The Reaction Process

SECTION 1

Objectives

- Explain the concept of reaction mechanism.
- Use the collision theory to interpret chemical reactions.
- Define *activated complex.*
- Relate activation energy to enthalpy of reaction.

By studying many types of experiments, chemists have found that chemical reactions occur at widely differing rates. For example, in the presence of air, iron rusts very slowly, whereas the methane in natural gas burns rapidly. The speed of a chemical reaction depends on the energy pathway that a reaction follows and the changes that take place on the molecular level when substances interact. In this chapter, you will study the factors that affect how fast chemical reactions take place.

Reaction Mechanisms

If you mix aqueous solutions of HCl and NaOH, an extremely rapid neutralization reaction occurs, as shown in **Figure 1.**

$$H_3O^+(aq) + Cl^-(aq) + Na^+(aq) + OH^-(aq) \longrightarrow 2H_2O(l) + Na^+(aq) + Cl^-(aq)$$

The reaction is practically instantaneous; the rate is limited only by the speed with which the H_3O^+ and OH^- ions can diffuse through the water to meet each other. On the other hand, reactions between ions of the same charge and between molecular substances are not instantaneous. Negative ions repel each other, as do positive ions. The electron clouds of molecules also repel each other strongly at very short distances. Therefore, only ions or molecules with very high kinetic energy can overcome repulsive forces and get close enough to react. In this section, we will limit our discussion to reactions between molecules.

Colorless hydrogen gas consists of pairs of hydrogen atoms bonded together as diatomic molecules, H_2. Violet-colored iodine vapor is also diatomic, consisting of pairs of iodine atoms bonded together as I_2 molecules. A chemical reaction between these two gases at elevated temperatures produces hydrogen iodide, HI, a colorless gas. Hydrogen iodide molecules, in turn, tend to decompose and re-form hydrogen and iodine molecules, producing the violet gas shown in **Figure 2.** The following chemical equations describe these two reactions.

$$H_2(g) + I_2(g) \longrightarrow 2HI(g)$$

$$2HI(g) \longrightarrow H_2(g) + I_2(g)$$

Such equations indicate only which molecular species disappear as a result of the reactions and which species are produced. They do not show the **reaction mechanism,** *the step-by-step sequence of reactions by which the overall chemical change occurs*.

FIGURE 1 As NaOH solution is poured into HCl solution, a very rapid neutralization reaction occurs. Excess NaOH turns the phenolphthalein indicator pink.