LESSON **18**

Changing Mixtures

BYRON AUGUSTIN/DDB STOCK PHOTO

This skyscraper was built using a wide variety of mixtures, including concrete, steel, and glass.

INTRODUCTION

Most of the materials used to make things are mixtures. In fact, if you look around your classroom, you will discover that it is very difficult to find any pure substances. Concrete, bricks, paper, wood, steel, and glass are all mixtures. Materials can be made with specific properties by altering the types and the amounts of substances that go into a mixture. For example, changing the amount of water or the amount and type of aggregate (stones) in concrete will change its strength when it is set. The wetter the original mix, the weaker the concrete. Adding different kinds of aggregate can also change concrete strength.

Solutions are a special kind of mixture. Can a solution be used to make things? Can the properties of a solution be altered? What happens to the properties of a solvent when you add a solute to it? Are the properties of a solution different from those of the solvent and the solute (or solutes) from which it is made? Does the amount of solute you add to a solution affect the properties of the solution? You may be surprised by the answers you find to these questions during the course of this lesson.

OBJECTIVES FOR THIS LESSON

Measure the effect of different quantities of salt on melting and boiling points.

Compare the melting points of different alloys.

Discuss the technological applications of solutions and other mixtures.

Getting Started

1. During this lesson, you will work in a group of four. Discuss the following questions with the members of your group:

A. Can you think of at least one mixture that has the properties of both of the substances from which it is composed?

B. Can you think of at least one mixture that has the properties of only one of the substances from which it is composed?

C. Can you think of at least one mixture that has properties completely different from the properties of the substances from which it is composed?

Record your answers in your science notebook.

2. Your teacher will conduct a brainstorming session on your answers. Be prepared to contribute to the discussion.

MATERIALS FOR LESSON 18

For you

- 1 copy of Student Sheet 18.1: Adding Salt to Ice
- 1 copy of Student Sheet 18.2: Adding Salt to Boiling Water
- 1 copy of Student Sheet 18.3: Investigating Solid Solutions
- 1 pair of safety goggles

For your group

- 1 plastic spoon
- 1 black marker
- 2 250-mL beakers
- 2 thermometers
- 1 aluminum pan
- 1 jar of sodium chloride (common salt)
- 1 piece of solder, color-coded blue
- 1 piece of solder, color-coded green
- 1 piece of solder, color-coded red
- 1 burner
- 1 burner stand or tripod and wire gauze
- Crushed ice
- Access to hot water
- Access to a clock or watch with a second hand

Inquiry 18.1
Adding Salt to Ice

PROCEDURE

1. One member of your group should collect the plastic box containing the materials. Label one of the beakers "A" and the other "B."

2. Collect the crushed ice from your teacher.

3. Fill Beaker A and Beaker B with crushed ice until one-third to one-half full.

4. Place a thermometer in each beaker. Measure the temperature of the crushed ice for each. Record your results on Student Sheet 18.1.

5. Discuss with other members of your group what you think will happen to the ice in Beaker A if you add 2 heaping spoonfuls of salt to it. What will happen in Beaker B without any salt? Record your predictions on Student Sheet 18.1.

6. Add the 2 spoonfuls of salt to Beaker A *only*. Use the plastic spoon to stir the mixture. Observe each beaker and measure the temperature of each. What happened to the ice in Beaker A when you added the salt? What happened in Beaker B? Record your answers on the student sheet.

7. On the student sheet, write what you think will happen if you add another two spoonfuls of salt to Beaker A. What will happen in Beaker B without the salt?

8. Add the salt as before and record your answer on the student sheet.

9. Answer the following questions on the student sheet: What effect does salt have on the state of matter of ice? What effect does salt have on the melting point of ice? What effect does the addition of more salt have on the temperature of the ice/saltwater mixture?

10. Does the amount of salt you add affect the temperature or melting point of the ice? Record your answer on the student sheet.

11. After a class discussion on your results, dispose of the contents of both beakers by pouring them down the sink. Rinse the beakers and the thermometers.

SAFETY TIP

Wear your safety goggles throughout the lesson.

Inquiry 18.2
Adding Salt to Boiling Water

PROCEDURE

1. Put about 100 mL of hot water in a 250-mL beaker. Place a thermometer in the beaker.

2. Follow the procedure outlined by your teacher for igniting the burner.

3. Place the thermometer and beaker on the stand and heat the water until it boils. Answer the following questions on Student Sheet 18.2: How can you tell the water is boiling? At what temperature does the water boil?

4. Predict what will happen to the boiling point of the water if you add 2 heaping spoonfuls of salt to it. Record your prediction on the student sheet.

5. Add 2 spoonfuls of salt to the water. Watch the boiling water and the thermometer. Record your observations on the student sheet.

6. Add an additional 2 spoonfuls of salt to the boiling water. Record your observations on the student sheet.

7. Answer the following questions on the student sheet: What effect did adding salt have on the boiling point of water? Does the amount of salt added affect the temperature or the boiling point of water?

8. Write a short paragraph on the student sheet summarizing the effect salt has on the melting and boiling points of water.

9. Your teacher will use the reader "Changing Melting and Boiling Points" as the basis for a short discussion.

SAFETY TIPS

Carefully follow your teacher's instructions for the use of burners.

Tie back long hair.

Be careful when handling hot objects.

CHANGING MELTING AND BOILING POINTS

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Do you know what is inside the strange building shown in this photograph? The building is used to store salt that is spread on the road when weather conditions are below the freezing point of water. What effect will the salt have on icy roads? Why store the salt in a building?

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This truck removes snow and spreads salt. How does spreading salt on roads reduce accidents?

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A solution of antifreeze is used to fill car radiators. It lowers the freezing point of the water in the radiator of the car. It also raises its boiling point and reduces corrosion. Why are the properties of this solution useful to motorists? Why isn't salt used instead?

Inquiry 18.3
Investigating Solid Solutions

PROCEDURE

1. In this inquiry, you will investigate how impurities affect the melting point of three metal mixtures called solders. Because these solders melt at temperatures above the range of the thermometers you will use, you will measure the amount of time it takes for each of the solders to melt. You will then compare these measurements to determine the melting points of the solders. Your teacher will demonstrate how the apparatus in this inquiry should be used. Watch carefully and then read the instructions and Safety Tips before you start.

2. Assemble the apparatus as shown in Figure 18.1, but *do not place the burner into position under the stand until Step 6.*

SAFETY TIP

Solder is toxic if ingested. Do not put solder in your mouth.

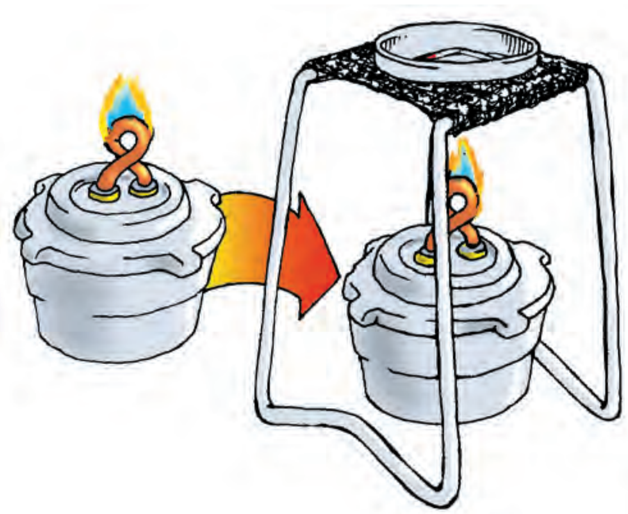
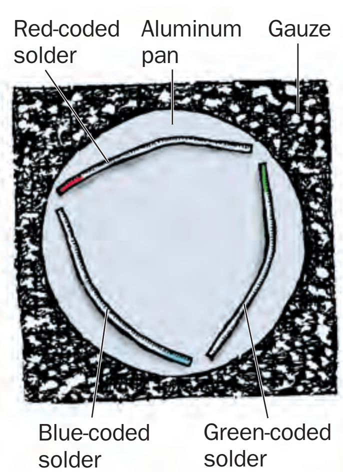


Figure 18.1 *How to assemble the alcohol burner apparatus for Inquiry 18.2. (Your burner may differ from this one.) Do not place the burner into position under the stand until Step 6.*

3. Place the pieces of solder on the aluminum pan in the same positions as those shown in Figure 18.2.

4. Make sure the aluminum pan is positioned in the center of the gauze. Make sure you know where each color-coded piece of solder is by completing the diagram in Step 1 on Student Sheet 18.3. **Warning:** As the solder gets hot, the color codes may disappear.



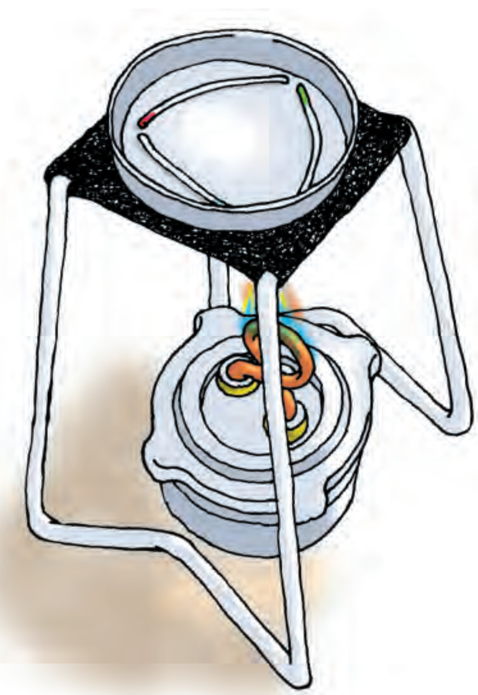


Figure 18.2 *Place the pieces of solder on the aluminum pan.*

SAFETY TIPS

Do not lean over the apparatus during heating.

Observe the solders from a distance of 2–3 feet.

5. Follow the procedure outlined by your teacher for igniting the burner. (If you are using a Bunsen burner, use the gas tap to make a flame about 4 cm high, and open the air hole about halfway.)

6. Using a clock or watch with a second hand, start recording the time at time 0. Move the burner so that the top of the flame is *exactly* in the center of the aluminum pan. Stand 2–3 feet (0.6–1 m) away from the apparatus.

7. Watch the pieces of solder very carefully, because changes may happen very quickly. Record in Table 1 on Student Sheet 18.3 when each piece of solder begins to show signs of melting (change in shape, seems more liquid than solid, etc.). Stop heating when all the pieces have melted or after 5 minutes (whichever comes first). If any of the pieces remains unmelted, record this information in Table 1.

8. Extinguish your burner.

9. Discuss the following questions with your group members. Once your group has agreed on the answers, write them under Steps 3 through 8 on Student Sheet 18.3.

   A. How do you think the length of time to melt relates to the melting points of these solders? (Obtain the melting points from your teacher and add them to Table 1.)

   B. Did all of the solders melt at the same temperature?

   C. What effect do other metals have on the melting point of tin? (Use the information in Table 1 on the student sheet to help you answer this question.)

   D. What effect does a greater amount of silver have on the melting points of the mixtures?

   E. Look at the melting points of the pure metals in Table 1. Three of these metals are very difficult or impossible to melt with a lab burner. On the basis of this information, do you think that mixtures of metals always show a combination of the properties of their components?

   F. Why are the low melting points of these alloys a useful property for solder?

10. Make sure your apparatus is cool. Return the materials to the plastic box and give any unused pieces of solder to your teacher.

SAFETY TIPS

Do not touch your apparatus for at least 5 minutes. It is still very hot.

Wash your hands before leaving the lab.

REFLECTING ON WHAT YOU'VE DONE

1. Read "About Alloys," below.

2. Your teacher will lead a class discussion on alloys, how their properties are manipulated, and how they are used. Be prepared to participate in the discussion.

ABOUT ALLOYS

Alloys are mixtures that contain at least one metal. Most alloys are solid solutions. Although many alloys consist of two metals mixed together (for example, silver and tin in some solders), the most widely used alloy is the mixture of carbon and iron that is called steel. Steel is much stronger than pure iron. Its properties can be changed by adding other substances to it. For example, manganese makes steel harder, and chromium, which is used to make stainless steel, stops steel from rusting.

Alloys of other metals, such as aluminum and titanium, provide the high-strength, low-density materials needed to make aircraft. Alloys of tungsten and cobalt are used in materials that must resist the effects of high temperature (for example, rocket engines). Bronze is an alloy of copper and tin. Pure gold is very soft, causing items made from it, such as jewelry, to be easily damaged. Therefore, gold is often alloyed with silver and copper to produce a harder metal. You will learn more about some of these metals in Lessons 21 and 22.

The Samurai's Sword

The properties of metal objects are determined not only by all the different metals that make them up but also by the way the metals are mixed together and treated. For thousands of years, metal workers, or smiths, have been altering the properties of metals by heating, hammering, and using other treatments to make objects as diverse as springs and gun barrels. The famous swords of the Samurai warriors of medieval Japan are one example of how smiths used the properties of particular metals for specific purposes.

The first Samurai were soldiers who were hired by landowners to protect their property from bands of robbers. From the 12th to the 19th century, even though Japan had emperors, the Samurai actually ruled Japan. The sons of Samurai were trained from early childhood for careers as warriors. A young man began his career at about age 15, when he received his first sword in a special ceremony.

The Samurai's sword was a formidable weapon.

Although each Samurai also carried a bow and arrow (and was trained in wrestling and judo), sword fighting was his most important skill. And the Samurai's swords were special indeed. Each Samurai had a long sword and a short one. The long sword, called the *katana*, was his main weapon. Its steel blade was designed to kill an enemy with one swipe!

To make a *katana*, a swordsmith used two types of steel. The core of the sword was made of soft, flexible, low-carbon steel (an alloy of iron with a little carbon). The jacket, or outer part of the sword, was made of hard steel that contained a greater proportion of carbon than did the core. The combination of these two kinds of steel gave the sword the flexibility to withstand a hard blow and a hard, razor sharp edge that would not be dulled during battle.

The swordsmith treated both steels with different techniques that improved the performance of the sword even further. He began by heating a lump of raw low-carbon steel—about the size of a brick—in a forge (a furnace that burns charcoal at very high temperatures). The swordsmith then hammered the steel on an anvil until it was flat. Then he folded it in half crosswise and

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Expert modern swordsmith Akitsugu Amada is one of two swordsmiths in Japan with the title Ningen Kokuho *(Living National Treasure).*

hammered it out again. He repeated this process many times to drive out any impurities from the metal. Finally, he shaped it into a long, thin wedge.

Next, the swordsmith began to work on the high-carbon steel. He followed the same process as the one he used for the low-carbon steel, but this time, he hammered and folded many more times. The final piece of metal had up to 30,000 folds or layers. The swordsmith made the jacket somewhat longer than the core.

Next, he joined together the two parts of the blade. The jacket was wrapped around the core, and the swordsmith heated and hammered the two pieces until they formed a solid bond. He had to be extremely careful; if an air bubble or piece of dirt remained between the two parts of the blade, the sword would be worthless in battle.

The blade was then tempered, a process that is used to control the properties of the steel. The blade was heated and then cooled by being plunged into water. The swordsmith coated the sword with clay to control the cooling process. Where the coat of clay was thick, the steel would cool more slowly, and this would make it flexible. The edge of the blade was given a thin coat of clay, which allowed it to cool very quickly, a process that made the edge even harder.

The swordsmith sharpened and polished the blade. The layers, or grain, were visible on the shiny surface. Finally, he tested the blade—on iron sheets, armor, and, sometimes, the bodies of executed criminals.

The Samurai swords were deadly but beautiful. The blades were decorated, and the handles were inlaid with pearls and other jewels.

Samurai swords were passed from generation to generation. Upon reaching manhood, a son received his father's sword, along with stories of the brave acts that had been accomplished with it. ☐

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Kenji Mishina, a great master sword polisher, carefully polishes a Samurai sword.

QUESTION

What techniques did the swordsmith use to modify the properties of different parts of a *katana* blade? Investigate how these techniques are applied for different purposes today.

Ice Cream in the Old Days

Which came first, ice cream or freezers? Everyone knows that a freezer is needed to store ice cream. To keep ice cream solid, it has to be stored well below the freezing point of water (0 °C). Making ice cream also requires the same low temperatures. People didn't have freezers in the old days, so were they able to make ice cream?

The answer is yes. Most people used to make their own ice cream at home. They would have ice delivered to their house by an ice-making company, or they would use ice they had collected in winter and stored underground. They would start by making an ice cream mixture. They would combine the mixture in a metal container (one that's good at conducting heat) and then place the container in a bucket containing crushed ice and a little water.

Next, they added salt to the ice. The ice

Delicious! But how was ice cream made without a freezer?

This ice cream machine required the use of ice and salt to lower the temperature of the ice cream mixture to the point where it would freeze.

would immediately start to melt. To melt, ice takes in heat from its surroundings, cooling down the container of the ice cream mixture to below the freezing point of water. They would continually stir the ice cream mixture so it produced small ice crystals, which gives ice cream its creamy texture. Sometimes they would have to use as much as a pound of salt to make the ice cream.

You can make your own ice cream by following Great Grandma's vanilla ice cream recipe. After you make it, you can add your favorite toppings. ☐