SECTION 4

Changes of State

Objectives

- Explain the relationship between equilibrium and changes of state.
- Interpret phase diagrams.
- Explain what is meant by equilibrium vapor pressure.
- Describe the processes of boiling, freezing, melting, and sublimation.

CHEMISTRY INTERACTIVE TUTOR

Module 1: States of Matter/Classes of Matter

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Topic: Factors Affecting Equilibrium

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Matter on Earth can exist in any of these states—gas, liquid, or solid—and can change from one state to another. **Table 2** lists the possible changes of state. In this section, you will examine these changes of state and the factors that determine them.

Changes of State and Equilibrium

Some liquid chemical substances, such as rubbing alcohol, have an odor that is very easily detected. This is because some molecules at the upper surface of the liquid have enough energy to overcome the attraction of neighboring molecules. These molecules leave the liquid phase and evaporate. *A* **phase** *is any part of a system that has uniform composition and properties.* In a closed bottle of rubbing alcohol, the gas molecules are confined to the area under the cap. Some of the gas molecules strike the liquid surface and reenter the liquid phase through *condensation.* **Condensation** *is the process by which a gas changes to a liquid.* A gas in contact with its liquid or solid phase is often called a *vapor.*

If the temperature of the liquid remains constant and the cap remains closed, the rate at which molecules move from the liquid phase to the vapor phase remains constant. Near the beginning of the evaporation process, very few molecules are in the gas phase, so the rate of condensation is very low. But as more liquid evaporates, the increasing number of gas molecules causes the rate of condensation to increase. Eventually, the rate of condensation equals the rate of evaporation, and a state of equilibrium is established, as shown in **Figure 13. Equilibrium** *is a dynamic condition in which two opposing changes occur at equal rates in a closed system.* Even though molecules are constantly moving

TABLE 2 ***Possible Changes of State***

Change of state	Process	Example
Solid ⟶ liquid	melting	ice ⟶ water
Solid ⟶ gas	sublimation	dry ice ⟶ CO_2 gas
Liquid ⟶ solid	freezing	water ⟶ ice
Liquid ⟶ gas	vaporization	liquid bromine ⟶ bromine vapor
Gas ⟶ liquid	condensation	water vapor⟶ water
Gas ⟶ solid	deposition	water vapor ⟶ ice