Pearson

10.2: A Particulate Model for Gases: Kinetic Molecular Theory

Key Concept Video **Kinetic Molecular Theory**

We can build a model (or theory) for a gas based on one of the core themes of this book—that matter is particulate. The model is called the **kinetic molecular theory of gases**. According to the kinetic molecular theory, a gas is a collection of particles (either molecules or atoms, depending on the gas) in constant motion (Figure 10.2).

Figure 10.2 **A Model for Gas Behavior**

In the kinetic molecular theory of gases, a gas sample is modeled as a collection of particles in constant straight-line motion. The size of each particle is negligibly small, and their collisions are elastic.

A single particle moves in a straight line until it collides with another particle (or with the wall of the container). The theory has three basic postulates (or assumptions):

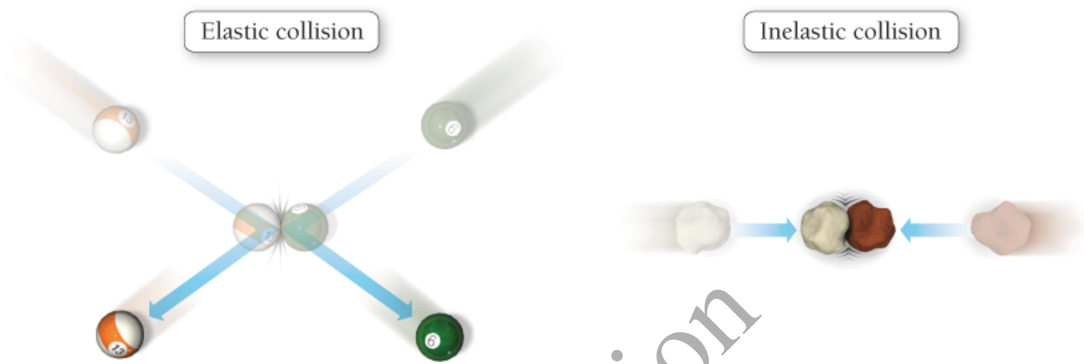
1. **The size of a particle is negligibly small.** Kinetic molecular theory assumes that the gas particles themselves occupy no volume, even though they have mass. This postulate is justified because, under normal pressures, the space between atoms or molecules in a gas is very large compared to the size of the atoms or molecule themselves. For example, in a sample of argon gas under normal atmospheric conditions, atoms occupy only about 0.01% of the volume, and the average distance from one argon atom to another is 3.3 nm. In comparison, the atomic radius of argon is 97 pm (0.097 nm). If an argon atom were the size of a golf ball, its nearest neighbor would be, on average, just over 4 ft away.
2. **The average kinetic energy of a particle is proportional to the temperature in kelvins.** The motion of atoms or molecules in a gas is due to thermal energy, which distributes itself among the particles in the gas. At any given moment, some particles are moving faster than others—there is a distribution of velocities—but the higher the temperature, the faster the overall motion, and the greater the average kinetic energy. Notice that *kinetic energy* $\left(\frac{1}{2}mv^2\right)$—not *velocity*—is proportional to temperature. The atoms in a sample of helium and a

sample of argon at the same temperature have the same average *kinetic energy*, but not the same average *velocity*. Because the helium atoms are lighter, they must move faster to have the same kinetic energy as argon atoms.

3. **The collision of one particle with another (or with the walls of its container) is completely elastic.** This means that when two particles collide, they may *exchange energy*, but there is no overall *loss of energy*. Any kinetic energy lost by one particle is completely gained by the other. In other words, the particles have no "stickiness," and they are not deformed by the collision. An encounter between two particles in kinetic molecular theory is more like the collision between two billiard balls than the collision between two lumps of clay (Figure 10.3). Between collisions, the particles do not exert any forces on one another.

Figure 10.3 Elastic versus Inelastic Collisions

When two billiard balls collide, the collision is elastic—the total kinetic energy of the colliding bodies is the same before and after the collision. When two lumps of clay collide, the collision is inelastic—the kinetic energy of the colliding bodies dissipates in the form of heat during the collision.



Conceptual Connection 10.1 Kinetic Molecular Theory

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