1.9

Corrosion

Have you ever wondered why metal car bodies rust but plastic bumpers do not? As you know, different substances have different physical properties, such as colour and hardness, and different chemical properties, such as combustibility and reactivity with acid. One chemical property that has great economic importance is the tendency of a substance to undergo **corrosion**—the slow chemical change that occurs when a metal reacts with oxygen from the air to form a new substance called an oxide.

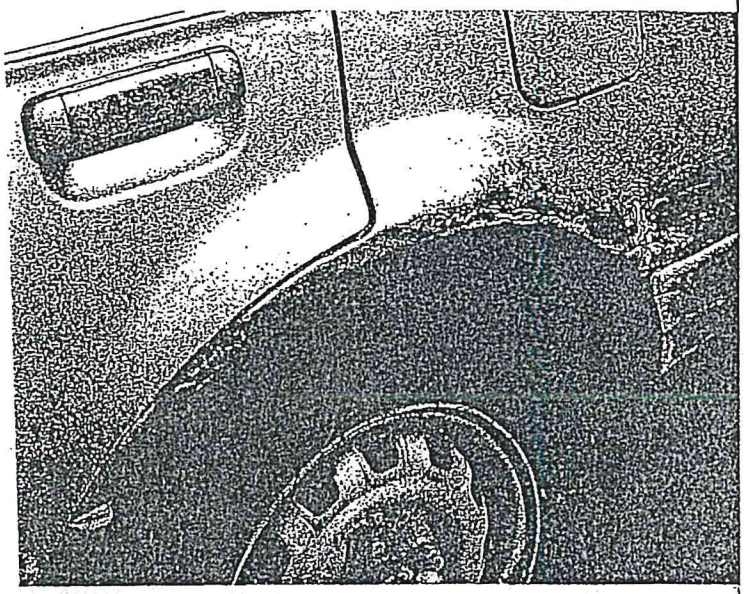


Figure 1
Rust damages many steel car bodies.

Kinds of Corrosion

The most dramatic example of corrosion is rusting—the reaction of iron with oxygen to form iron oxide. Iron is usually found in the form of steel, a mixture of iron, carbon, and other substances. This alloy or mixture of metals is much harder and tougher than the original iron.

Rusting is a chemical change that involves iron, oxygen from the air, and water, as well as the salts or other minerals dissolved in the water. Every year, millions of dollars of damage are caused to building structures, vehicles (like the car in **Figure 1**), and other iron and steel products due to this process. Rust is particularly damaging because of one of its physical properties: rust is porous, absorbing water almost like a sponge. As a result, it dissolves or flakes off, leaving another layer of fresh metal underneath to be attacked by oxygen. The process continues until the rust has eaten its way through the metal.

By contrast, aluminum has a similar chemical property in that it also reacts with oxygen, but the aluminum oxide that forms is strong and unaffected by water. The corrosion stops and the oxide acts as a protective coating. If you have aluminum cooking pans at home, you will be familiar with the grayish, dull coating of aluminum oxide.

Even silver develops a surface coating of tarnish if it comes into contact with sulfur-containing foods such as eggs or mustard. The black coating seen in **Figure 2** is silver sulfide. Silver tarnishes slowly if left out in the air; the more sulfur-containing pollutants in the air, the more quickly it tarnishes. The black layer can be removed by polishing the silver.

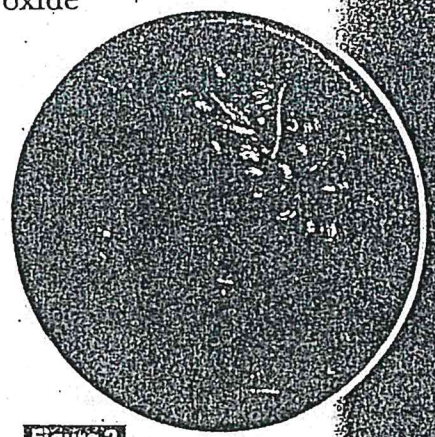


Figure 2
Silver slowly corrodes in air.

Preventing Corrosion

There are several ways to prevent corrosion. One method is to paint the surface of the metal (Figure 3). As long as the painted surface is not broken or cracked, oxygen in the air cannot get at the metal. For the same reason, cars are often sprayed with oil to coat the bottom and inner surfaces of the car body. Iron can also be protected by coating it with other metals.

Some metals have the chemical property of being easier to corrode than iron. This property is used to protect the hulls of ships and boat motors. For example, as seen in Figure 4, a plate of zinc is attached to steel boat motors. The steel motor parts remain untouched as the zinc is slowly used up. The zinc is replaced when it has completely corroded.

A special alloy of steel, made by mixing iron with nickel and copper, is now used in some building structures. The metals corrode quickly but the nickel and copper oxides form a protective layer that prevents further rusting.

Another way to prevent corrosion is to use materials that have different chemical properties. Plastics are being used increasingly in car bumpers and panels that get frequent bumps and scratches. Steel loses its strength if air and water penetrate through a scratch in the paint, but plastics never corrode and remain strong and flexible.

Figure 3

Some bridges are so large that painters take years to finish the whole structure. Then they have to begin again!

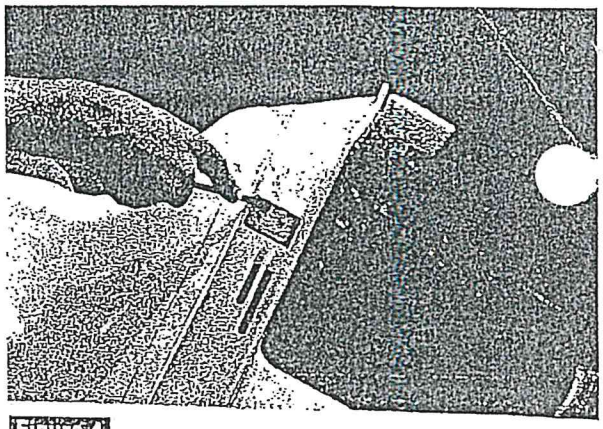


Figure 4

Another metal attached to a boat motor can protect it from corrosion in a process called cathodic protection.

Understanding Concepts

1. What is "corrosion"?
2. How is an oxide formed?
3. Describe two processes that form two different oxides.
4. Make a poster describing three ways to protect a metal from corrosion.

Making Connections

5. Corrosion of automobiles causes millions of dollars of damage every year. Which parts of the automobile corrode the most? Why? Describe how car owners and manufacturers can help to reduce the effect of corrosion.
6. Make a list of the products that you have in your home that can corrode. What decisions or steps can you take to protect these products from corrosion?

Reflecting

7. Engineers design pipelines to carry oil or natural gas over hundreds of kilometres. These pipelines are made of steel, but do not corrode. The engineers attach other metals to the pipelines every kilometre or so. How does this protect the steel?

1.11

Combustion

What chemical reaction occurs in the gas furnace that heats your home? What kind of chemical reaction occurs when you light a match? What caused the forest fire in **Figure 1**? What makes a car engine work? These, and the fires shown in **Figures 2** and **3**, are examples of an important type of chemical reaction called combustion. In **combustion**, a substance reacts rapidly with oxygen and releases energy. The energy is observed as heat and light. Many substances, such as wood, kerosene, and diesel oil, burn readily in air, which is only about 20% oxygen. This makes them useful as fuels.

The three necessary components of combustion are illustrated in **Figure 4**, called the fire triangle.

Fossil Fuels and Combustion

Coal, oil, natural gas, and gasoline are all fuels. They are called **fossil fuels** because they were formed from plants, animals, and microorganisms that lived millions of years ago. When these organisms died, they did not decompose completely. Instead, they were buried by sediments and the energy in their cells remained "locked up."

Human technology, developed over the centuries, depends on these long-buried organisms. Their stored energy powers homes, industries, and various means of transportation.

When any fossil fuel burns, the main products of the reaction are carbon dioxide and water vapour. The particles that make up fossil fuels are called **hydrocarbons**. To represent the combustion of a fossil fuel simply, the following word equation can be used:

hydrocarbon + oxygen → carbon dioxide + water

In a **word equation**, the substances you start with are written on the left and are called the **reactants**. The resulting substances, written on the right, are called **products**.

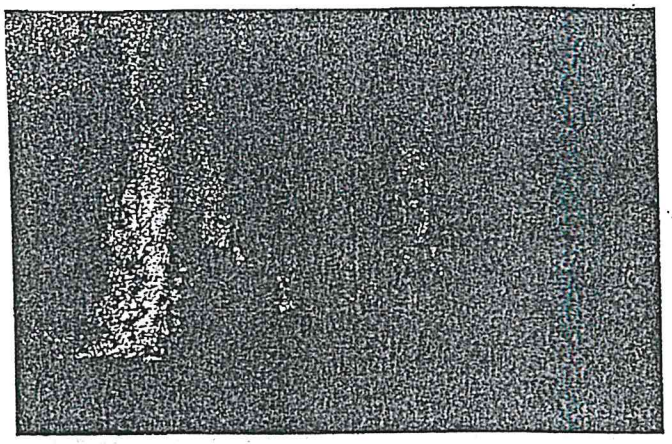


Figure 1
Some combustion reactions are destructive. Forest fires consume thousands of hectares of trees every year in Canada.

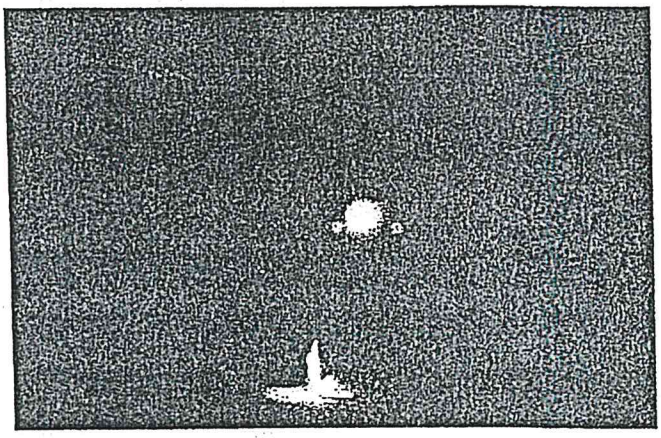


Figure 2
The quick reaction of magnesium with oxygen is combustion. Magnesium is often used as a component of emergency flares, which produce a bright light even in rain or snow.

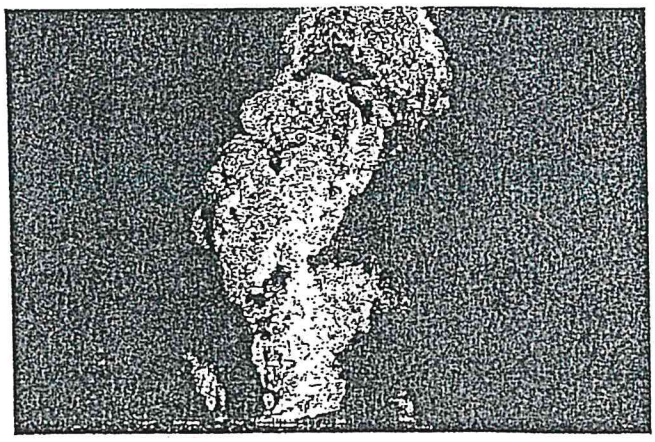
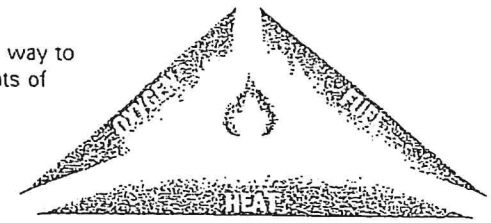


Figure 3
Fires can rage for months when oil wells burn out of control. The fires can be extinguished using explosives and other methods that seal the leaking oil. Which component of the fire triangle is removed to stop the fire?

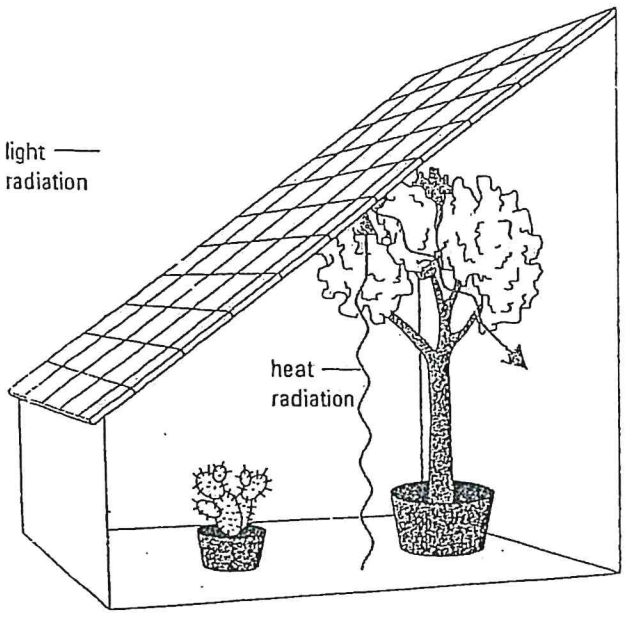


The fire triangle is a convenient way to remember the three components of any combustion reaction. Removing any one of these makes the triangle incomplete and puts out the fire.

Combustion and Air Pollution

Under ideal conditions, the combustion of hydrocarbons produces only carbon dioxide and water. But ideal conditions rarely exist. Fossil fuels are not pure hydrocarbons but rather are mixtures of many different substances. Also, the chemical action of combustion can be less efficient if there is not enough oxygen or heat. When not enough oxygen is available, two other products may be produced: carbon monoxide and carbon. Carbon monoxide is a poisonous gas that you will learn more about in Section 2.8.

When gasoline burns in an automobile engine, the carbon dioxide that is produced increases the greenhouse effect, which may be causing global warming (Figure 5). Other products include carbon monoxide, smaller hydrocarbons, sulphur dioxide, and nitrogen oxides, all of which can harm people and the environment. In fact, combustion is the major source of air pollution in the environment.



Carbon dioxide gas produced by combustion in industry and automobile engines increases the so-called greenhouse effect. The glass panes of a greenhouse allow sunlight to pass through but prevent heat from escaping. A similar situation occurs in the atmosphere: carbon dioxide in the atmosphere acts like the glass in a greenhouse, trapping heat close to Earth's surface. Many scientists believe this is causing a gradual increase in Earth's temperature.

Understanding Concepts

1. What is "combustion"?
2. (a) When fossil fuels burn, what are the reactants?
   (b) What are the two main products of this combustion?
   (c) Why are other products also formed?
3. Illustrate which part of the fire triangle is removed when each of the following methods is used to stop combustion.
   (a) closing the valve on a propane tank that supplies propane to a barbecue
   (b) dropping and rolling if your clothing catches fire
   (c) pouring water on a campfire
   (d) pouring baking soda on a grease fire
   (e) blowing on a flaming marshmallow

Making Connections

4. Why should you never operate a gas or charcoal barbecue inside a building?
5. Explain why building codes require an external source of air for fireplaces in new homes.

Exploring

6. Fossil fuels may be obtained from (3A) the black oil that is pumped from oil wells. Use the Internet or CD-ROM database to find out how these substances are found and separated. Some key words you might want to use in your search are: petroleum, fractionation, fractional distillation, and oil refining.

Reflecting

7. Wood is combustible but chalk is not. Is combustibility a physical or chemical property of substances? Explain.

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