Kinetic Molecular Theory

By the mid 1800s the theory used to explain the behavior of gasses had received a very successful treatment from James Maxwell and Ludwig Boltzman.

There are four postulates that describe the theory:

1- Particles of a gas are in constant motion. It is the collisions between the gas particles and the container walls that cause pressure.

2- The average kinetic energy is directly proportional to the Kelvin temperature.

3- The particles of a gas are so small as compared to the volume that they occupy that we can consider the particles to have no volume.

4- The particles of the gas do not interact with each other. That is there are no attractive or repulsive forces.

Effusion and Diffusion

Effusion and diffusion are the terms that we use to describe how gases move about in more realistic situations.

Effusion is the term used to describe the rate that a gas moves through a small hole in to a vacuum. Formalized by Scottish chemist Thomas Graham.

$$\frac{\text{Rate of effusion for gas 1}}{\text{Rate of effusion for gas 2}} = \frac{\sqrt{M_2}}{\sqrt{M_1}}$$

Using KMT we can see how this relationship can be derived.

$$\text{rate of effusion} = \mathrm{u_{rms}} = \sqrt{\bar{\mathrm{u}^2}}$$

where $\bar{u^2}$ is the average of the square of the velocities.

$$KE_{avg} = N_A(\frac{1}{2}m\bar{u^2}) = \frac{3}{2}RT$$

$$\bar{u^2} = \frac{3RT}{N_A m}$$

$$u_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{\mathrm{u_{H_2}}}{\mathrm{u_{CO_2}}} = \sqrt{\frac{\mathrm{M_{CO_2}}}{\mathrm{M_{H_2}}}} = \sqrt{\frac{44.01}{2.016}} = \sqrt{22.83}$$

$$\frac{\mathrm{u_{H_2}}}{\mathrm{u_{CO_2}}} = 4.672$$

Ex:

Diffusion

Diffusion is the term that we use to describe how gases mix. At a first approximation it is similar to effusion and mathematically can be described the same way. However careful experimentation shows that this is not quite the case.

$$\frac{\text{Distance traveled by gas 1}}{\text{Distance traveled by gas 2}} = \frac{u_{rms} \text{ for gas 1}}{u_{rms} \text{ for gas 2}} = \frac{\sqrt{M_2}}{\sqrt{M_1}} \neq \text{actual ratio}$$