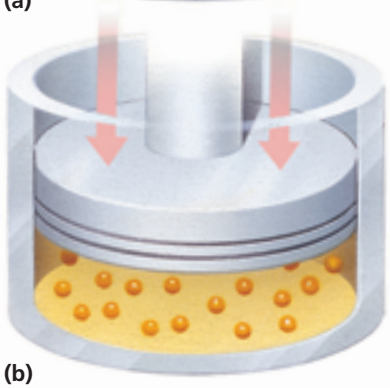
(a)



(b)

FIGURE 3 (a) Gas molecules in a car engine cylinder expand to fill the cylinder. (b) As pressure is exerted on them, the gas molecules move closer together, reducing their volume.

Diffusion is a process by which particles of a gas spread out spontaneously and mix with other gases. In contrast, **effusion** *is a process by which gas particles pass through a tiny opening*. The rates of effusion of different gases are directly proportional to the velocities of their particles. Because of this proportionality, molecules of low mass effuse faster than molecules of high mass.

Deviations of Real Gases from Ideal Behavior

Because particles of gases occupy space and exert attractive forces on each other, all real gases deviate to some degree from ideal gas behavior. *A* **real gas** *is a gas that does not behave completely according to the assumptions of the kinetic-molecular theory*. At very high pressures and low temperatures, the gas particles will be closer together and their kinetic energy will be insufficient to overcome completely the attractive forces. At such conditions, the gas is most likely to behave like a nonideal gas. These conditions are illustrated in **Figure 3.**

The kinetic-molecular theory is more likely to hold true for gases whose particles have little attraction for each other. The noble gases, such as helium, He, and neon, Ne, show essentially ideal gas behavior over a wide range of temperatures and pressures. The particles of these gases are monatomic and thus nonpolar. The particles of gases, such as nitrogen, N_2, and hydrogen, H_2, are nonpolar diatomic molecules. The behavior of these gases most closely approximates that of the ideal gas under certain conditions. The more polar the molecules of a gas are, the greater the attractive forces between them and the more the gas will deviate from ideal gas behavior. For example, highly polar gases, such as ammonia, NH_3, and water vapor, deviate from ideal behavior to a larger degree than nonpolar gases.

SECTION REVIEW

1. Use the kinetic-molecular theory to explain each of the following properties of gases: expansion, fluidity, low density, compressibility, and diffusion.
2. Describe the conditions under which a real gas is most likely to behave ideally.
3. Which of the following gases would you expect to deviate significantly from ideal behavior: He, O_2, H_2, H_2O, N_2, HCl, or NH_3?
4. How does the kinetic-molecular theory explain the pressure exerted by gases?
5. What happens to gas particles when a gas is compressed?
6. What happens to gas particles when a gas is heated?

Critical Thinking

7. **DRAWING CONCLUSIONS** Molecules of hydrogen escape from Earth, but molecules of oxygen and nitrogen are held to the surface and remain in the atmosphere. Explain.