5.17 ELECTROLYTIC CELLS

TRY THIS ACTIVITY: PENCIL PLATING

(Page 429)

(a) A reddish material formed on the surface of the negative electrode. Bubbles of gas were observed at the positive electrode.
(b) The colour change occurred at the negative electrode: a reddish solid formed over the graphite.
(c) Copper
(d) Since zinc metal would probably be produced at the negative electrode (instead of copper), a silvery-coloured deposit is expected (instead of reddish-brown).
(e) The cell used in this activity differs from a galvanic cell in that:
- an external power source was used
- the electrodes were identical
- the electrodes were in the same container

Note: The separation of anode and cathode into different containers is not a requirement for all galvanic cells. See the Try This Activity in Section 5.10.

SECTION 5.17 QUESTIONS

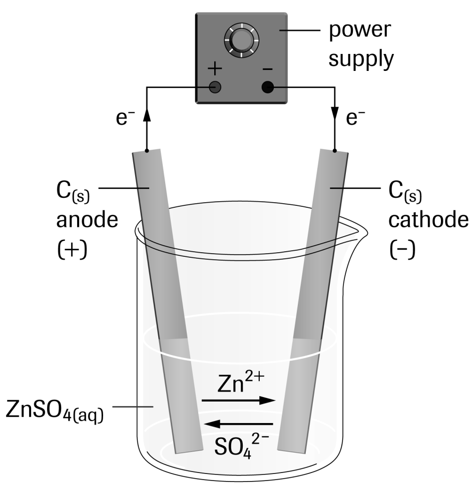
(Page 432)

Understanding Concepts

1. (a) A nonspontaneous reaction will not occur on its own. It requires a continuous input of energy.
   (b) An external energy source, such as a battery or power supply, is required to force the reaction to occur.
2. The energy changes in these cells are opposites: galvanic cells convert chemical energy to electrical energy, while electrolytic cells convert electrical energy into chemical energy.
3. Recharging a battery supplies the electrical energy required to force the cell reactions to proceed in the opposite, nonspontaneous direction.
4. It is necessary to separate the chemicals in a galvanic cell to prevent them from reacting directly with each other.

Applying Inquiry Skills

5. (a)–(d)



   (e) $Zn^{2+}_{(aq)} + 2\ e^- \rightarrow Zn_{(s)}$
6. (a) Tin
   (b) Chlorine
   (c) Cathode half-reaction: $Sn^{2+}_{(aq)} + 2\ e^- \rightarrow Sn_{(s)}$
   Anode half-reaction: $2\ Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2\ e^-$
7. Attaching the negative terminal of the battery to the zinc electrode would pump electrons into the zinc electrode, forcing the reduction of zinc to occur:
   $Zn^{2+}_{(aq)} + 2\ e^- \rightarrow Zn_{(s)}$

A silvery-grey deposit should be observed on the zinc electrode.
The battery would “pull” electrons from the copper electrode, forcing oxidation to occur:
$Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2\ e^-$
The copper electrode should slowly decrease in size and the solution should become more blue in colour.

Making Connections

8. The dark tarnish that accumulates on silver coins and artifacts is mostly silver sulfide, Ag_2S. Attaching the silver objects to the negative terminal of a power supply and electrolyzing them in a dilute solution of sodium hydroxide can remove the tarnish. As the cell operates, silver ions present in surface tarnish (Ag_2S) are reduced to metallic silver. Negatively charged sulfide ions migrate away from the coin towards the positive electrode where they are oxidized to sulfate, $SO^{2-}_{4(aq)}$ As a result, the thin layer of silver sulfide tarnish is converted to silver metal.

Extension

9. (a) Potassium ions (cations) flow toward the negative electrode (the cathode) while iodide ions (anions) flow towards the positive electrode (the anode).
   (b) $2\ I^-_{(aq)} \rightarrow I_{2(aq)} + 2\ e^-$
   (c) Bubbles of hydrogen gas should be observed at the cathode surface.
   (d) The addition of phenolphthalein indicator to the solution around the cathode would change the colour of the solution to pink if hydroxide ions are produced.
   (e) Anode half-reaction: $2\ I^-_{(aq)} \rightarrow I_{2(aq)} + 2\ e^-$
   Cathode half-reaction: $2\ H_2O_{(l)} + 2\ e^- \rightarrow H_{2(g)} + 2\ OH^-_{(aq)}$
   Overall cell reaction: $2\ H_2O_{(l)} + 2\ I^-_{(aq)} \rightarrow I_{2(aq)} + H_{2(g)} + 2\ OH^-_{(aq)}$

5.18 APPLICATIONS OF ELECTROLYSIS

CAREER CONNECTION: ENVIRONMENTAL TECHNICIAN

(Page 437)

(i) Sault College in Sault Ste. Marie offers a program that trains environmental technicians.
(ii) Minimum requirements are an Ontario Secondary School diploma with Grade 12 English (C) ENG4C and Grade 12 College and Apprenticeship Mathematics (C) MAP4C, or mature student status.
(iii) The following are some of the related careers that could be pursued by graduates of an environmental technician program:
- process technicians
- water quality technicians
- water/wastewater treatment plant operators
- field technicians
- maintenance operators
- water treatment supplies and equipment sales and service representatives
- water inspectors
- water quality technicians

SECTION 5.18 QUESTIONS

(Pages 438–439)

Understanding Concepts

1. Some of the reasons for aluminum’s versatility include:
   - it is abundant—aluminum is the third most abundant element on Earth, behind only oxygen and silicon
   - it can be produced inexpensively on a large scale
   - it is lightweight and can be formed into almost any shape
   - it can be mixed with other metals to form lightweight corrosion-resistant alloys that are stronger than steel
   - it is a good conductor of both electricity and heat
   - its silvery lustre is attractive
2. Aluminum oxide’s high melting point makes it difficult to electrolyze.
3. Aluminum is produced at the cathode and oxygen is produced at the anode.
4. Certain regions of Canada, such as British Columbia and Quebec, have a huge supply of inexpensive hydroelectric power.