

# Ch. 10 Sections 4, 5

# Gases

- Introduce gas into a container, the gas will fill the volume of the container.
- Gases are described by their pressure, volume, temperature, and amount. These quantities are related by an equation of state.
- These are macroscopic properties.
- We will work with 'ideal gases'.

# Ideal Gas

- In an ideal gas, the atoms or molecules move randomly
- exert no long range forces on each other
- The particles are pointlike, they have negligible volume.

# Avogadro's Number

- Since gases usually consist of very large amounts of particles, we want a convenient unit for the amount of particles.
- moles
- $N_A = 6.02 \times 10^{23}$  particles/mole

# Ideal Gas Law

Tells us how the pressure, volume and temperature are related.

$$PV = nRT$$

R = Universal Gas constant 8.31 J/(mol K)

n = number of moles

P = pressure

V = volume

T = temperature

# Ideal Gas Law

If instead of using the number of moles, we use the number of molecules,  $N$ .

$$n = N/N_A$$

Now the Gas Law becomes:

$$PV = Nk_B T$$

$k_B$  = Boltzmann's constant

$$k_B = R/N_A = 1.38 \times 10^{-23} \text{ J/K}$$

# Kinetic Theory of Gases

Using model of ideal gas, try to study gas in microscopic terms.

Using assumptions:

- 1) number of molecules is large, and average separation between is large compared to their dimensions.
- 2) molecules obey Newton's Laws, but as a whole they move randomly
- 3) molecules interact only through short-range forces during elastic collisions
- 4) molecule collide elastically with the walls
- 5) the molecules are identical

# Molecular Interpretation of Temperature

- Because the molecules are moving, they have kinetic energy. The higher the temperature, the faster the average speed of the gas molecules.
- Average kinetic energy per molecule

$$\frac{1}{2} m \bar{v}^2 = \frac{3}{2} k_B T$$

# For N molecules

$$KE_{\text{total}} = N \left( \frac{1}{2} m \bar{v}^2 \right) = \frac{3}{2} N k_B T = \frac{3}{2} n R T$$

From this equation we can measure the average velocity of the gas particles.

$$v_{\text{rms}} = \sqrt{\frac{3k_B T}{m}}$$

If the translational kinetic energy is the only type of energy the molecules have, then the internal energy,  $U$ , for the gas is:

$$U = (3/2)nRT$$

Not all the gas molecules move at the same speed.

See figure 10.15

We use the rms speed. Related to the average velocity.

See table 10.2

Do quick quiz 10.5