**Key Terms**
chemical property
combustibility
stability
toxicity

## 4.3 Chemical Properties

When people think of chemistry, they usually think of different chemicals reacting with each other to produce something new—often envisioning frothing material or an explosion. How a substance reacts with other substances refers to another type of property, called a chemical property. A **chemical property** describes the ability of a substance to react with another substance and form one or more new substances. In **Figure 4.16**, different compounds are reacting with each other to produce a new substance. This reaction involves the production of energy, which is given off as light in a process called *chemiluminescence*.

**chemical property** the ability of a substance to change (react) and form new substances

The chemical properties of a substance are exhibited during a chemical reaction, or the transformation of a substance to form one or more new substances.

**Figure 4.16** Glow sticks are tubes containing different compounds that, when mixed, undergo a chemical reaction. This produces light. The colour of the glow stick depends on the type of dye in the stick.

## Reactivity with Other Substances

A large part of chemistry is based on reactions between substances, namely performing chemical reactions to synthesize new chemicals or products. Some examples of the types of reactions that elements and compounds undergo are summarized in **Table 4.4**. You will learn more about chemical reactions in Grade 10 science.

**Table 4.4 Examples of Reactivities**

| Description | Example |
|---|---|
| **Reactivity with Water** Calcium carbide is a compound that reacts with water to generate acetylene gas. The acetylene gas is combustible, which makes it useful for generating light. This type of light source was common before battery-operated and electric lights became available. Many cavers still use this as a light source when they are deep underground. |  |
| **Reactivity with Oxygen** Aluminum metal is very reactive with oxygen. The reaction causes a layer of aluminum oxide to form on the surface of the aluminum, which protects the metal from weathering. This helps to keep aluminum objects that are always exposed to the environment from corroding. |  |
| **Reactivity with Acids** Baking soda, or sodium bicarbonate, is a compound that reacts with acids to create carbon dioxide gas. Many recipes for baked goods use baking soda because the bubbles of carbon dioxide that form help to make batter and dough rise. |  |
| **Reactivity with Another Pure Substance** Knowing how pure substances react with each other provides the basis that enables chemists to develop new products. |  |

# Activity 4-7

## What's New?

Although there are too many different types of reactions to demonstrate all of them, these reactions will give you some idea of the different ways that you can observe chemical properties. Can you see evidence that indicates the formation of new substances?

### Safety Precautions

- Wear safety goggles.

### Materials

- sodium bicarbonate
- 5% acetic acid
- test-tube rack
- balloon
- test tube
- 5 mL water
- universal indicator
- calcium

### Procedure

**Part 1: Reaction with Acids**

1. Two common substances are sodium bicarbonate (baking soda) and acetic acid. Vinegar is a solution of acetic acid in water. Your teacher has already put the sodium bicarbonate in a balloon and the acetic acid in a test tube.
2. Place the balloon that contains sodium bicarbonate over the test tube that contains acetic acid. The baking soda should fall into the test tube so that it can react with the acid. Watch what happens to the balloon!

**Part 2: Reaction with Water**

3. Your teacher has prepared a test tube that contains 10 mL of water and a few drops of universal indicator.
4. Your teacher will add a small piece of calcium metal to the test tube. Watch to see what happens to the metal and the solution.

### Questions

1. What happened to the balloon? Why do you think this happened?
2. What happened to the solution in the test tube when the calcium was added?
3. Some substances, such as sodium metal, react very violently with water. Why do you think they are stored in oil?

### Don't Touch That Dye!

Hydrogen peroxide, also called peroxide, is a common ingredient in many hair dyes. Its chemical properties help to decolorize hair by reacting with the compound melanin, which is responsible for giving hair its colour. Peroxide changes melanin into a colourless compound, and the hair becomes a lighter colour. Peroxide also helps to develop the dyeing compounds that are used to recolour hair. Caution must be taken, however, when using peroxide on hair. Frequent use can damage the outer layer of hair, causing the hair to become brittle and break easily. At low concentrations, peroxide can irritate the eyes or broken skin. At higher concentrations, it can cause bleaching, redness, and even skin blisters.

## Combustibility

The ability of an element or compound to burn in air is a chemical property referred to as **combustibility**. For example, the combustibility of propane is an important chemical property that many people take advantage of, as shown in **Figure 4.17**. The reaction of propane with oxygen in the air releases a large amount of heat. Nevertheless, as you saw in the beginning of Section 4.1, the combustibility of propane can be a hazardous property of this compound.

**combustibility** the ability of a substance to burn in air

**Figure 4.17** Propane is combustible, which makes it useful for heating the air in hot-air balloons.

### Learning Check

1. Which of the following is a chemical property?
   - **a.** the smell of natural gas
   - **b.** the combustibility of propane
   - **c.** the freezing point of water
2. Is the ability of a substance to reflect light a chemical property? Why or why not?
3. How could the combustibility of a substance influence how the substance is used?
4. Carbonation in soft drinks is due to carbon dioxide. Is the process of carbon dioxide gas leaving a drink as it goes flat a chemical property? Explain.

**Suggested Investigation**

Inquiry Investigation 4-B, Chemical Properties of Common Gases, on page 168

## Stability and Toxicity

**stability** the ability of a substance to remain unchanged

**toxicity** the ability of a substance to cause harmful effects in plants and animals

The **stability** of a substance refers to how easily the substance decomposes or breaks down. The more stable a substance is, the longer it will take to break down. For scientists who focus on trying to synthesize new chemicals, stability is often an issue they must deal with. For a chemical to be useful, it must have enough stability to exist long enough to carry out its required function.

Another chemical property of a substance is toxicity. Generally speaking, **toxicity** refers to the harm that exposure to a substance can cause to animals and plants. Almost all chemicals are poisonous at high enough concentrations. For example, you need oxygen to breathe, but too much will kill you. Therefore, it is important to know how toxic a chemical is. Toxicity is typically reported as a $LD_{50}$ value. This unit of measure refers to the dose required to kill 50 percent of the exposed population.

**Suggested Investigation**

Plan Your Own Investigation 4-C, Properties of Common Substances, on page 170

The tetanus toxin from the bacteria *Clostridium tetani*, shown in **Figure 4.18**, is one of the most poisonous substances to humans. Only $1 \times 10^{-9}$ g for each kilogram of body mass is needed to kill a person! Other substances may not be as acutely poisonous, but they can cause toxicity due to prolonged exposure over time.

Although the toxicity of a substance is related to its chemical properties, the harm that it does can be related to its stability. Toxicity and stability are often linked together, particularly in discussions of the environmental impact of a chemical. For example, the toxic effects of DDT are made worse by its stability. If DDT easily broke down, then it would not bioaccumulate and biomagnify, and its toxic effects on animals and humans would be lower. You will learn more about stability and toxicity later in this unit, when you explore the impact of certain elements and compounds on the environment.

**Study Toolkit**

**Summarizing** Make a table like the one on page 138 to summarize the information on this page. This process of organization will help you to learn the material.

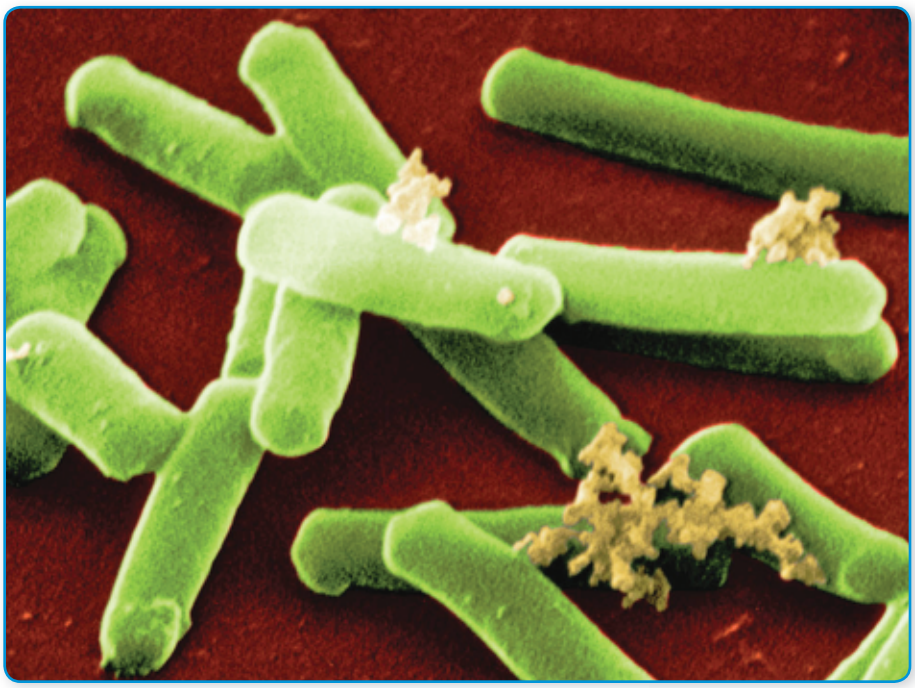

**Figure 4.18** This photo of *Clostridium tetani* was taken using an electron microscope. This organism produces one of the most toxic substances to humans.

## Section 4.3 Review

### Section Summary

- A chemical property of an element or a compound describes its ability to react with other substances and form new substances.
- Chemical properties of a substance include reactivity with other substances, combustibility, stability, and toxicity.
- The chemical properties of peroxide make it useful in hair dye. Nevertheless, there are hazards associated with its use that include skin and eye irritation.
- The stability and toxicity of a substance may influence its impact on the environment. For example, the toxic effects of DDT are made worse by its high stability.

### Review Questions

A **1.** Which property could be a chemical property of hydrogen?

**a.** It is a gas.

**b.** It is colourless.

**c.** It can explode and burn in the presence of air.

K/U **2.** Does the production of a new gas by a substance represent a chemical property? Explain.

A **3.** When objects like this horseshoe are left outside over time, the iron in them will react with oxygen to produce rust. Is this a chemical property of iron? Explain.

C **4.** Write a statement that warns people about the presence of peroxide in hair dyes.

K/U **5.** Name a chemical property of propane.

K/U **6.** Why is the stability of a compound considered a chemical property?

A **7.** Do you think toxicity is a qualitative property or a quantitative property? Explain.

T/I **8.** Explain how stability and toxicity can work together to increase the effects of a chemical on the environment.

Horseshoes are made of iron and, therefore, will rust when left outside.