 2\,S_2O_3^{2-}$	+0.017	
Sodium		
$Na^+ + e^- \rightleftharpoons Na(s)$	−2.714	
Sulfur		
$S(s) + 2\,H^+ + 2\,e^- \rightleftharpoons H_2S(g)$	+0.141	
$H_2SO_3 + 4\,H^+ + 4\,e^- \rightleftharpoons S(s) + 3\,H_2O$	+0.450	
$SO_4^{2-} + 4\,H^+ + 2\,e^- \rightleftharpoons H_2SO_3 + H_2O$	+0.172	
$S_4O_6^{2-} + 2\,e^- \rightleftharpoons 2\,S_2O_3^{2-}$	+0.08	
$S_2O_8^{2-} + 2\,e^- \rightleftharpoons 2\,SO_4^{2-}$	+2.01	
Thallium		
$Tl^+ + e^- \rightleftharpoons Tl(s)$	−0.336	−0.551 in 1 M HCl; −0.33 in 1 M $HClO_4$, H_2SO_4
$Tl^{3+} + 2\,e^- \rightleftharpoons Tl^+$	+1.25	0.77 in 1 M HCl
Tin		
$Sn^{2+} + 2\,e^- \rightleftharpoons Sn(s)$	−0.136	−0.16 in 1 M $HClO_4$
$Sn^{4+} + 2\,e^- \rightleftharpoons Sn^{2+}$	+0.154	0.14 in 1 M HCl
Titanium		
$Ti^{3+} + e^- \rightleftharpoons Ti^{2+}$	−0.369	
$TiO^{2+} + 2\,H^+ + e^- \rightleftharpoons Ti^{3+} + H_2O$	+0.099	0.04 in 1 M H_2SO_4
Uranium		
$UO_2^{2+} + 4\,H^+ + 2\,e^- \rightleftharpoons U^{4+} + 2\,H_2O$	+0.334	
Vanadium		
$V^{3+} + e^- \rightleftharpoons V^{2+}$	−0.256	−0.21 in 1 M $HClO_4$
$VO^{2+} + 2\,H^+ + e^- \rightleftharpoons V^{3+} + H_2O$	+0.359	
$V(OH)_4^+ + 2\,H^+ + e^- \rightleftharpoons VO^{2+} + 3\,H_2O$	+1.00	1.02 in 1 M HCl, $HClO_4$
Zinc		
$Zn^{2+} + 2\,e^- \rightleftharpoons Zn(s)$	−0.763	

Half-Reaction	E^0, V*	Formal Potential, V†
Silver		
$Ag^+ + e^- \rightleftharpoons Ag(s)$	+0.799	0.228 in 1 M HCl; 0.792 in 1 M $HClO_4$; 0.77 in 1 M H_2SO_4
$AgBr(s) + e^- \rightleftharpoons Ag(s) + Br^-$	+0.073	
$AgCl(s) + e^- \rightleftharpoons Ag(s) + Cl^-$	+0.222	0.228 in 1 M KCl
$Ag(CN)_2^- + e^- \rightleftharpoons Ag(s) + 2\ CN^-$	−0.31	
$Ag_2CrO_4(s) + 2\ e^- \rightleftharpoons 2\ Ag(s) + CrO_4^{2-}$	+0.446	
$AgI(s) + e^- \rightleftharpoons Ag(s) + I^-$	−0.151	
$Ag(S_2O_3)_2^{3-} + e^- \rightleftharpoons Ag(s) + 2\ S_2O_3^{2-}$	+0.017	
Sodium		
$Na^+ + e^- \rightleftharpoons Na(s)$	−2.714	
Sulfur		
$S(s) + 2\ H^+ + 2\ e^- \rightleftharpoons H_2S(g)$	+0.141	
$H_2SO_3 + 4\ H^+ + 4\ e^- \rightleftharpoons S(s) + 3\ H_2O$	+0.450	
$SO_4^{2-} + 4\ H^+ + 2\ e^- \rightleftharpoons H_2SO_3 + H_2O$	+0.172	
$S_4O_6^{2-} + 2\ e^- \rightleftharpoons 2\ S_2O_3^{2-}$	+0.08	
$S_2O_8^{2-} + 2\ e^- \rightleftharpoons 2\ SO_4^{2-}$	+2.01	
Thallium		
$Tl^+ + e^- \rightleftharpoons Tl(s)$	−0.336	−0.551 in 1 M HCl; −0.33 in 1 M $HClO_4$, H_2SO_4
$Tl^{3+} + 2\ e^- \rightleftharpoons Tl^+$	+1.25	0.77 in 1 M HCl
Tin		
$Sn^{2+} + 2\ e^- \rightleftharpoons Sn(s)$	−0.136	−0.16 in 1 M $HClO_4$
$Sn^{4+} + 2\ e^- \rightleftharpoons Sn^{2+}$	+0.154	0.14 in 1 M HCl
Titanium		
$Ti^{3+} + e^- \rightleftharpoons Ti^{2+}$	−0.369	
$TiO^{2+} + 2\ H^+ + e^- \rightleftharpoons Ti^{3+} + H_2O$	+0.099	0.04 in 1 M H_2SO_4
Uranium		
$UO_2^{2+} + 4\ H^+ + 2\ e^- \rightleftharpoons U^{4+} + 2\ H_2O$	+0.334	
Vanadium		
$V^{3+} + e^- \rightleftharpoons V^{2+}$	−0.256	−0.21 in 1 M $HClO_4$
$VO^{2+} + 2\ H^+ + e^- \rightleftharpoons V^{3+} + H_2O$	+0.359	
$V(OH)_4^+ + 2\ H^+ + e^- \rightleftharpoons VO^{2+} + 3\ H_2O$	+1.00	1.02 in 1 M HCl, $HClO_4$
Zinc		
$Zn^{2+} + 2\ e^- \rightleftharpoons Zn(s)$	−0.763	