Section 1

States of Matter

Reading Preview

Key Concepts

- What are the characteristics of a solid?
- What are the characteristics of a liquid?
- What are the characteristics of a gas?

Key Terms

- solid
- crystalline solid
- amorphous solid
- liquid
- fluid
- surface tension
- viscosity
- gas

Target Reading Skill

Building Vocabulary A definition states the meaning of a word or phrase by telling about its most important feature or function. After you read the section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Lab zone **Discover Activity**

What Are Solids, Liquids, and Gases?

1. Break an antacid tablet (fizzing type) into three or four pieces. Place them inside a large, uninflated balloon.
2. Fill a 1-liter plastic bottle about halfway with water. Stretch the mouth of the balloon over the top of the bottle, taking care to keep the tablet pieces inside the balloon.
3. Jiggle the balloon so that the pieces fall into the bottle. Observe what happens for about two minutes.
4. Remove the balloon and examine its contents.

Think It Over

Forming Operational Definitions Identify examples of the different states of matter—solids, liquids, and gases—that you observed in this activity. Define each of the three states in your own words.

It's a bitter cold January afternoon. You are practicing ice hockey moves on a frozen pond. Relaxing later, you close your eyes and recall the pond in July, when you and your friends jumped into the refreshing water on a scorching hot day. Was the water in July made of the same water you skated on this afternoon? Perhaps, but you're absolutely certain that solid water and liquid water do not look or feel the same. Just imagine trying to swim in an ice-covered pond in January or play hockey on liquid water in July!

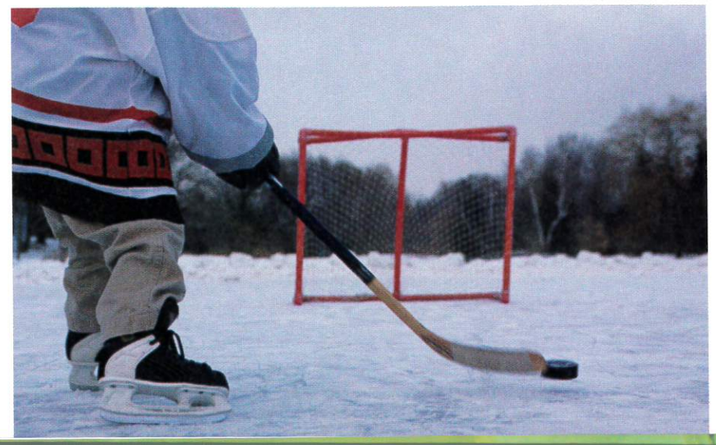


FIGURE 1
A Wintry Solid
As a solid, water makes a great surface for ice hockey.
Observing *What useful property does the frozen water have here?*

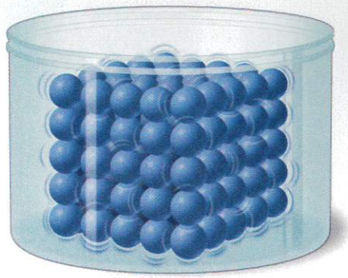
Your everyday world is full of substances that can be classified as solids, liquids, or gases. (You will read about a less familiar form of matter, called plasma, in a later chapter.) Solids, liquids, and gases may be elements, compounds, or mixtures. Gold is an element. Water is a compound you've seen as both a solid and a liquid. Air is a mixture of gases. Although it's easy to list examples of these three states of matter, defining them is more difficult. To define solids, liquids, and gases, you need to examine their properties. The familiar states of matter are defined not by what they are made of but mainly by whether or not they hold their volume and shape.

Solids

What would happen if you were to pick up a solid object, such as a pen or a comb, and move it from place to place around the room? What would you observe? Would the object ever change in size or shape as you moved it? Would a pen become larger if you put it in a bowl? Would a comb become flatter if you placed it on a tabletop? Of course not. A **solid** has a definite shape and a definite volume. If your pen has a cylindrical shape and a volume of 6 cubic centimeters, then it will keep that shape and volume in any position and in any container.

FIGURE 2
Liquid Lava, Solid Rock
Hot, liquid lava flows from a volcano. When it cools to a solid, new rock will be formed.

FIGURE 3
Particle View of a Solid
Particles of a solid vibrate back and forth but stay in place.



Particles in a Solid The particles that make up a solid are packed very closely together. In addition, each particle is tightly fixed in one position. **This fixed, closely packed arrangement of particles causes a solid to have a definite shape and volume.**

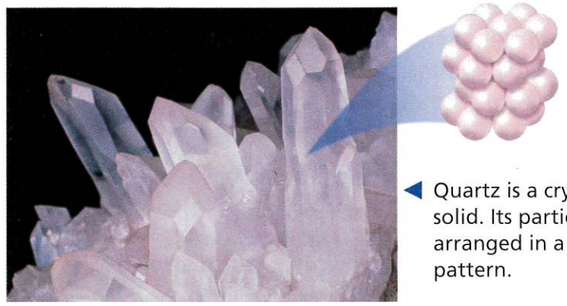
Are the particles in a solid completely motionless? No, not really. The particles vibrate, meaning that they move back and forth slightly. This motion is similar to a group of people running in place. The particles that make up a solid stay in about the same position, but they vibrate in place.

Types of Solids In many solids, the particles form a regular, repeating pattern. These patterns create crystals. Solids that are made up of crystals are called **crystalline solids** (KRIS tuh lin). Salt, sugar, and snow are examples of crystalline solids. When a crystalline solid is heated, it melts at a specific temperature.

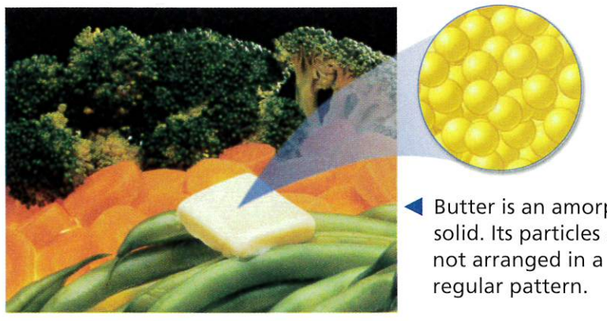
In **amorphous solids** (uh MAWR fus), the particles are not arranged in a regular pattern. Plastics, rubber, and glass are amorphous solids. Unlike a crystalline solid, an amorphous solid does not melt at a distinct temperature. Instead, it may become softer and softer or change into other substances.

Reading Checkpoint **How do crystalline and amorphous solids differ?**

FIGURE 4
Types of Solids
Solids are either crystalline or amorphous.



◀ Quartz is a crystalline solid. Its particles are arranged in a regular pattern.



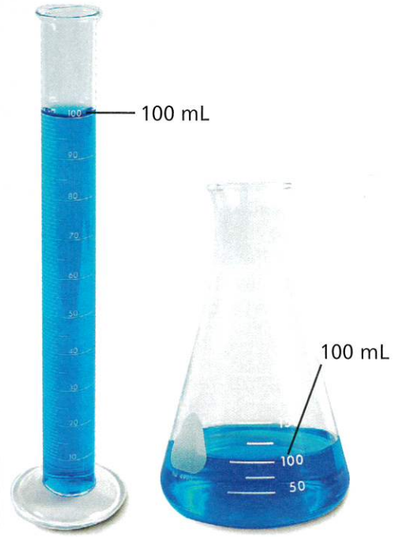
◀ Butter is an amorphous solid. Its particles are not arranged in a regular pattern.

Liquids

A **liquid** has a definite volume but no shape of its own. Without a container, a liquid spreads into a wide, shallow puddle. Like a solid, however, a liquid does have a constant volume. If you gently tried to squeeze a water-filled plastic bag, for example, the water might change shape, but its volume would not decrease or increase. Suppose that you have 100 milliliters of milk in a pitcher. If you pour it into a tall glass, you still have 100 milliliters. The milk has the same volume no matter what shape its container has.

Particles in a Liquid In general, the particles in a liquid are packed almost as closely as in a solid. However, the particles in a liquid move around one another freely. You can compare this movement to the way you might move a group of marbles around in your hand. In this comparison, the solid marbles serve as models for the particles of a liquid. The marbles slide around one another but stay in contact. **Because its particles are free to move, a liquid has no definite shape. However, it does have a definite volume.** These freely moving particles allow a liquid to flow from place to place. For this reason, a liquid is also called a **fluid,** meaning "a substance that flows."

FIGURE 5
Equivalent Volumes
A liquid takes the shape of its container but its volume does not change.



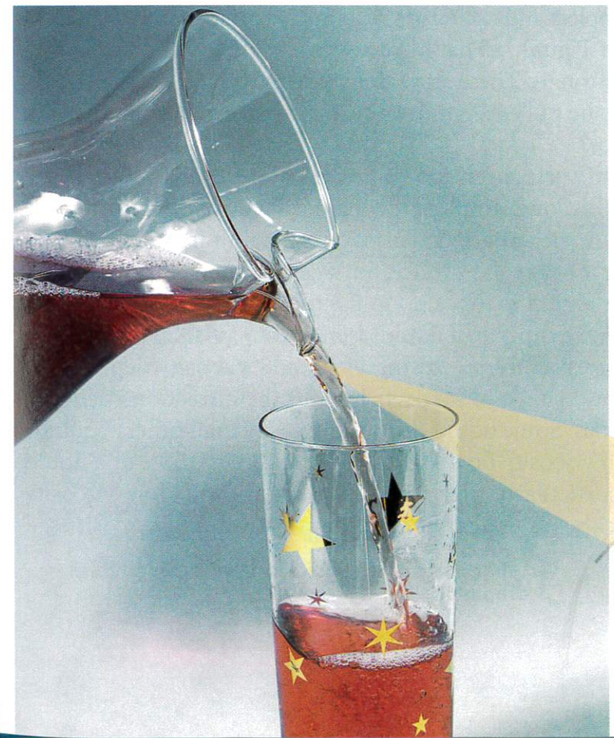
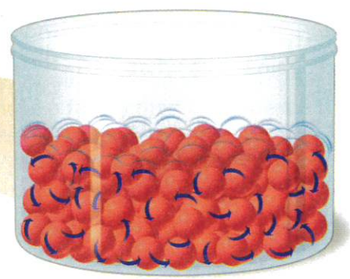


FIGURE 6
Particle View of a Liquid
Particles in a liquid are packed close together but move freely, allowing liquids to flow.
Comparing and Contrasting *How are liquids and solids alike? How do they differ?*



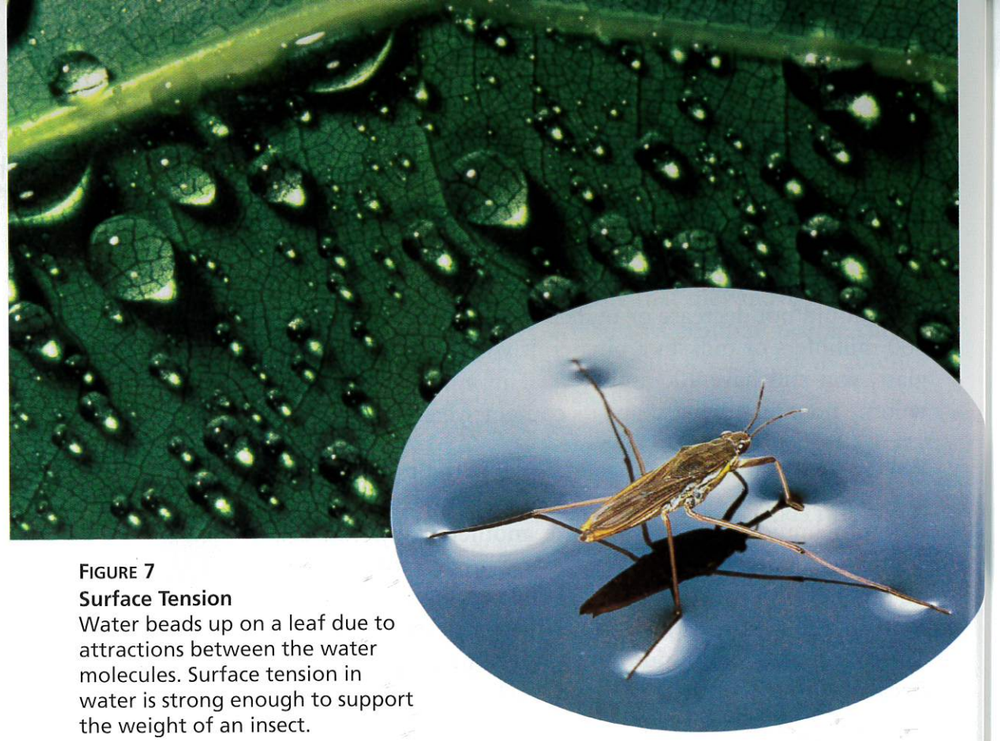


FIGURE 7
Surface Tension
Water beads up on a leaf due to attractions between the water molecules. Surface tension in water is strong enough to support the weight of an insect.

Properties of Liquids One characteristic property of liquids is surface tension. **Surface tension** is the result of an inward pull among the molecules of a liquid that brings the molecules on the surface closer together. Perhaps you have noticed that water forms droplets and can bead up on many surfaces, such as the leaf shown in Figure 7. That's because water molecules attract one another strongly. These attractions cause molecules at the water's surface to be pulled slightly toward the water molecules beneath the surface.

Due to surface tension, the surface of water can act like a sort of skin. For example, a sewing needle floats when you place it gently on the surface of a glass of water, but it quickly sinks if you push it below the surface. Surface tension enables the water strider in Figure 7 to "walk" on the calm surface of a pond.

Another property of liquids is **viscosity** (vis KAHS uh tee)—a liquid's resistance to flowing. A liquid's viscosity depends on the size and shape of its particles and the attractions between the particles. Some liquids flow more easily than others. Liquids with high viscosity flow slowly. Honey is an example of a liquid with a particularly high viscosity. Liquids with low viscosity flow quickly. Water and vinegar have relatively low viscosities.

Reading Checkpoint **What property of liquids causes water to form droplets?**

Lab zone **Try This Activity**

As Thick as Honey

You can compare the viscosity of two liquids.

1. Place on a table a clear plastic jar almost filled with honey and another clear plastic jar almost filled with vegetable oil. Make sure that the tops of both jars are tightly closed.
2. Turn the jars upside down at the same time. Observe what happens.
3. Turn the two jars right-side up and again watch what happens.

Drawing Conclusions Which fluid has a greater viscosity? What evidence leads you to this conclusion?

Gases

Like a liquid, a gas is a fluid. Unlike a liquid, however, a **gas** can change volume very easily. If you put a gas in a closed container, the gas particles will either spread apart or be squeezed together as they fill that container. Take a deep breath. Your chest expands, and your lungs fill with air. Air is a mixture of gases that acts as one gas. When you breathe in, air moves from your mouth to your windpipe to your lungs. In each place, the air has a different shape. When you breathe out, the changes happen in reverse.

What about the volume of the air? If you could see the particles that make up a gas, you would see them moving in all directions. The particles are no longer limited by the space in your body, so they move throughout the room. **As they move, gas particles spread apart, filling all the space available. Thus, a gas has neither definite shape nor definite volume.** You will read more about the behavior of gases in Section 3.

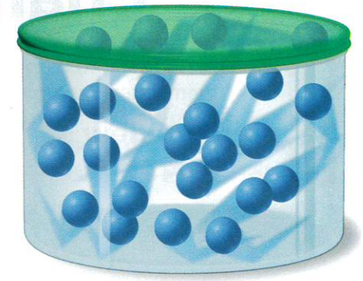


FIGURE 8
Modeling Gas Particles
The particles of a gas can be squeezed into a small volume.
Predicting *What will happen if the container lid is removed?*

Reading Checkpoint **How does breathing demonstrate that gases are fluids?**

Section 1 Assessment

Target Reading Skill

Building Vocabulary Use your definitions to help answer the questions below.

Reviewing Key Concepts

1. a. **Listing** What are the general characteristics of solids?
   b. **Comparing and Contrasting** How do crystalline solids differ from amorphous solids?
   c. **Drawing Conclusions** A glass blower can bend and shape a piece of glass that has been heated. Is glass a crystalline or an amorphous solid? Explain.
2. a. **Describing** How may liquids be described in terms of shape and volume?
   b. **Explaining** How do the positions and movements of particles in a liquid help to explain the shape and volume of the liquid?
   c. **Relating Cause and Effect** Explain why a sewing needle can float on the surface of water in a glass.
3. a. **Reviewing** What determines the shape and volume of a gas inside a container?
   b. **Applying Concepts** Use what you know about the particles in a gas to explain why a gas has no definite shape and no definite volume.

Lab zone **At-Home Activity**

Squeezing Liquids and Gases Show your family how liquids and gases differ. Fill the bulb and cylinder of a turkey baster with water. Seal the end with your finger and hold it over the sink. Have a family member squeeze the bulb. Now empty the turkey baster. Again, seal the end with your finger and have a family member squeeze the bulb. Did the person notice any difference? Use what you know about liquids and gases to explain your observations.