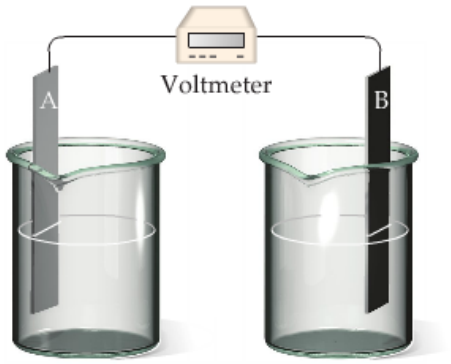
20.4 Assume that you want to construct a voltaic cell that uses the following half-reactions:

$$A^{2+}(aq) + 2\,e^- \longrightarrow A(s) \quad E^\circ_{red} = -0.10\ V$$

$$B^{2+}(aq) + 2\,e^- \longrightarrow B(s) \quad E^\circ_{red} = -1.10\ V$$

You begin with the incomplete cell pictured here in which the electrodes are immersed in water.



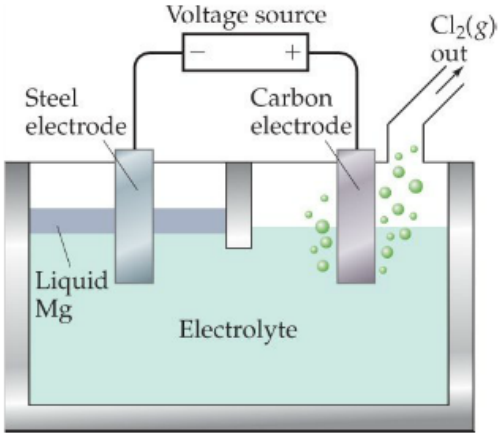
(a) What additions must you make to the cell for it to generate a standard emf? **(b)** Which electrode functions as the cathode? **(c)** Which direction do electrons move through the external circuit? **(d)** What voltage will the cell generate under standard conditions? [Sections 20.3 and 20.4]

20.89 **(a)** What is *electrolysis*? **(b)** Are electrolysis reactions thermodynamically spontaneous? Explain. **(c)** What process occurs at the anode in the electrolysis of molten NaCl? **(d)** Why is sodium metal not obtained when an aqueous solution of NaCl undergoes electrolysis?

20.93 (**a**) Calculate the mass of Li formed by electrolysis of molten LiCl by a current of 7.5×10^4 A flowing for a period of 24 h. Assume the electrolytic cell is 85% efficient. (**b**) What is the minimum voltage required to drive the reaction?

20.7 Consider a redox reaction for which $E°$ is a negative number.
(**a**) What is the sign of $\Delta G°$ for the reaction?
(**b**) Will the equilibrium constant for the reaction be larger or smaller than 1?
(**c**) Can an electrochemical cell based on this reaction accomplish work on its surroundings? [Section 20.5]

20.12 Magnesium is produced commercially by electrolysis from a molten salt using a cell similar to the one shown here. **(a)** What salt is used as the electrolyte? **(b)** Which electrode is the anode, and which one is the cathode? **(c)** Write the overall cell reaction and individual half-reactions. **(d)** What precautions would need to be taken with respect to the magnesium formed? [Section 20.9]



20.24 Complete and balance the following equations, and identify the oxidizing and reducing agents. (Recall that the O atoms in hydrogen peroxide, H_2O_2, have an atypical oxidation state.)

(a) $NO_2^-(aq) + Cr_2O_7^{2-}(aq) \longrightarrow Cr^{3+}(aq) + NO_3^-(aq)$ (acidic solution)

(b) $S(s) + HNO_3(aq) \longrightarrow H_2SO_3(aq) + N_2O(g)$ (acidic solution)

(c) $Cr_2O_7^{2-}(aq) + CH_3OH(aq) \longrightarrow HCO_2H(aq) + Cr^{3+}(aq)$ (acidic solution)

(d) $BrO_3^-(aq) + N_2H_4(g) \longrightarrow Br^-(aq) + N_2(g)$ (acidic solution)

(e) $NO_2^-(aq) + Al(s) \longrightarrow NH_4^+(aq) + AlO_2^-(aq)$ (basic solution)

(f) $H_2O_2(aq) + ClO_2(aq) \longrightarrow ClO_2^-(aq) + O_2(g)$ (basic solution)

20.38 Using data in Appendix E, calculate the standard emf for each of the following reactions:

(a) $H_2(g) + F_2(g) \longrightarrow 2\,H^+(aq) + 2\,F^-(aq)$

(b) $Cu^{2+}(aq) + Ca(s) \longrightarrow Cu(s) + Ca^{2+}(aq)$

(c) $3\,Fe^{2+}(aq) \longrightarrow Fe(s) + 2\,Fe^{3+}(aq)$

(d) $2\,ClO_3^-(aq) + 10\,Br^-(aq) + 12\,H^+(aq) \longrightarrow Cl_2(g) + 5\,Br_2(l) + 6\,H_2O(l)$

20.41 A 1 *M* solution of $Cu(NO_3)_2$ is placed in a beaker with a strip of Cu metal. A 1 *M* solution of $SnSO_4$ is placed in a second beaker with a strip of Sn metal. A salt bridge connects the two beakers, and wires to a voltmeter link the two metal electrodes. **(a)** Which electrode serves as the anode and which as the cathode? **(b)** Which electrode gains mass and which loses mass as the cell reaction proceeds? **(c)** Write the equation for the overall cell reaction. **(d)** What is the emf generated by the cell under standard conditions?

20.51 Given the following reduction half-reactions:

$$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq) \qquad E^\circ_{red} = +0.77\ V$$

$$S_2O_6^{2-}(aq) + 4\,H^+(aq) + 2\,e^- \longrightarrow 2\,H_2SO_3(aq) \qquad E^\circ_{red} = +0.60\ V$$

$$N_2O(g) + 2\,H^+(aq) + 2\,e^- \longrightarrow N_2(g) + H_2O(l) \qquad E^\circ_{red} = -1.77\ V$$

$$VO_2^+(aq) + 2\,H^+(aq) + e^- \longrightarrow VO^{2+} + H_2O(l) \qquad E^\circ_{red} = +1.00\ V$$

(a) Write balanced chemical equations for the oxidation of $Fe^{2+}(aq)$ by $S_2O_6^{2-}(aq)$, by $N_2O(aq)$, and by $VO_2^+(aq)$. **(b)** Calculate ΔG° for each reaction at 298 K. **(c)** Calculate the equilibrium constant K for each reaction at 298 K.

20.57 A cell has a standard cell potential of +0.177 V at 298 K. What is the value of the equilibrium constant for the reaction **(a)** if $n = 1$? **(b)** if $n = 2$? **(c)** if $n = 3$?

20.84 (**a**) Based on standard reduction potentials, would you expect copper metal to oxidize under standard conditions in the presence of oxygen and hydrogen ions? (**b**) When the Statue of Liberty was refurbished, Teflon spacers were placed between the iron skeleton and the copper metal on the surface of the statue. What role do these spacers play?