Nickel metal hydride cells from one manufacturer have the following capacities:

Cell size	Capacity (mA•h)
AA	1400
AAA	550

The AA cell will last significantly longer, under the same operating conditions, than the AAA cell because the AA cell is larger and contains more chemicals to produce electricity.

14. Ni–Cd cells/batteries can suffer from "memory effect" that occurs when the battery is repeatedly drained less than its full capacity, and then recharged. This is a particular problem with portable phones. If portable telephones are replaced on the charger after each call, the capacity of the battery becomes greatly reduced. The cell "remembers" the point to which it was repeatedly discharged, and eventually will not discharge beyond that point. Memory effect can be avoided by allowing the battery to fully discharge before placing it back on the charger.

5.10 EXPLORE AN ISSUE: SHOULD NI–CD BATTERIES BE BANNED?

Understanding the Issue

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1. When Ni–Cd batteries in landfills corrode and break open, they release cadmium into the environment. Cadmium is an extremely toxic metal, implicated in a number of serious disorders of vital organs.
2. Ni–Cd batteries are plagued by "memory effect" resulting from improper recharging. If the battery is not fully drained, it may not fully recharge. This is caused by crystal growth at the cadmium anode.
3. Nickel metal hydride batteries have become viable alternatives to Ni–Cd batteries. They deliver high-energy output, can be recharged hundreds of times, and have the advantage of not suffering from "memory effect."

TAKE A STAND: SHOULD THE PRODUCTION OF NI–CD BATTERIES BE BANNED?

(a) Possible alternatives include:
- increasing public awareness of the hazards associated with Ni–Cd batteries
- encouraging recycling programs for Ni–Cd batteries
- promoting the use of environmentally-friendly alternatives through advertising and education programs
- encouraging more research into safer battery alternatives through government and corporate research grants
- developing nickel metal hydride batteries than can be used in existing portable devices

(b) Possible suggestions include:
- reducing the cost of environmentally friendly batteries using government incentives
- increasing the cost of Ni–Cd batteries by applying an "environment" tax
- introducing a mandatory phase-out period for the production of Ni–Cd batteries

(c) Pros and Cons of Ni–Cd Batteries

Pros	Cons
• Ni–Cd batteries remain the most common rechargeable battery. • Many portable devices are specifically designed to work with Ni–Cds. • They can be recharged more often than popular alternatives if handled properly. • They are generally less expensive than the alternatives currently available.	• They contain cadmium, which is hazardous to the environment. • Many alternatives are currently available to replace Ni–Cds. • Ni–Cds suffer from memory effect, which can drastically reduce their lifetime. • General purpose Ni–Cds are becoming more difficult to find

Student answers will vary, and the following Web sites may no longer be available. Resources:
Nelson Chemistry 12 College Preparation
http://www.night-sun.com/htmldocs/faq.html
http://www.matchrockets.com/teamstupid/power.html

(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)