Chapter

3

Chemical Reactions

In this chapter, you will be able to

- show that you understand the relationship between various types of chemical reactions and the nature of the reactants;
- use both the periodic table and experimentation to predict the reactivity of a series of elements and compare the reactivity of metals and alloys;
- predict the products of various types of reactions, write chemical equations to represent the reactions, and test your predictions experimentally, demonstrating safe handling of chemicals;
- identify chemical compounds and reactions in everyday use or of environmental significance.

Plastics, synthetic fabrics, pharmaceuticals, chemical fertilizers, and pesticides, all of which are very much a part of modern society, are each produced as a result of our knowledge and understanding of chemical reactions. These products illustrate the value of chemicals and the reactions that produce them. However, chemical reactions also have the potential to produce hazardous substances. On July 9, 1997, 400 t (4.00×10^5 kg) of plastic caught fire at a plastics manufacturing site in Hamilton, Ontario (**Figure 1**). The fire raged for more than three days, engulfing parts of Hamilton in thick black smoke. As a result of the fire, many people were exposed to hydrochloric acid, benzene, and other such potentially hazardous compounds. The Hamilton fire was an example of chemical reactions allowed to proceed in an uncontrolled fashion.

The fire was also an example of the release of energy that accompanies many chemical reactions. Energy, whether produced or absorbed, is an important aspect of chemical reactions. When fossil fuels such as oil, natural gas, gasoline, and diesel fuel are burned, energy is released in the form of heat. Combustion converts chemical energy to thermal energy, which allows us to drive cars, fly airplanes, and heat our homes. Not all chemical reactions produce energy. Some, including photosynthesis, require energy. Photosynthesis is perhaps the most important chemical reaction on Earth. In green plants, energy from the Sun is used to convert carbon dioxide and water into starch and oxygen. This process converts light energy to chemical energy and is largely responsible for the maintenance of life on Earth.

The reactions in the Hamilton fire were obviously bad for people and the environment. We work to avoid such catastrophes. The consequences of other reactions require a more balanced approach. Environmental problems such as acid rain and the greenhouse effect have been linked to the products of everyday combustion reactions, the ones that keep us warm and mobile. Although resolving such issues involves more than an understanding of science concepts, we will be in a better position to decide how to act if we understand chemical reactions.

Reflect on your Learning

1. How do you know whether or not a chemical reaction has taken place? What clues do you use to help you decide?
2. What types of chemical reactions are there? Describe as many categories as you can.
3. If you put solid aluminum in a solution that contains dissolved iron(III) nitrate, the following reaction will take place:

   $Al_{(s)} + Fe(NO_3)_{3(aq)} \rightarrow Fe_{(s)} + Al(NO_3)_{3(aq)}$

   However, if you put solid lead in an iron(III) nitrate solution, the following reaction does *not* occur:

   $3\ Pb_{(s)} + 2\ Fe(NO_3)_{3(aq)} \rightarrow 2\ Fe_{(s)} + 3\ Pb(NO_3)_{2(aq)}$

   Why do some reactions occur, but others do not?

Try This **Activity**

Observing Chemical Change

All around us, and even inside us, substances are combining to produce new substances. Sometimes the products are useful, and other times not so useful. Sometimes they may even be very hazardous. For instance, common household bleach can react with acidic toilet bowl cleaners to produce poisonous chlorine gas.

In some reactions, the change is almost undetectable. Other reactions produce a visible product, a colour change, or a temperature change. In this activity, you will observe what happens when an ordinary iron nail is placed in a solution of copper(II) sulfate.

Materials: eye protection, apron, iron nail, copper(II) sulfate solution, test tube, test-tube rack

- Place an iron nail in the test tube.
- Add 5 to 10 mL of copper(II) sulfate solution to the test tube.
- Place the test tube in a test-tube rack. Examine the test tube periodically over the next 20 min. Note any changes.

(a) Which of your observations provide evidence of a chemical change?

(b) What products may have formed?

(c) Suggest additional steps that you could take to identify the products.

Copper(II) sulfate is harmful if swallowed.

Wash hands thoroughly after this activity.

Figure 1
In 1997, a chemical fire burned out of control for several days, exposing Hamilton residents to noxious fumes.