5.8: The Kinetic Molecular Theory of Gases

- The Kinetic Molecular Theory explains the gas laws by examining the behavior of a gas at the molecular level.

General principles:

1. Gas molecules are in continuous, random motion.

- Pressure is caused by gas molecules colliding with a surface, such as the walls of the container.
- If the volume is reduced, collisions will be more frequent (Boyle's Law)

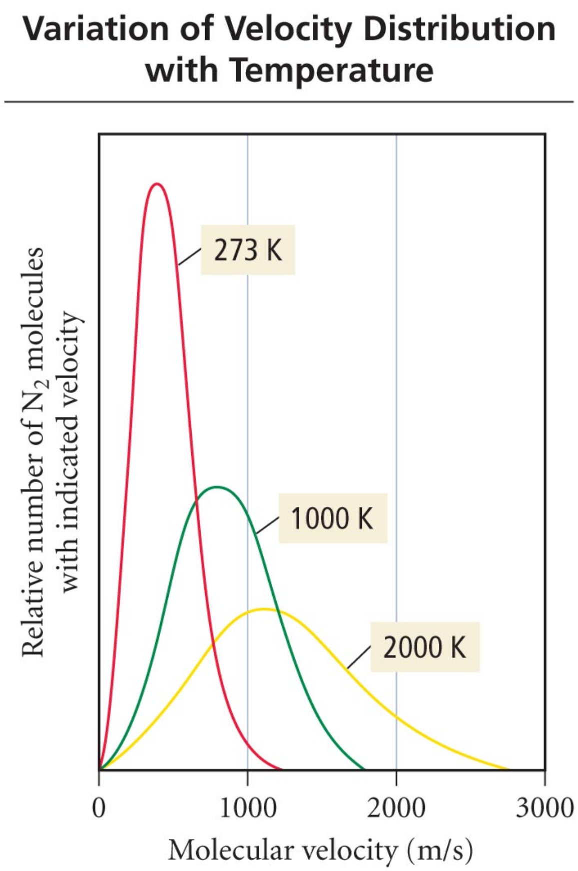
Figure 5.15

Kinetic Molecular Theory of Gases (contd.)

2. A sample of gas molecules has a distribution of **speeds** and **kinetic energies** (*i.e.* some molecules have more energy than others).

- The **temperature** of a gas is a measure of its average K.E.

Figure 5.19



Kinetic Molecular Theory of Gases (contd.)

3. The volume of gas molecules is negligible compared to the space they occupy.

- Gases are easily compressed, since most of the volume of a gas is just empty space.
- The volume of the gas does not depend on the size of the molecules that make it up.

4. Attractions and repulsions between gas molecules are negligible.

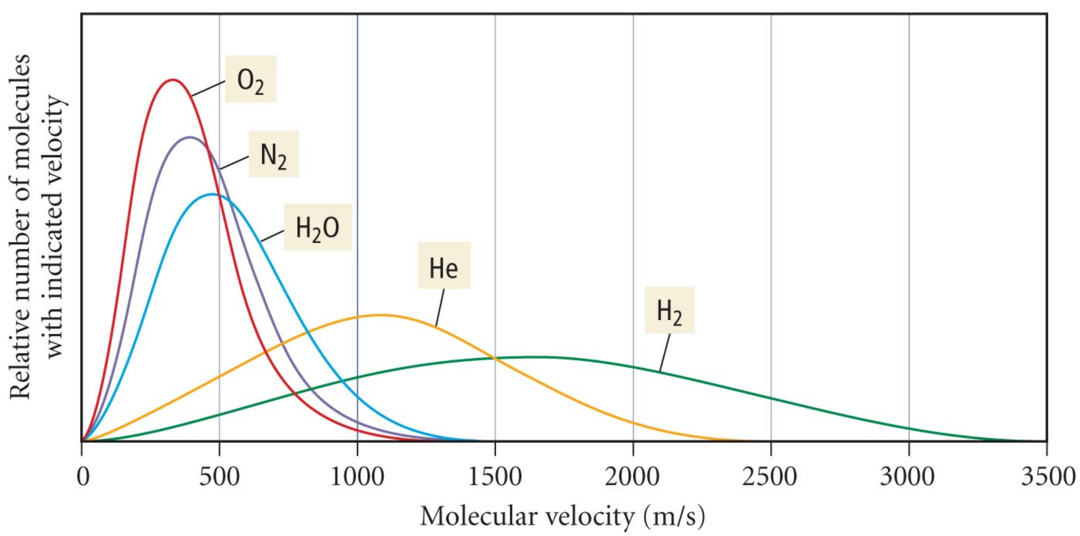
Kinetic Molecular Theory of Gases (contd.)

Kinetic Energy =

So the average kinetic energy of a sample =

Since all gases have the same average kinetic energy at the same temperature, **lighter molecules move faster and heavier molecules move slower** on average.

Figure 5.18 **Variation of Velocity Distribution with Molar Mass**



The Kinetic Molecular Theory of Gases (contd.)

- The average speed of a molecule in a gas sample can be estimated by taking the square root of the average of the square of the speeds, $\sqrt{\overline{u^2}}$
- This is called the root-mean-square speed (u_{rms}). It is close to (but not exactly the same as) the average speed of the molecules.
- The **total kinetic energy of 1 mol** of an ideal gas is:

The Kinetic Molecular Theory of Gases (contd.)

- u_{rms} =

- u_{rms} increases as the molar mass decreases and as temperature increases (Figures 5.18-19).

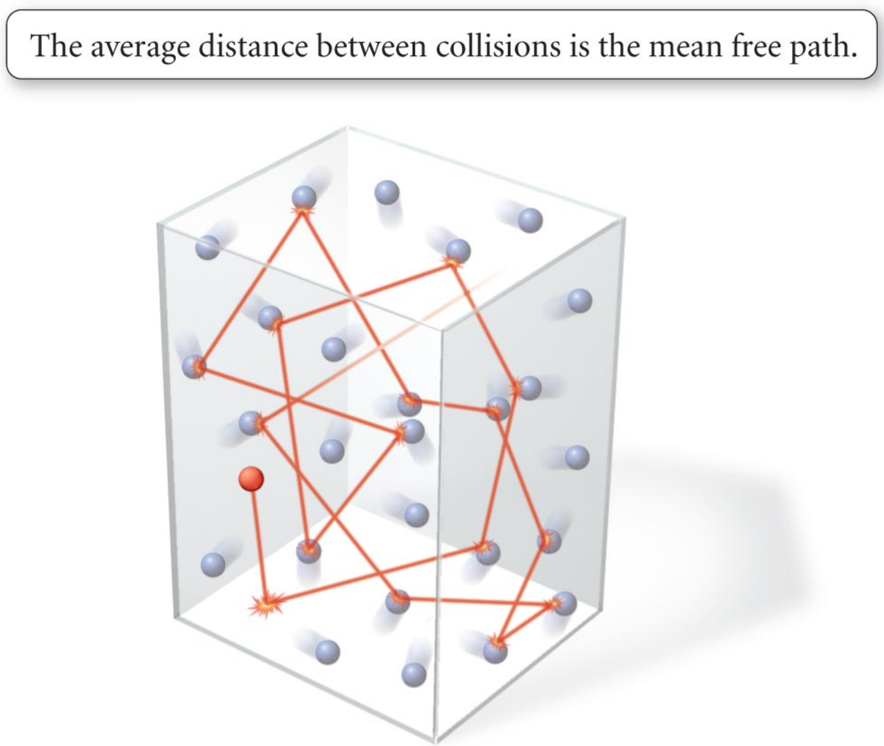
Summary of Kinetic Molecular Theory:

- **All gases have the same average kinetic energy** at the same temperature (but KE increases as T increases).
- On average, **lighter gases travel faster than heavier gases** at the same temperature.

5.9: Diffusion and Effusion

- **Diffusion** is the movement of one gas through another.
- Gas molecules do not diffuse in a straight line, but have a random path due to collisions with other molecules:

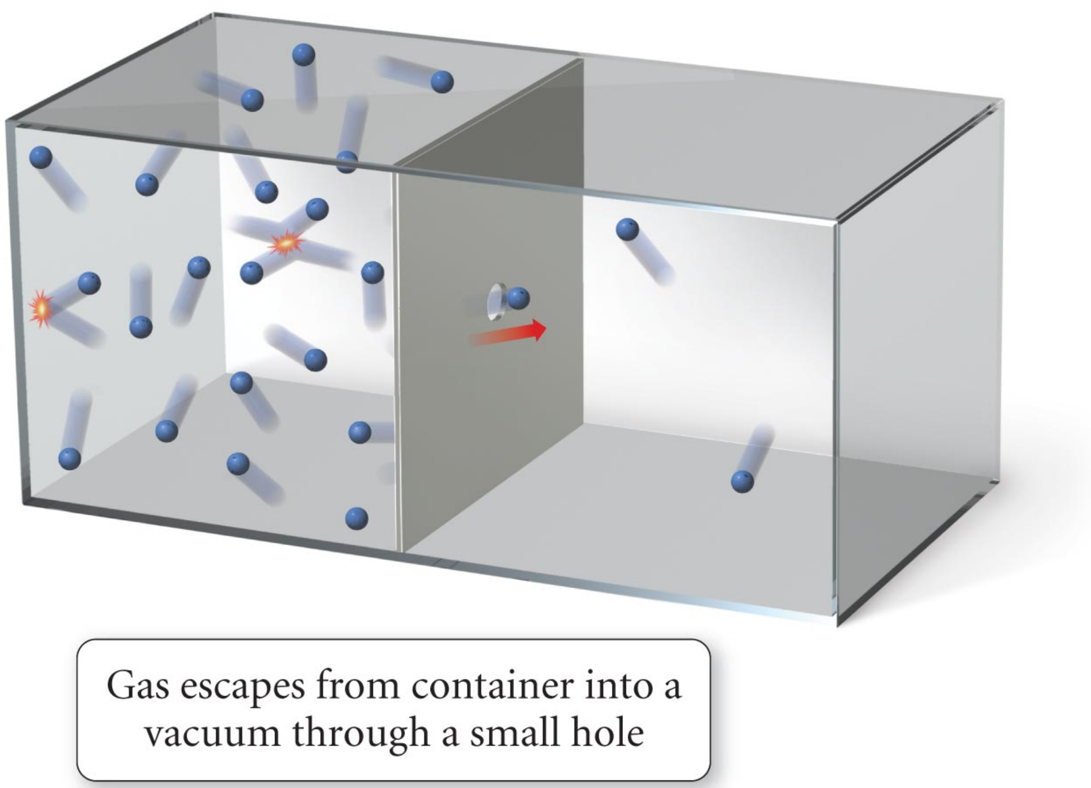
Figure 5.20 **Typical Gas Molecule Path**



Diffusion and Effusion (contd.)

- **Effusion** is the leaking of a gas through a hole in a container.

Figure 5.21 **Effusion**



Diffusion and Effusion (contd.)

- The rates of both diffusion and effusion depend on the average speed of the gas molecules.
- So **lighter molecules diffuse and effuse faster than heavier molecules**.
- **Graham's Law of Effusion**: Rate of effusion $\propto \dfrac{1}{\sqrt{MM}}$
- or, comparing two gases: $\dfrac{rate_1}{rate_2} = \sqrt{\dfrac{MM_2}{MM_1}}$