SECTION 1

Three States of Matter

You've just walked home on one of the coldest days of the year. A fire is blazing in the fireplace. And there is a pot of water on the stove to make hot chocolate.

The water begins to bubble. Steam rises from the pot. You make your hot chocolate, but it is too hot to drink. You don't want to wait for it to cool down. So, you add an ice cube. You watch the ice melt in the hot liquid until the drink is at just the right temperature. Then, you enjoy your hot drink while warming yourself by the fire.

The scene described above has examples of the three most familiar states of matter: solid, liquid, and gas. The **states of matter** are the physical forms in which a substance can exist. For example, water commonly exists in three states of matter: solid (ice), liquid (water), and gas (steam).

Particles of Matter

Matter is made up of tiny particles called *atoms* and *molecules* (MAHL i kyoolz). These particles are too small to see without a very powerful microscope. Atoms and molecules are always in motion and are always bumping into one another. The particles interact with each other, and the way they interact with each other helps determine the state of the matter. **Figure 1** describes three states of matter—solid, liquid, and gas—in terms of the speed and attraction of the particles.

READING WARM-UP

Objectives

- Describe the properties shared by particles of all matter.
- Describe three states of matter.
- Explain the differences between the states of matter.

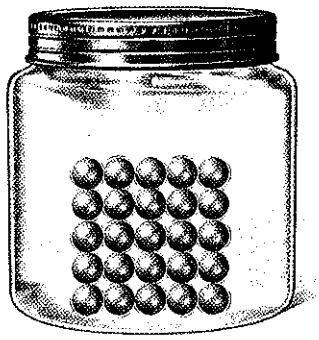
Terms to Learn

states of matter
solid
liquid
surface tension
viscosity
gas

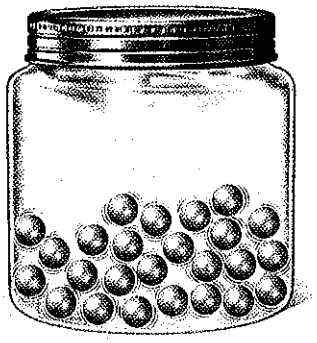
READING STRATEGY

Paired Summarizing Read this section silently. In pairs, take turns summarizing the material. Stop to discuss ideas that seem confusing.

Figure 1 **Models of a Solid, a Liquid, and a Gas**



Particles of a solid do not move fast enough to overcome the strong attraction between them. So, they are close together and vibrate in place.



Particles of a liquid move fast enough to overcome some of the attraction between them. The particles are close together but can slide past one another.

Particles of a gas move fast enough to overcome almost all of the attraction between them. The particles are far apart and move independently of one another.

Solids

Imagine dropping a marble into a bottle. Would anything happen to the shape or size of the marble? Would the shape or size of the marble change if you put it in a larger bottle?

states of matter the physical forms of matter, which include solid, liquid, and gas

solid the state of matter in which the volume and shape of a substance are fixed

Solids Have Definite Shape and Volume

Even in a bottle, a marble keeps its original shape and volume. The marble's shape and volume stay the same no matter what size bottle you drop it into because the marble is a solid. A **solid** is the state of matter that has a definite shape and volume.

The particles of a substance in a solid state are very close together. The attraction between them is stronger than the attraction between the particles of the same substance in the liquid or gaseous state. The particles in a solid move, but they do not move fast enough to overcome the attraction between them. Each particle vibrates in place. Therefore, each particle is locked in place by the particles around it.

CONNECTION TO Physics

Is Glass a Liquid? At one time, there was a theory that glass was a liquid. This theory came about because of the observation that ancient windowpanes were often thicker at the bottom than at the top. People thought that the glass had flowed to the bottom of the pane, so glass must be a liquid. Research this theory. Present your research to your class in an oral presentation.

ACTIVITY

There Are Two Kinds of Solids

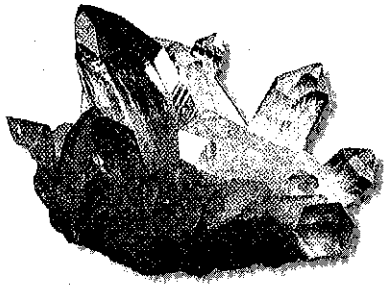
There are two kinds of solids—*crystalline* (KRIS tuhl in) and *amorphous* (uh MAWR fuhs). Crystalline solids have a very orderly, three-dimensional arrangement of particles. The particles of crystalline solids are in a repeating pattern of rows. Iron, diamond, and ice are examples of crystalline solids.

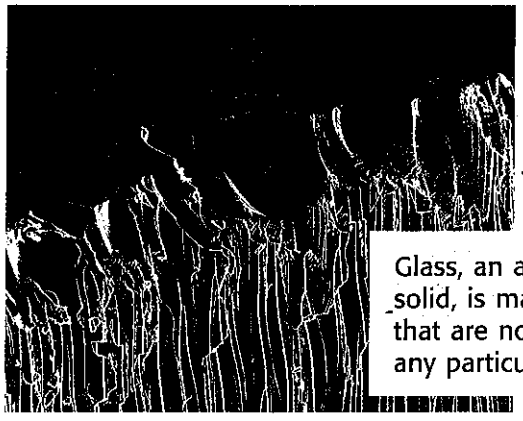
Amorphous solids are made of particles that do not have a special arrangement. So, each particle is in one place, but the particles are not arranged in a pattern. Examples of amorphous solids are glass, rubber, and wax. **Figure 2** shows a photo of quartz (a crystalline solid) and glass (an amorphous solid).

Reading Check **How are the particles in a crystalline solid arranged?** (*See the Appendix for answers to Reading Checks.*)

Figure 2 Crystalline and Amorphous Solids

The particles of crystalline solids, such as this quartz crystal, have an orderly three-dimensional pattern.





Glass, an amorphous solid, is made of particles that are not arranged in any particular pattern.

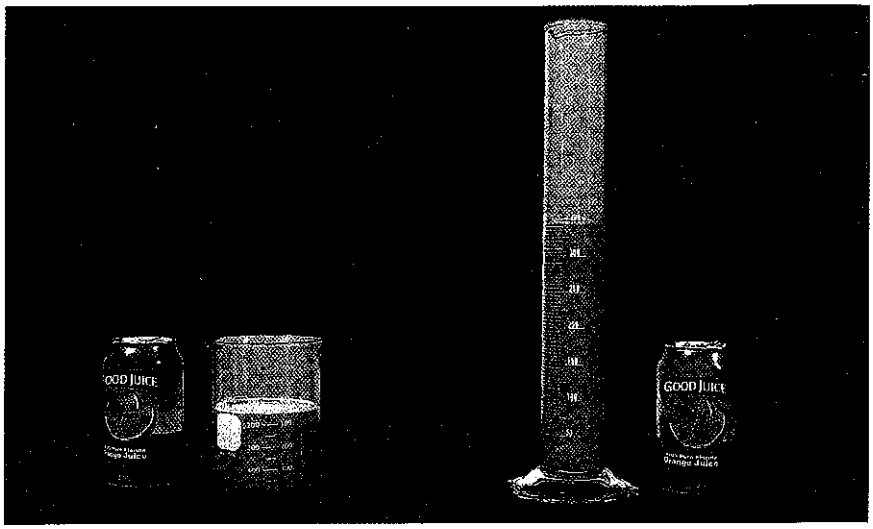


Figure 3 *Although their shapes are different, the beaker and the graduated cylinder each contain 350 mL of juice.*

liquid the state of matter that has a definite volume but not a definite shape

surface tension the force that acts on the surface of a liquid and that tends to minimize the area of the surface

viscosity the resistance of a gas or liquid to flow

gas a form of matter that does not have a definite volume or shape

Liquids

What do you think would change about orange juice if you poured the juice from a can into a glass? Would the volume of juice be different? Would the taste of the juice change?

Liquids Change Shape but Not Volume

The only thing that would change when the juice is poured into the glass is the shape of the juice. The shape changes because juice is a liquid. **Liquid** is the state of matter that has a definite volume but takes the shape of its container. The particles in liquids move fast enough to overcome some of the attractions between them. The particles slide past each other until the liquid takes the shape of its container.

Although liquids change shape, they do not easily change volume. A can of juice contains a certain volume of liquid. That volume stays the same if you pour the juice into a large container or a small one. **Figure 3** shows the same volume of liquid in two different containers.

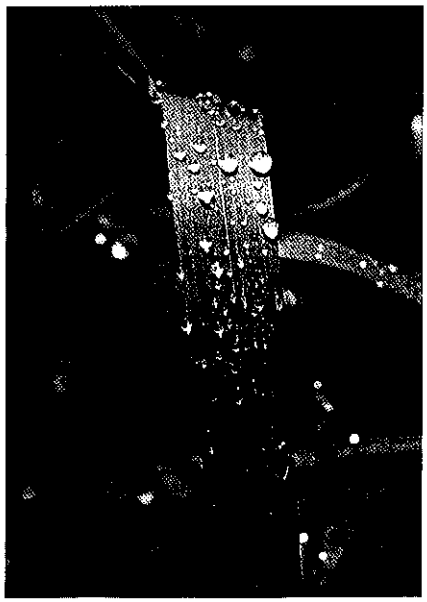


Figure 4 *Water forms spherical drops as a result of surface tension.*

Liquids Have Unique Characteristics

A special property of liquids is surface tension. **Surface tension** is a force that acts on the particles at the surface of a liquid. Surface tension causes some liquids to form spherical drops, like the beads of water shown in **Figure 4.** Different liquids have different surface tensions. For example, gasoline has a very low surface tension and forms flat drops.

Another important property of liquids is viscosity. **Viscosity** is a liquid's resistance to flow. Usually, the stronger the attractions between the molecules of a liquid, the more viscous the liquid is. For example, honey flows more slowly than water. So, honey has a higher viscosity than water.

Reading Check What is viscosity?

Gases

Would you believe that one small tank of helium can fill almost 700 balloons? How is this possible? After all, the volume of a tank is equal to the volume of only about five filled balloons. The answer has to do with helium's state of matter.

Gases Change in Both Shape and Volume

Helium is a gas. **Gas** is the state of matter that has no definite shape or volume. The particles of a gas move quickly. So, they can break away completely from one another. The particles of a gas have less attraction between them than do particles of the same substance in the solid or liquid state.

The amount of empty space between gas particles can change. Look at **Figure 5.** The particles of helium in the balloons are farther apart than the particles of helium in the tank. The particles spread out as helium fills the balloon. So, the amount of empty space among the gas particles increases.

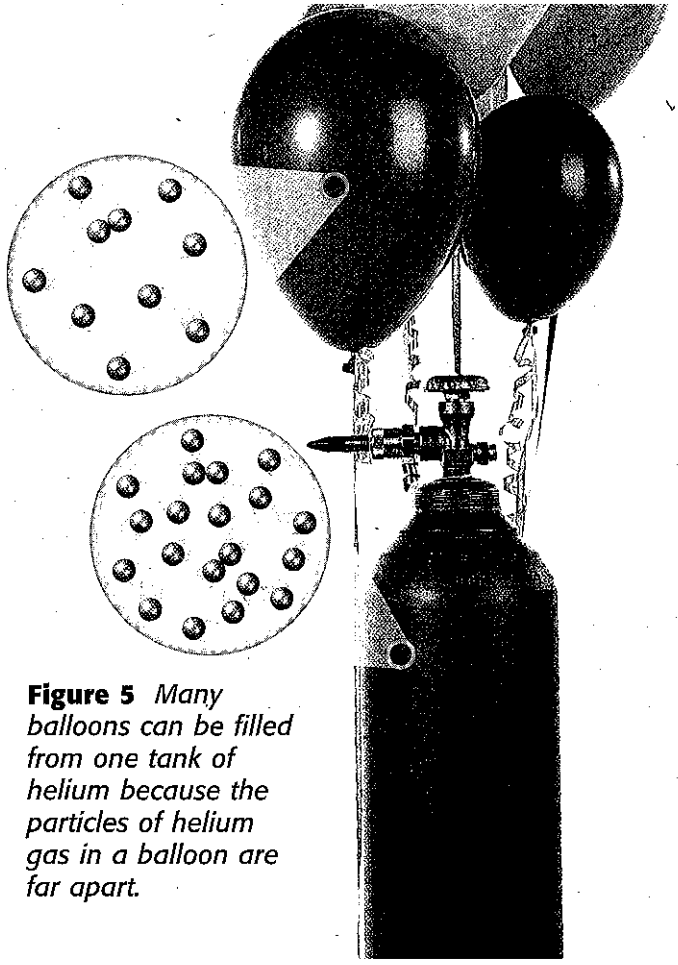


Figure 5 *Many balloons can be filled from one tank of helium because the particles of helium gas in a balloon are far apart.*

SECTION
Review

Summary

- The three most familiar states of matter are solid, liquid, and gas.
- All matter is made of tiny particles called atoms and molecules that attract each other and move constantly.
- A solid has a definite shape and volume.
- A liquid has a definite volume but not a definite shape.
- A gas does not have a definite shape or volume.

Using Key Terms

1. Use each of the following terms in a separate sentence: *viscosity* and *surface tension.*

Understanding Key Ideas

2. One property that all particles of matter have in common is they
   - **a.** never move in solids.
   - **b.** only move in gases.
   - **c.** move constantly.
   - **d.** None of the above
3. Describe solids, liquids, and gases in terms of shape and volume.

Critical Thinking

4. **Applying Concepts** Classify each substance according to its state of matter: apple juice, bread, a textbook, and steam.
5. **Identifying Relationships** The volume of a gas can change, but the volume of a solid cannot. Explain why this is true.

Interpreting Graphics

Use the image below to answer the questions that follow.

6. Identify the state of matter shown in the jar.
7. Discuss how the particles in the jar are attracted to each other.

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