(d) Student responses will vary depending on how passionately they feel about the environment. The production of Ni–Cd batteries should not be banned because they are popular and widely used. They meet our needs at a reasonable cost. Alternatives are too expensive.
(e) The leaflet or letter will vary depending on the strength of the student's position. However, the writing should clearly state the student's position, and reasons for it.

5.11 TECH CONNECT: HYDROGEN FUEL CELLS

TECH CONNECT 5.11 QUESTIONS

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Understanding Concepts

1. The primary difference between a fuel cell and an alkaline dry cell is that the chemicals used to generate electricity in a fuel cell are continually fed into the device while the reaction products are continually removed. This allows the fuel cell to provide an uninterrupted supply of electricity. An alkaline cell has only a finite supply of chemicals, and stops generating electricity once its chemicals are consumed.
2. The waste product from the hydrogen–oxygen fuel cell is water.
3. As a fuel, hydrogen is only as clean as the energy used to produce it. Hydrogen produced using a renewable energy resource, like light or geothermal energy, is considered "clean." Hydrogen produced using energy from a polluting source, like the combustion of fossil fuels, defeats the purpose of creating a non-polluting fuel.

Making Connections

4. A safe and convenient method of producing small quantities of hydrogen must be available so that the consumer can readily re-supply the phone with fuel. This could either be in the form of small cylinders of compressed hydrogen available at local stores, or through a safe home hydrogen-generating device.
5. Reforming technology involves extracting hydrogen from conventional hydrocarbon fuels like methane and methanol. This process (for methanol) generally involves two steps:
   (i) splitting methanol, using a catalyst
   $CH_3OH_{(g)} \xrightarrow{\text{catalyst}} CO_{(g)} + 2\ H_{2(g)}$ and
   (ii) oxidizing carbon monoxide
   $CO_{(g)} + H_2O_{(g)} \rightarrow CO_{2(g)} + H_{2(g)}$
   Unfortunately, this process also produces carbon dioxide—a greenhouse gas. The good news, however, is that the amount of carbon dioxide released would be considerably less than the amount released by burning gasoline.
6. Iceland has a great deal of hydroelectric and geothermal energy sources that can be developed to produce the "clean" electricity required to generate hydrogen gas.

5.12 CORROSION

CAREER CONNECTION: PLUMBER

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(i) A common situation in which metals can be mismatched occurs when fasteners, such as nuts, bolts, and washers, are used to hold metallic objects together. Unless all the fastening components are made of the same metal, corrosion can occur. This form of corrosion is sometimes called galvanic corrosion. Galvanic corrosion can also occur when metal roof or siding products are installed. A plastic liner is sometimes used to cover nail heads in the framing lumber of a roof, to prevent the nails from coming into direct contact with the metal roof. Galvanic corrosion also occurs where chrome-plated (or nickel-plated) accessories are bolted to steel car bodies. The corrosion of steel is accelerated.
(ii) Lead was banned from use in solder because of its toxicity. Lead from the solder can be oxidized, becoming toxic lead(II) ions in drinking water.
(iii) A number of community colleges offer plumbing apprenticeship programs. The basic entrance requirements for these programs include:
- a solid science background
- Grade 10 Mathematics (applied or academic)

- Grade 10 English (applied or academic)
- Grade 10 Ontario Secondary School at or above the general level
- minimum age of 16 years

An apprenticeship program can last between two and five years, during which time the apprentices can spend up to 90 % of their time learning on the job under the supervision of a licensed plumber. The remaining time is spent in class, on the theoretical aspects of the trade and their application in the field.

The employment trends in this trade vary directly with the economy. When the economy is strong, the construction industry demands more plumbers.

SECTION 5.12 QUESTIONS

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Understanding Concepts

1. Corrosion is the deterioration of a metal as a result of slow oxidation.
2. Reactive metals such as zinc and aluminum are corrosion-resistant because, as they corrode, their corrosion products form a tough protective layer that adheres well to the underlying metal. Thus, the metal is protected from the environment, so no further corrosion can occur.
3. Iron is oxidized; oxygen is reduced.
4. $\frac{1}{2}\ O_{2(g)} + H_2O_{(l)} + 2\ e^- \rightarrow 2\ OH^-_{(aq)}$

   Since water is a reactant in the reduction of oxygen, the corrosion of iron objects in the desert is extremely slow or nonexistent.

   Corrosion can also occur, very slowly, in the absence of water:

   $Fe_{(s)} + O_{2(g)} \rightarrow Fe_2O_{3(s)}$
5. The factors that affect the rate of corrosion include
   - the presence of moisture
   - presence of electrolytes
   - contact with less reactive metals
   - mechanical stresses
   - the presence of oxygen
6. Sodium chloride (salt), $NaCl_{(s)}$, does not cause corrosion to occur, but it can speed up corrosion. Because it is an electrolyte, sodium chloride increases the conductivity of water, allowing the anode and cathode reactions in a corrosion cell to occur faster. In particular, the migration of the sodium ions to the anode and chloride ions to the cathode help complete the electric circuit and prevent charge build-up at the anode and cathode.

Applying Inquiry Skills

7. (a) Independent variable: pH of the solution

   Controlled variables: the solution concentrations (identical at 0.1 mol/L); the nails (identical); and temperature

   (b) The nails in the acidic solutions showed the greatest amount of corrosion.

   (c) The nails in the basic solutions showed the least amount of corrosion.

Making Connections

8. Bringing the car inside a warm garage allows the snow that has accumulated on the underside of the car to melt. Road salt picked up with the snow can then be dissolved and carried to possible corrosion sites. Leaving the car outside keeps the water frozen and prevents salt from dissolving. However, if the garage is unheated, it would probably be better to keep the car there, where it might be slightly dryer.
9. The layer of plastic prevents the steel nails from coming into direct contact with the copper roof and corroding the roof prematurely from underneath.
10. (a) The extremely cold temperatures at the bottom of the ocean may have helped to slow the corrosion process. Also, a lack of dissolved oxygen deep in the ocean could contribute to the slow corrosion rate.

    (b) The information provided on several web sites verifies the prediction. In addition, there are reports that biological activity was an important contributor to the rusting of *Titanic*.

Extension

11. As aluminum oxidizes, it forms a tough protective coating of aluminum oxide that is a poor conductor of electricity. The formation of aluminum oxide at the end of an aluminum wire, such as at the connection to a receptacle, increases the resistance to current flow of the wire. As resistance increases, the temperature of the wire increases. To compound matters, aluminum expands more than the other metals used in electrical connections. When an electric current is applied, the heat generated causes aluminum to expand. The pressure of expansion pushes aluminum into

spaces in the connector. When the current is turned off, the decrease in temperature causes the aluminum to contract, creating a small gap between it and the connector. Oxidation of the aluminum can now fill the gap created, further increasing the resistance of the connection. The temperature of the connection is slightly higher the next time current flows through the wire. This cycle can continue until either the connection burns out or surrounding building materials ignite. The aluminum oxidation problem is made worse if aluminum is in contact with copper or steel and trace amounts of moisture. Under these circumstances, aluminum corrodes even faster.

5.13 CASE STUDY: PIERCING PROBLEMS

CASE STUDY 5.13 QUESTIONS

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Understanding Concepts

1. Nickel allergies are difficult to overcome because metallic objects containing nickel are very common.
2. Metals such as silver and gold would not be affected by the acidity of skin because they are listed below hydrogen on the activity series.
3. A lower pH value indicates increased acidity. Perspiration with a lower pH increases the rate of release (oxidation) of nickel from a piercing.
4. Washing removes most of the electrolytes from your skin or the back of the watch. Reducing the concentration of electrolytes reduces the rate of corrosion.
5. Tongue piercing is riskier than earlobe piercing because the tongue is thicker and contains far more blood vessels than the earlobe, making the healing period for a tongue piercing much longer than that for an ear piercing. Longer healing times and increased blood flow also increase the risk of infection. Furthermore, since a tongue piercing is continually bathed by saliva, the risk of nickel being oxidized out of the piercing and ingested is greatly increased.

Making Connections

6. Wearing jewellery is a very ancient custom, with deep roots in many traditions. Jewellery can symbolize one's financial status, marital status, social affiliation, sexual orientation, etc. While wearing jewellery may make a person a target for theft, people wear jewellery to make a statement, to make themselves blend in with or stand out from the crowd, to show appreciation for a gift, to attract a partner, or for many other reasons.
   (Student evaluations of their own use of jewellery will vary, but should include some of the abovementioned considerations.)
7. Student answers will vary. However, most will agree that some standardization and formal training should be required, especially for practitioners who administer tongue piercings.
   Possible training requirements include:
   - training in antiseptic methods
   - screening clients for certain medical conditions or medications that may cause prolonged bleeding
   - screening clients who have compromised immune systems
   - providing appropriate client education on the risks of the procedure before proceeding, and screening clients who do not understand the potential risks
   - educating clients to follow appropriate oral hygiene practices
   - the importance of follow ups with medical professionals should complications arise
   - how to maintain a sterile environment where the procedure is performed

5.14 INVESTIGATION: FACTORS THAT AFFECT THE RATE OF CORROSION

(Pages 420–421)

Prediction

(a) **Part 1:** The corrosion of the nail in distilled water will be significantly less than in the solutions because distilled water contains no ions. Corrosion will probably occur fastest in the acidic solution, $HCl_{(aq)}$, and more slowly in the basic and neutral solutions, $NaOH_{(aq)}$ and $NaCl_{(aq)}$.