IDEAL GAS

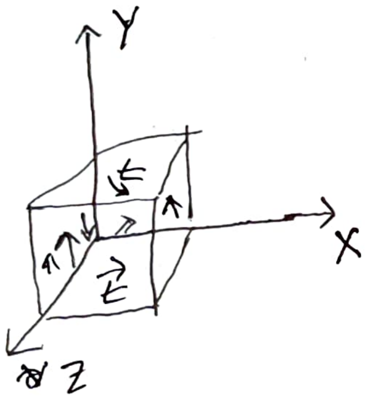
Basic Assumtion of kinetic Theory :-

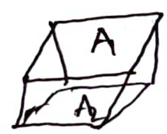
- A gas consists a very large no. of identical molecules, [As in a kilo-mole of gas consists 6.03×10^{26} number of molecules, this assumption a make sense.]
- The molecules can be regarded as point masses.
- The gas molecules are in a state of constant random motion.
- The force of inteation between the molecules is negligible.
- The molecules of gas experience force only during collision.

• Pressure Exerted by Ideal gas :-

Let, M Kilo-moles of a gas confined in a cubical container of side L, Total no of particle in container is N,

$\therefore$ number density $= \frac{N}{V}$ molecules / m^3 $[\because V = L^3]$





From the assumption, we know, the gas a large no. of identical molecules.

Let, consider the motion, of molecules in group 1 moving with velocity v_1.

resolving in orthogonal coordinate we can write it,

$$v_1^2 = v_{1x}^2 + v_{1y}^2 + v_{1z}^2$$

The initial momentum of the molecule at surface A_1 along x-axis $= m v_{1x}$, normal to face of the cube.

It's moves to face A_2 at $x = L$, and makes elastic collision. so it doesn't loss any momentum.

$\therefore$ momentum after collision, $= -mv_{1x}$

$\therefore$ change in momentum, $= mv_{1x} - (-mv_{1x}) = 2mv_{1x}$

After ~~o~~ rebounding the molecules travels back to surface A_1. The distance cover by molecules $= 2L$

$\therefore$ The time between ~~tow~~ two successive collision at face of the molecule, $\Delta t = \dfrac{2L}{v_{1x}}$

$\therefore$ Rate of change of momentum $= \dfrac{2mv_{1x}}{\Delta t} = \dfrac{\cancel{2}mv_{1x}^2}{\cancel{2}L}$

$$= \frac{mv_{1x}^2}{L}$$

$\therefore$ Exerted force by the molecules at surface A_1,

$$F_{1x} = \frac{mv_{1x}^2}{L}$$

$\therefore$ Pressure, $\dfrac{F_{1x}}{\text{Area}} = \dfrac{F_{1x}}{L^2} = \dfrac{mv_{1x}^2}{L^3}$

Now, consider the pressure exerted by others group molecules along x axis, to the wall $x = L$, ~~consider A~~ tagged the group 2, 3, ... n.

$$P_{2x} = \frac{mv_{2x}^2}{L} \qquad P_{nx} = \frac{mv_{nx}^2}{L}$$

$$P_{3x} = \frac{mv_{3x}^2}{L}$$

$\therefore$ Total pressure exerted by all molecules along x - axis,

$$P_x = \sum_i P_{ix} = \frac{m}{L_3} \sum_{i=1}^{G} n_i v_{ix}^2$$

Average value of, v_x^2,

$$\overline{v_x^2} = \frac{\sum_{i=1}^{G} n_i v_{ix}^2}{\sum_{i=1}^{G} n_i} = \frac{\sum_{i=1}^{G} n_i v_{ix}^2}{N}$$

Now,

$$P_x = \frac{m N \overline{v_x^2}}{L^3}$$

When gas is in equilibrium, molecules moves entirely random, All direction of motion are equally probable, we can write,

$$\overline{v_x^2} = \overline{v_y^2} = \overline{v_z^2} = \frac{1}{3} \left(\overline{v_x^2 + v_y^2 + v_z^2} \right) = \frac{\overline{v^2}}{3}$$

$$\overline{v_2} = \frac{\Sigma n_i v_i^2}{N}$$

$$\therefore p = \frac{1}{3} m n \overline{v^2} = \frac{1}{3V} m N \overline{v^2}.$$

$$\therefore pV = \frac{1}{3} m N \overline{v^2}$$

For, a mole of gas, Avogadro's number, N_A

$$pV = \frac{1}{3} m N_A \overline{v^2} = \frac{1}{3} M \overline{v^2}$$

M = molecular weight of the gas.

$$P = \frac{1}{3} m n \overline{v^2} = \frac{1}{3} \rho \overline{v^2}$$

n = ~~m~~ number density, ρ = density of the gas.

$$v_{rms} = \sqrt{\overline{v^2}}$$

$$P = \frac{1}{3} m n v_{rms}^2$$