These problems are intended to ***supplement*** the problems in the textbook, not ***replace*** them.

E° (V)	*Half-Cell Reaction*
+0.799	$Ag^+(aq) + e^- \rightarrow Ag(s)$
+0.095	$AgBr(s) + e^- \rightarrow Ag(s) + Br^-(aq)$
–1.66	$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$
+1.42	$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$
–2.90	$Ba^{2+}(aq) + 2e^- \rightarrow Ba(s)$
+1.065	$Br_2(l) + 2e^- \rightarrow 2\ Br^-(aq)$
+1.52	$2\ BrO_3^-(aq) + 12\ H^+(aq) + 10e^- \rightarrow Br_2(l) + 6\ H_2O(l)$
–0.403	$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$
+1.359	$Cl_2(g) + 2e^- \rightarrow 2\ Cl^-(aq)$
–0.277	$Co^{2+}(aq) + 2e^- \rightarrow Co(s)$
+1.842	$Co^{3+}(aq) + e^- \rightarrow Co^{2+}(aq)$
–0.74	$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$
+1.33	$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O$
+0.337	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
+0.153	$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$
+2.87	$F_2(g) + 2e^- \rightarrow 2\ F^-(aq)$
–0.440	$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$
+0.771	$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$
0.000	$2\ H^+(aq) + 2e^- \rightarrow H_2(g)$
–0.83	$2\ H_2O(l) + 2e^- \rightarrow H_2(g) + 2\ OH^-(aq)$
+0.88	$HO_2^-(aq) + H_2O(l) + 2e^- \rightarrow 3\ OH^-(aq)$
+1.776	$H_2O_2(aq) + 2\ H^+(aq) + 2e^- \rightarrow 2\ H_2O(l)$
+0.536	$I_2(s) + 2e^- \rightarrow 2\ I^-(aq)$

E° (V)	*Half-Cell Reaction*
–3.05	$Li^+(aq) + e^- \rightarrow Li(s)$
–2.37	$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$
–1.18	$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$
+1.51	$Mn^{3+}(aq) + e^- \rightarrow Mn^{2+}(aq)$
+1.23	$MnO_2(s) + 4\ H^+(aq) + 2e^- \rightarrow Mn^{2+}(aq) + 2\ H_2O(l)$
+1.695	$MnO_4^-(aq) + 4\ H^+(aq) + 3e^- \rightarrow MnO_2(s) + 2\ H_2O(l)$
+1.51	$MnO_4^-(aq) + 8\ H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4\ H_2O(l)$
–1.16	$N_2(g) + 4\ H_2O(l) + 4e^- \rightarrow N_2H_4(aq) + 4\ OH^-(aq)$
+0.96	$NO_3^-(aq) + 4\ H^+(aq) + 3e^- \rightarrow NO(g) + 2\ H_2O(l)$
–0.28	$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$
+0.49	$NiO_2(s) + 2H_2O(l) + 2e^- \rightarrow Ni(OH)_2(s) + 2OH^-(aq)$
+1.23	$O_2(g) + 4\ H^+(aq) + 4e^- \rightarrow 2\ H_2O(l)$
+2.07	$O_3(g) + 2H^+(aq) + 2e^- \rightarrow O_2(g) + H_2O(l)$
–0.126	$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$
+1.46	$PbO_2(s) + 4\ H^+(aq) + 2e^- \rightarrow Pb^{2+}(aq) + 2\ H_2O(l)$
+0.25	$PbO_2(s) + H_2O(l) + 2e^- \rightarrow PbO(s) + 2\ OH^-(aq)$
+1.685	$PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O$
–0.356	$PbSO_4(s) + H^+(aq) + 2e^- \rightarrow Pb(s) + HSO_4^-(aq)$
+1.20	$Pt^{2+}(aq) + 2e^- \rightarrow Pt(s)$
–0.136	$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$
+0.45	$SO_2(aq) + 4\ H^+(aq) + 4e^- \rightarrow S(s) + 2\ H_2O(l)$
–1.18	$V^{2+}(aq) + 2e^- \rightarrow V(s)$
–0.763	$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$

Questions

For each of the following electrolytic cells…

a. Determine the most likely anode half-reaction.

b. Determine the most likely cathode half-reaction.

c. Calculate $E°_{cell}$.

1. molten $BaBr_2$ with two inert electrodes
2. molten LiF with two inert electrodes
3. molten $CuCl_2$ with two inert electrodes
4. aqueous CoF_2 with two inert electrodes
5. aqueous $Pb(NO_3)_2$ in acidic solution with two inert electrodes
6. aqueous $FeCl_2$ in basic solution with one copper electrode and one inert electrode
7. aqueous MnI_2 in acidic solution with one NiO_2 electrode and one inert electrode
8. aqueous $AgNO_3$ in acidic solution with one gold electrode and one platinum electrode

Answer the following questions.

9. a. Calculate the mass of magnesium formed by electrolysis of molten $MgCl_2$ by a current of 7.6×10^3 A flowing for 24 hours. Assume the electrolytic cell is 85% efficient.

   b. What is the energy requirement for this electrolysis is the applied emf is 2.80 V? Express the answer in terms of kilowatt-hour per kg of magnesium formed.

10. a. Calculate the mass of aluminum formed by electrolysis of molten AlF_3 by a current of 5.95×10^5 A flowing for 15.5 hours. Assume the electrolytic cell is 75.0% efficient.

    b. What is the energy requirement for this electrolysis is the applied emf is 2.25 V? Express the answer in terms of kilowatt-hour per kg of aluminum formed.

11. a. Calculate the mass of nickel formed by electrolysis of molten $NiBr_2$ by a current of 6.8×10^4 A flowing for 18 hours. Assume the electrolytic cell is 80.0% efficient.

    b. What is the energy requirement for this electrolysis is the applied emf is 0.50 V? Express the answer in terms of kilowatt-hour per kg of nickel formed.

12. A Pb^{2+} solution is electrolyzed in a cell with 80.0% efficiency.

    a. If the current is 155 A, then what mass of lead is plated out after 4.00 days?

    b. What current is required to plate out 1.00 pound of lead in 24.0 hours?

13. A Cl^- solution is electrolyzed in a cell with 70.0% efficiency.

    a. If the current is 17.5 A, then after 2.00 hours what volume of chlorine gas is collected at STP?

    b. What current is required to produce 5.00 L of chlorine gas at STP in 90.0 minutes?

14. Calcium metal can be obtained by the electrolysis of molten $CaCl_2$ at a voltage of 3.2 V.

    a. How many joules of electrical energy are required to obtain 12.0 pounds of calcium? Assume 95% efficiency.

    b. What is the cost of this energy at a rate of 12.5¢ per kilowatt-hour?

15. Lithium metal can be obtained by the electrolysis of molten LiCl at a voltage of 4.5 V.

    a. How many joules of electrical energy are required to obtain 1 metric ton of lithium? Assume 80% efficiency.

    b. What is the cost of this energy at a rate of 12.5¢ per kilowatt-hour?

16. A solution containing iron ions was electrolyzed with a 0.75 A current for 30.0 minutes and 0.3906 g of iron was deposited on the cathode. What was the charge on the iron ion? Assume 100% efficiency.

<u>Answers</u>

If you cannot figure out how to get the correct answer, go to your instructor, Science Tutoring Center, etc.

The Faraday constant was taken to be 96,485 C/mol.

1. a. $2\ Br^-(l) \rightarrow Br_2(l) + 2\ e^-$ b. $Ba^{2+}(l) + 2\ e^- \rightarrow Ba(l)$ c. –3.97 V

2. a. $2\ F^-(l) \rightarrow F_2(g) + 2\ e^-$ b. $Li^{1+}(l) + e^- \rightarrow Li(l)$ c. –5.92 V

3. a. $2\ Cl^-(l) \rightarrow Cl_2(g) + 2\ e^-$ b. $Cu^{2+}(l) + 2\ e^- \rightarrow Cu(l)$ c. –1.022 V

4. a. $2\ H_2O(l) \rightarrow O_2(g) + 4\ H^+(aq) + 4\ e^-$ b. $Co^{2+}(aq) + 2\ e^- \rightarrow Co(s)$ c. –1.51 V

5. a. $2\ H_2O(l) \rightarrow O_2(g) + 4\ H^+(aq) + 4\ e^-$
   b. $NO_3^-(aq) + 4\ H^+(aq) + 3\ e^- \rightarrow NO(g) + 2\ H_2O(l)$
   c. –0.27 V

6. a. $Cu(s) \rightarrow Cu^{2+}(aq) + 2\ e^-$ b. $Fe^{2+}(aq) + 2\ e^- \rightarrow Fe(s)$ c. –0.777 V

7. a. $2\ I^-(aq) \rightarrow I_2(s) + 2\ e^-$
   b. $NiO_2(s) + 2\ H_2O(l) + 2\ e^- \rightarrow Ni(OH)_2(s) + 2\ OH^-(aq)$
   c. –0.05 V

8. a. $Pt(s) \rightarrow Pt^{2+}(aq) + 2\ e^-$
   b. $NO_3^-(aq) + 4\ H^+(aq) + 3\ e^- \rightarrow NO(g) + 2\ H_2O(l)$
   c. –0.24 V

9. a. 7.0×10^4 g b. 7.3 kwh per kg Mg

10. a. 2.32×10^6 g Al b. 8.94 kwh per kg Al

11. a. 1.1×10^6 g Ni b. 0.56 kwh per kg Ni

12. a. 4.60×10^4 g Pb b. 6.11 A

13. a. 10.2 L Cl_2 at STP b. 11.4 A

14. a. 8.8×10^7 J b. \$3.1

15. a. 7.8×10^{10} J b. \$2700

16. +2