23. Distinguish between a voltaic cell and an electrolytic cell in terms of the nature of the reaction involved.

24. a. What is electroplating?
b. Identify the anode and cathode in such a process.

MIXED REVIEW

25. Predict whether each of the following reactions will occur spontaneously as written by determining the E^0 value for potential reaction. Write and balance the overall equation for each reaction that does occur spontaneously.
a. $Mg + Sn^{2+} \longrightarrow$
b. $K + Al^{3+} \longrightarrow$
c. $Li^{+} + Zn \longrightarrow$
d. $Cu + Cl_2 \longrightarrow$

26. Why is it possible for alkaline batteries to be smaller than zinc-carbon dry cells?

27. Draw a diagram of a voltaic cell whose two half-reactions consist of Ag in $AgNO_3$ and Ni in $NiSO_4$. Identify the anode and cathode, and indicate the directions in which the electrons and ions are moving.

28. Can a solution of $Sn(NO_3)_2$ be stored in an aluminum container? Explain, using E^0 values.

29. A voltaic cell is made up of a cadmium electrode in a solution of $CdSO_4$ and a zinc electrode in a solution of $ZnSO_4$. The two half-cells are separated by a porous barrier.
a. Which is the cathode, and which is the anode?
b. In which direction are the electrons flowing?
c. Write balanced equations for the two half-reactions, and write a net equation for the combined reaction.

30. Would the following pair of electrodes make a good battery? Explain.
$Cd \longrightarrow Cd^{2+} + 2e^{-}$
$Fe \longrightarrow Fe^{2+} + 2e^{-}$

31. a. What would happen if an aluminum spoon were used to stir a solution of $Zn(NO_3)_2$?
b. Could a strip of Zn be used to stir a solution of $Al(NO_3)_3$? Explain, using E^0 values.

32. How do the redox reactions for each of the following types of batteries differ?
a. zinc-carbon
b. alkaline
c. mercury

33. a. Why are some standard reduction potentials positive and some negative?
b. Compare the E^0 value for a metal with the reactivity of that metal.

CRITICAL THINKING

34. **Applying Models** Explain how the oxidation-reduction chemistry of both the voltaic cell and the electrolytic cell are combined in the chemistry of rechargeable cells.

35. **Applying Ideas** In lead-acid batteries, such as your car battery, the degree of discharge of the battery can be determined by measuring the density of the battery fluid. Explain how this is possible.

36. **Applying Ideas** In lead-acid batteries, the battery cannot be recharged indefinitely. Explain why not.

37. **Interpreting Graphics** A voltaic cell is pictured below. Identify the species that is oxidized if current is allowed to flow.