LESSON 6

Applying the Heat

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Even Cordon Bleu chefs use heat to change matter.

INTRODUCTION

Have you ever baked a chocolate cake? After mixing the ingredients, you have a sticky brown liquid. You put it in the oven at a certain temperature. Twenty minutes later . . . presto! You have a chocolate sponge. Now for the chocolate topping. You slowly heat the chocolate until it melts. Then you spread it quickly on top of the cake before it turns solid again. The next stage? Well, eat it, of course!

It's time to stop thinking about food and get on with the science. Of course, what you just read contains a great deal of science. Most of the ingredients in a cake change when they are heated (see Figure 6.1). But each one changes in a different way. The way they behave depends on their characteristic properties.

The changes that occur in a cake mixture when it is heated are very complex. Some of the substances in the mixture change phase; others break down or combine with one another to form new substances. It is easier to examine the effect of heating on other, simpler substances. In this lesson, you will discuss how heating affects some familiar substances. Next, you will investigate six different substances as they are heated. You will be asked to make careful observations, accurately record them, and discuss your results.

OBJECTIVES FOR THIS LESSON

Review what you already know about how heating affects substances.

Observe and record the effects of heating on different substances.

Discuss the results of the inquiry.

Figure 6.1 *What effect does heat have on the ingredients of a cake?*

Getting Started

1. Take 5 minutes to think of two familiar household substances that you have heated. In your science notebook, write what happened when you heated the two substances.

2. Your teacher will lead a brainstorming session on heating substances. Be ready to contribute your examples and ideas to the discussion.

MATERIALS FOR LESSON 6

For you

- 1 copy of Student Sheet 6.1: Applying the Heat
- 1 copy of Student Sheet 6: Review for Characteristic Properties
- 1 pair of safety goggles

For your group

- 1 burner
- 1 250-mL beaker
- 1 test tube clamp
- 5 test tubes
- 1 lab scoop
- 1 test tube brush
- 1 test tube containing sulfur
- 5 jars containing:
  - Ammonium chloride
  - Copper (II) carbonate
  - Copper (II) sulfate
  - Sodium chloride
  - Zinc oxide

SAFETY TIPS

Use safety goggles at all times.

Tie back long hair and restrict loose clothing.

Never smell or taste chemicals.

Handle chemicals only with the lab scoop.

Use only a test tube holder to pick up test tubes.

Never move around with a lit burner.

Never refill the alcohol burners.

Do not walk around while substances are being heated; remain at your workstation at all times.

Follow classroom procedures for disposing of broken glassware and cleaning up spills.

Wash your hands at the end of the lesson.

Inquiry 6.1
Heating Substances

PROCEDURE

1. Your teacher will explain the purpose of Inquiry 6.1 and review safety procedures.

2. Your teacher will demonstrate the procedure you will follow for heating substances. Watch the demonstration carefully.

3. Copy the information from the class table onto Table 1 on Student Sheet 6.1.

4. Participate in a class discussion.

5. You will be working in groups of four. One member of your group should collect the plastic box containing the apparatus. Check the contents of the plastic box against the materials list.

6. Read Steps 7 through 17 below *before* starting to heat the substances.

7. Your teacher will allocate a workstation to your group. Each workstation has a burner. Check that it is ready for use before asking your teacher to ignite it. Make sure you carefully follow the procedure demonstrated by your teacher for using your burner.

8. Place one lab scoop of the first substance into a test tube.

9. Write the name of the first substance you are going to heat in the first column of Table 1 on Student Sheet 6.1.

10. Examine the substance carefully. In the second column of Table 1, record its appearance before you start heating it.

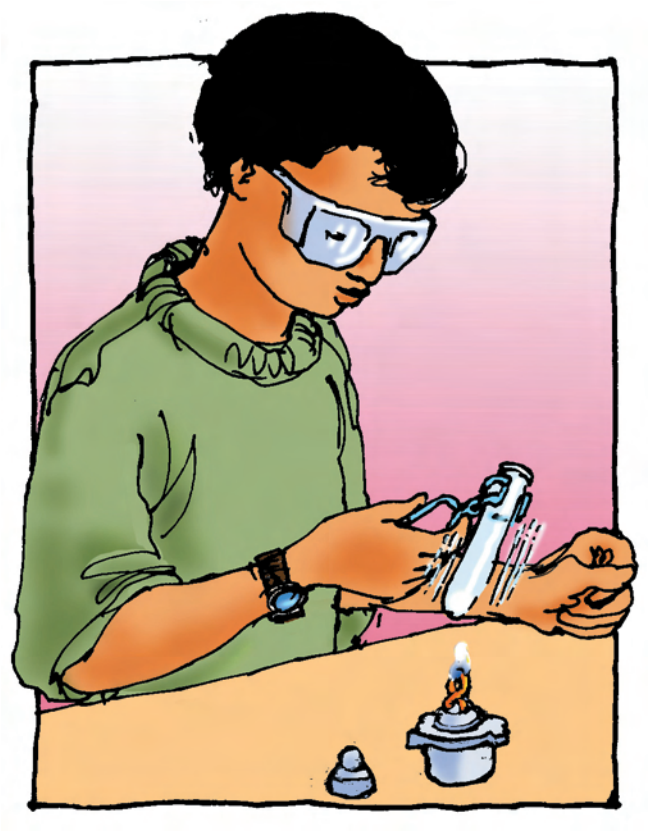

Figure 6.2 *Hold the test tube over the flame and keep it moving to heat the substance evenly. (The burner shown here is an alcohol burner, yours may differ from this one.)*

11. Attach the test tube clamp near the mouth of the test tube.

12. Heat the bottom of the test tube containing the substance for 1–2 minutes. Keep the tube moving to heat the substance evenly (see Figure 6.2).

13. Observe any changes and record your observations in the third column of Table 1.

SAFETY TIP

Do not walk around while holding the hot test tube.

SAFETY TIP

Hold the test tube at an angle of about 45° to the flame. Make sure you are not pointing the open end of the test tube at yourself or anyone else.

14. Allow the test tube and the substance to cool for 1 minute. Place the test tube in the 250-mL beaker. In the fourth column of Table 1, record the appearance of the solid after it has cooled.

15. Use the same procedure to heat the other four substances in the jars.

16. Use the same procedure to observe, describe, and heat the sulfur. After cooling, return the test tube containing the sulfur to the plastic box. These test tubes may be used later by another class.

17. When you finish heating all six substances, extinguish the burner.

18. Make sure all the tubes are cool before disposing of the chemicals in the container provided for that purpose. *Do not* empty or clean the test tube containing the sulfur.

19. Use the test tube brush and water to clean the other test tubes thoroughly. Allow the tubes to drain and then stand them upside down in the 250-mL beaker. Return your apparatus to the plastic box.

20. Answer these questions on Student Sheet 6.1 and be prepared to discuss your answers with the rest of the class: Which substances (if any) showed no change when heated? Which of the substances produced new substances when they were heated? How can heating a substance help you to identify it?

REFLECTING ON WHAT YOU'VE DONE

1. Your teacher will conduct a class discussion. Be prepared to participate.

2. Read "Heat and Changing Matter."

HEAT AND CHANGING MATTER

You have discovered that heat affects different substances in different ways. When you heated one of the solids, it melted. Then when the substance cooled, it solidified again. Another substance turned into a gas and then turned back to a solid farther up the tube. When a substance changes from one phase to another it is called a phase change. Did any of the substances you heated exist in all three phases of matter (solid, liquid, and gas) within the test tube?

Many of the other substances changed their appearance when you heated them and did not return to their original form when they cooled. This is usually a sign that a chemical reaction has taken place. In a chemical reaction, one or more substances (called reactants) are changed into new substances (called products).

In Inquiry 6.1, the substances that underwent chemical reactions decomposed when they were heated and then formed products that did not look like the original substances. This type of chemical reaction is called thermal decomposition. Some of the substances you heated decomposed and gave off invisible gas as one of the products. Can you identify one of the substances that you heated that did this? What evidence do you have that an invisible gas may have been produced? There are many other types of chemical reactions. You will investigate some later in the module.

Some substances change in other ways when they are heated. Can you identify any of these changes? How could these types of changes be useful to people? The way a substance behaves when it is heated is a characteristic property of that substance.

The Properties of Asbestos: The Pros and Cons

Many substances burn when they are heated. Others melt or evaporate. Some substances, such as asbestos, do not change when they are heated. This property can be very useful. For centuries, people have known that this fibrous mineral has many useful properties. It is fire resistant. It does not melt or react with air, at least not until it gets very hot. One form of the mineral withstands temperatures up to 2750 °C. It is a very good insulator. It is strong. It resists acid. It is chemically inactive. It can be woven into cloth. Asbestos has some very useful properties, and it is readily available at a low cost.

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This is a close-up of a piece of asbestos rock. Can you see the fibers?

CORBIS/JONATHAN BLAIR

Asbestos is a naturally occurring mineral that is mined.

The Romans used asbestos for lamp wicks. Egyptians used it to make burial cloths. In modern times, asbestos has been used in roofing and flooring, electrical and heat insulation, and brake linings. Because of its fire-resistant properties, asbestos has been used for a wide variety of other purposes, from theater curtains to firefighters' suits and gloves.

Until the 1970s, asbestos was widely used and asbestos mining and production were important

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These firefighters are wearing suits woven from asbestos to protect them from the intense heat produced by a fire in an oil refinery.

industrial activities in the United States. Today, asbestos mining is banned in this country, and the use of asbestos has been strictly regulated.

Why? It is now known that inhaling asbestos fibers can cause lung disease. Asbestos releases tiny particles that remain suspended in the air. Once inhaled, these downy particles can remain in the lungs for decades. They cause delicate lung tissue to stiffen. A lung disease, called asbestosis, and a type of cancer may occur years after the original exposure.

Today, construction companies are not allowed to use asbestos as insulation or fireproofing in new buildings. Workers who are exposed to asbestos must wear protective clothing. They have to shower and change clothes before going home.

Government regulations also apply to some buildings that had already been built when the new laws were passed. For example, schools that contain asbestos products have had to remove them.

So, there's good news and bad news. Regulating the mining, manufacture, and use of

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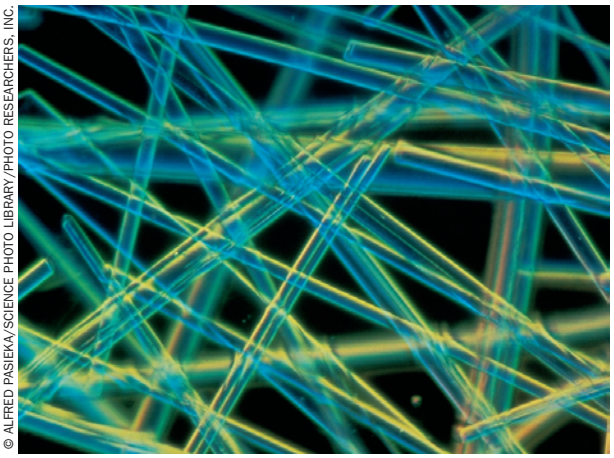

Asbestos fibers as seen through a microscope

asbestos has reduced the health risk that millions of Americans were being exposed to daily. But nothing has yet been found that can replace asbestos. However, researchers are exploring the use of synthetic fibers, fiberglass, and plastics as asbestos substitutes.

It's a trade-off: using a substance that has many useful properties versus having a safer environment. In the United States, the decision has been made. What other similar trade-offs can you think of? □

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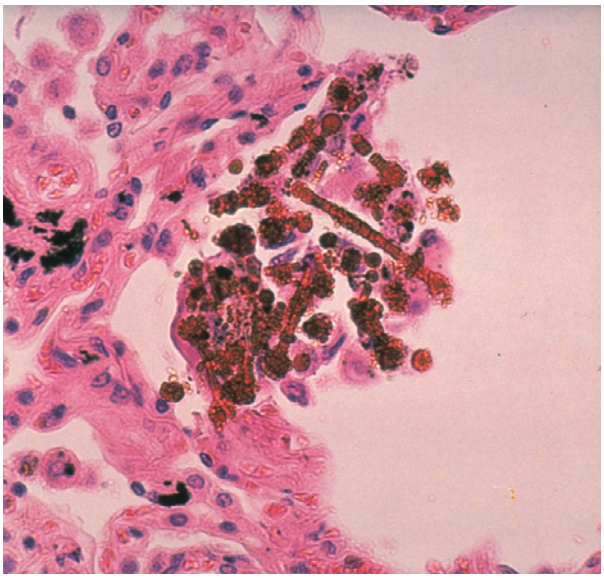

Asbestos fibers in the human lung can cause several diseases, some fatal.

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Asbestos has been removed from some buildings to reduce the risk of inhabitants being exposed. How do the workers removing the asbestos minimize the risks to themselves?

QUESTION

Many substances with useful properties have some undesirable ones as well. Use library and Internet resources to answer the following question: What are some properties and some of the pros and cons of using one of the following substances: mercury, plutonium, or benzene?