Chapter One

KINETIC THEORY OF GASES

1.1 Basic Assumption of Kinetic Theory

1. Any infinitely small volume of a gas contains a large number of molecule.

2. A gas is made up identical molecule which behaves as rigid, perfectly elastic, hard sphere.

3. The molecules continuously move about in random directions. All directions of motion are equally probable.

4. The size of the molecules is much less than the average distance between them.

5. The molecule of a gas exert no force on each other except when they collide.

6. The collision between molecules and with walls are perfectly elastic.

7. The direction of molecular velocities are assumed to be distribute uniformly.

8. The molecules move with all speeds ranging from 0 to ∞.

9. The time of collision is much less than the time between collisions.

Pressure Exerted by a Gas

Suppose there are n molecules per cubic meter each of mass m, and it is assumed that n_i number of molecule have velocity v_i.

Mathematically

$$\sum n_i = n \text{ and } v_i^2 = v_{ix}^2 + v_{iy}^2 + v_{iz}^2$$

where v_{ix} v_{iy} and v_{iz} are $x,\ y,\ z$ component of velocity of gases.

From assume of kinetic theory of gases $v_{ix}^2 = v_{iy}^2 = v_{iz}^2 = \frac{v_i^2}{3}$

suppose molecules are kept in the cubic container of parameter L.

A molecule moving in the x direction will have momentum mv_{ix} normal to face of the cube before collision

$$\Delta P_{ix} = mv_{ix} - (-mv_{ix}) = 2mv_{ix}$$

Force acting on the wall by molecule is $f_{ix} = \frac{n_i 2mv_{ix}}{\Delta t} = \frac{n_i 2mv_{ix}^2}{2L} == \frac{n_i mv_{ix}^2}{L}$

Pressure exert on the wall of container by molecule $P_{ix} = \frac{mn_i v_{ix}^2}{L^3}$

so that pressure in the x direction expected by all group

$$P_x = \sum P_{ix} = \frac{m}{L^3}\sum n_i v_{ix}^2$$

Average value of v^2 is given by

$$\langle v_x^2 \rangle = \frac{\sum_i n_i v_{ix}^2}{\sum n_i} = \frac{\sum_{i=1} n_i v_{ix}^2}{n}$$

For three dimensional system $\langle v_x^2 \rangle + \langle v_y^2 \rangle + \langle v_z^2 \rangle = \langle v^2 \rangle$ and

for isotropic system $\langle v_x^2 \rangle = \langle v_y^2 \rangle = \langle v_z^2 \rangle = \frac{\langle v^2 \rangle}{3}$

So P_x can be written as

$$P_x = \frac{m}{L^3} n \langle v_x^2 \rangle \text{ , } P = P_x = \frac{1}{3}\frac{m}{L^3} n \langle v^2 \rangle \quad P = \frac{1}{3}\frac{mn\langle v^2 \rangle}{V}$$

$$PV = \frac{1}{3} mN \langle v^2 \rangle$$

where V is volume of the container and $\langle v^2 \rangle$ is average value of square of velocity.