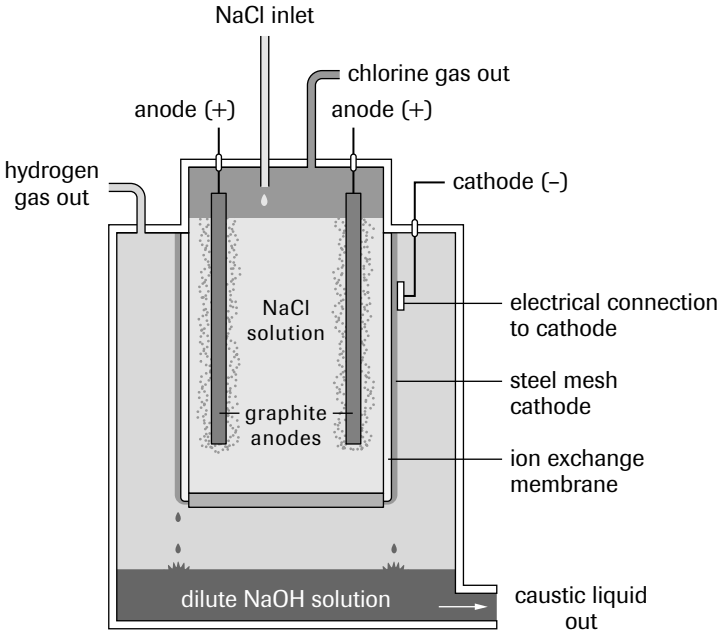
Making Connections

4. Caustic drain cleaners and chlorine bleaches may come from a chlor-alkali process.
5. Recycling metals such as aluminum lessens the need for mining, and thus benefits the environment. It helps to reduce the cost of the metal and thus benefits the consumer. It also encourages the process of recycling and waste management, helping to foster the idea of sustainable lifestyles.
6. Uses for aluminum listed on this site include jewellery, sculpture, furniture, fabrics (fashionable or protective), cars, trains, aircraft, containers (cans), cookware, and stereo components. All make use of aluminum's light weight, high strength, and corrosion resistance.

Extension

7. The new chlor-alkali cell design eliminates the use of mercury as a cathode, or of diaphragm designs that incorporate asbestos. Both of the older designs use toxic/dangerous materials. The membrane design requires the aqueous sodium ions to pass through a fluoropolymer membrane before reacting at the steel-mesh cathode. The hydrogen gas formed by the cathode half-reaction is thus separated from the chlorine that is formed at the anodes inside the cell—a critical point, as these gases are explosively reactive when mixed! The membrane design is really an example of molecular design—it is structured at a molecular level to allow sodium ions and water molecules through only when attracted by a negative charge on the other side.



Explore an Issue: Take a Stand: The Case For and Against Chlorine
(Page 742)

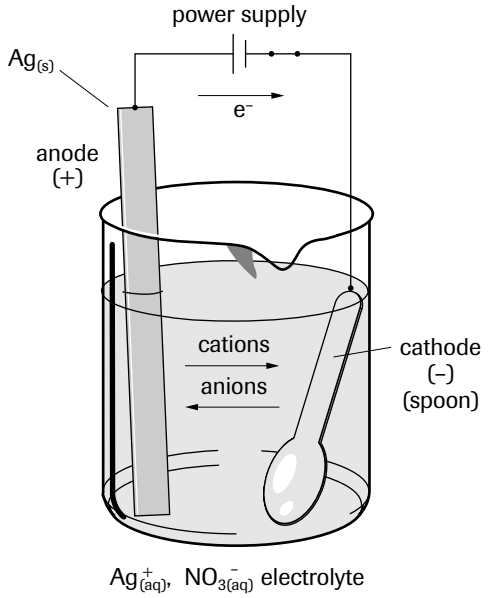
(a) (A typical student report will contain information such as some of the following.)
Production of chlorine is primarily by chlor-alkali electrolysis of brine solutions. Chlorine is made in huge quantities: in 1985 it was ninth in the list of chemicals produced (in volume) in North America. The chemical is normally stored as a liquid under pressure (about 8 atm). Chlorine is transported by ship in sealed tanks; and overland in railway tank cars, in tanker trucks, and by pipeline. Chlorine has a huge variety of uses. It is used in bleaching of paper products and in laundering fabrics; in making pharmaceuticals; for air-conditioning and refrigerating fluids; in manufacturing vinyl plastics; and in water purification and disinfecting. Chlorine is very corrosive, and a very strong oxidizing agent. The chemical is harmful to humans by skin contact and especially harmful by breathing the vapour. Edema of the lungs and chronic bronchitis may result from exposure by inhalation. Many groups concerned with chlorine's potential for harm to the environment and to human health are actively campaigning to have its use in water treatment and the pulp industry replaced by other chemicals. Some chlorine compounds are now banned. While these compounds initially seemed chemically inert, it has been discovered that they accelerate the breakdown of ozone in the stratosphere — "thinning" the ozone layer that absorbs some of our sun's harmful UV radiation.

(b) (Answers will vary, depending on the issue assessed, but should include a presentation of findings, and a strongly reasoned argument for the chosen position.)

PRACTICE
(Page 744)

Understanding Concepts
8. A metal product must form at the cathode during electrolysis because metal ions are positively charged, and must gain electrons (be reduced) to become atoms of metal.
9. (a) Impure copper is placed at the anode to oxidize copper atoms to copper ions, which dissolve in solution.
   (b) The minimum electric potential difference required for this cell is theoretically zero.
   (c) The minimum potential difference is a theoretical minimum and would mean a very long reaction time. A higher voltage is used to get the reaction to occur rapidly. (Note that the choice of voltage is also influenced by the cost of electricity.)
10. A reduction potentials table may be used to predict which metals might be refined from an aqueous solution. Metal ions that are weaker oxidizing agents (lower) than water cannot be easily refined from solution.
11. Electroplating is done usually to coat a strong base metal with a surface that is more attractive, or corrosion resistant, or both. Other metals are commonly plated with silver and gold for appearance, nickel for corrosion resistance, and chromium for both appearance and corrosion resistance.

Applying Inquiry Skills
12. (a)



   (b) Some variables that need to be considered when planning the electrolysis include the selection, solubility, and concentration of the electrolyte, the potential difference that will be applied and the current to be used, the time the cell will operate, and the mass of silver. (Some of these variables are related to each other.)

Making Connections
13. (a) A copper wire is attached to a shoe or other nonconducting object. A conductive lacquer paint, containing copper, is then sprayed onto the object which becomes the cathode of the electrolytic cell.
   (b) The object is first washed and dried, and then sprayed with a lacquer, shellac, or varnish. A copper wire is attached and the object is sprayed with two coats of a conductive lacquer. The object is plated at 1 V for about 30 min and then at 1.5 to 2 V for additional time required to produce a coating of the desired thickness (0.025 mm of copper per hour). One particular kit with all equipment and supplies costs $460.