

Chapter 3 Structure of Matter

Changes of State

3. d. *Students know* the states of matter (solid, liquid, gas) depend on molecular motion.

States of Matter

Matter occurs in three familiar states—solid, liquid, and gas. A fourth state of matter, called plasma, is common on the sun and other stars, but does not often occur naturally on Earth. The state of a substance is a physical property. A substance can take the form of a solid, liquid, or gas and remain the same substance.

A **solid** has a definite shape and a definite volume. A solid keeps its shape and volume in any container it is in or in any position. An example of a solid is ice. Ice is the solid form of the compound water.

A **liquid** has a definite volume but no shape of its own. A liquid takes the shape of the container it is in. For example, if you pour yourself a glass of water, the liquid water takes the shape of the glass. Without a container, a liquid spreads into a wide, shallow puddle. But a liquid does have a fixed volume. A liquid has the same volume no matter what the shape or size of the container it is in.

A **gas** has no definite shape and no definite volume. A gas can change volume easily. In a closed container, a gas spreads out to fill the container, no matter how big or small the container. Water in the gaseous state is called water vapor. Air is a mixture of gases, including water vapor.

Changing State

The state of a substance depends on the motion of its atoms or molecules. For any substance, the freedom of motion of its particles increases from solids to liquids to gases. **Thermal energy** refers to the total energy of all the particles in a sample of matter. Particles in a liquid have more thermal energy than particles of the same substance in solid form. As a gas, the particles have even more thermal energy than as a liquid.

The change of state from a solid to a liquid is called **melting**. In most pure substances, melting occurs at a specific temperature called the **melting point**. The table lists the melting points of some common substances. The melting point of water is 0°C. At 0°C, water changes from ice to liquid water. This change involves an increase in thermal energy. When a substance changes from a solid to a liquid, the freedom of motion of its particles increases.

Chapter 3 Structure of Matter**Melting and Boiling Points of Common Substances**

Substance	Melting Point (°C)	Boiling Point (°C)
Water	0	100
Ethanol	−117	79
Propane	−190	−42
Table Salt	801	1,465

The change of state from a liquid to a solid is called **freezing**. Freezing is the reverse of melting. Liquid water freezes at 0°C. (The freezing point of a substance is the same as its melting point.) When water freezes, the water molecules move more slowly as they lose energy. The freedom of motion of the molecules decreases. Over time, the water becomes solid ice.

The change of state from a liquid to a gas is called **vaporization**. Vaporization takes place when the particles in a liquid gain enough energy to move independently, forming a gas. When a substance changes from a liquid to a gas, the freedom of motion of its particles increases.

Figure 3–7 shows two types of vaporization. Vaporization that takes place only at the surface of a liquid is called **evaporation**. Vaporization that takes place both at the surface and below the surface of a liquid is called **boiling**. The temperature at which a liquid boils is called its **boiling point**. The table lists the boiling points of some common substances. Water boils at 100°C. When water boils, vaporized water molecules form bubbles below the surface. The bubbles rise and eventually break the surface of the liquid.

The change of state from a gas to a liquid is called **condensation**. Condensation is the reverse of vaporization. An example of condensation is when the water vapor in a person's warm breath condenses into liquid water on a cool window or mirror. During condensation, the particles in a gas lose enough thermal energy to form a liquid. When a substance changes from a gas to a liquid, the freedom of motion of its particles decreases.

The change of state from a solid directly to a gas is called **sublimation**. An example of sublimation is when solid carbon dioxide—commonly known as dry ice—changes directly into a gas. Instead of melting, the solid carbon dioxide sublimates.

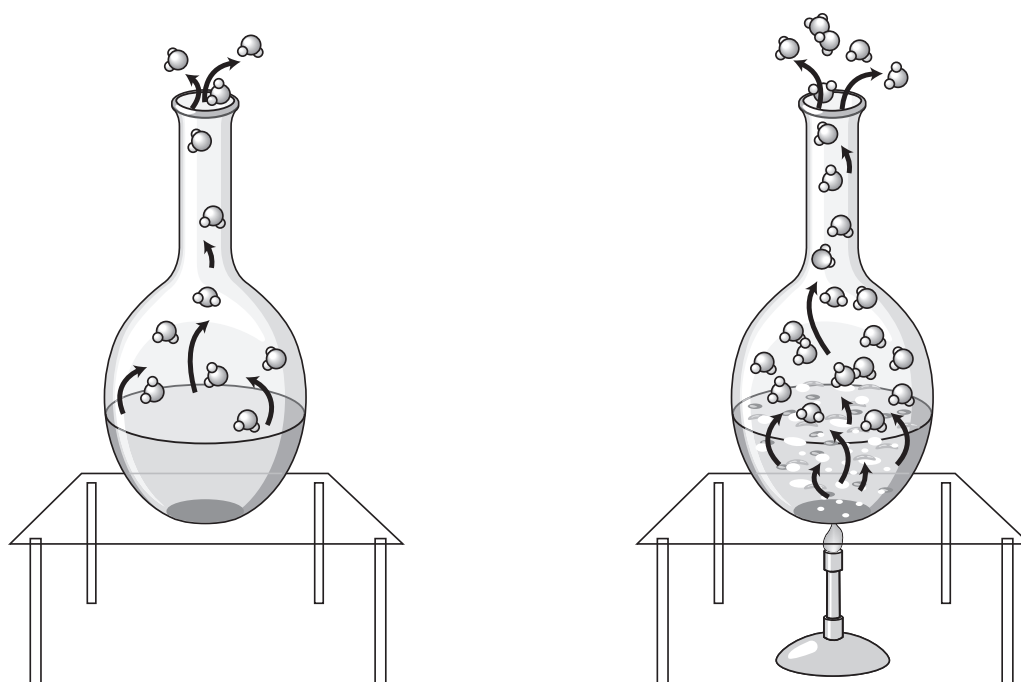
Chapter 3 Structure of Matter

Figure 3-7 Evaporation and boiling Two types of vaporization are evaporation and boiling. During evaporation, water vaporizes only at the surface. During boiling, water vaporizes both at the surface and below the surface.

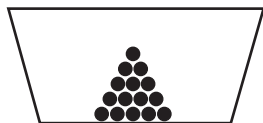
Standard 3. d. Check

14 Which change in state involves a *decrease* in molecular motion?

- A melting
- B sublimation
- C condensation
- D boiling

15 Which state of matter has definite volume but no shape of its own?

- A solid
- B liquid
- C gas
- D plasma

Chapter 3 Structure of Matter**16**

The diagram illustrates the particles of a solid substance held in a container. What would happen if the substance gained enough energy so that it melted completely?

- A The particles would remain locked together in the same shape.
- B The particles would spread out into a layer that fills the bottom part of the container.
- C The particles would spread apart widely and fill the entire container.
- D The particles would chemically change into new substances.

17

In which process do the particles in a liquid gain enough energy to move independently, forming a gas?

- A condensation
- B freezing
- C vaporization
- D melting