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Day-1 (11) Physical Chemistry
Topic — Gaseous State

Postulates of Kinetic theory of gases

To explain the behaviour behaviour of gas Maxwell & Boltzmann developed a theory known as Postulates of Kinetic theory of gases.

Important Postulates / Assumption of this Theory

1. All gases are made up of a very large number of extremely small particles called molecules / atoms.
2. All the molecules of the same gas are identical in all respect like mass, size & shape but differ from other gases.
3. The molecules of gas are separated from one another by large distance. Thus their actual volume is negligible w.r.t. respect to total volume of the gas. It means that the volume of gas is the volume of cylinder in which it is present.
4. The gases molecule are free to move in all possible direction in straight line motion. They are in a state of ceaseless & random motion.
5. Due to large distance of separation b/w the molecules the force of attraction / Repulsion b/w them are negligible.
6. Molecular collision are perfectly elastic

then there is no loss of energy b/w the colliding molecules thus its momentum remain conserved.

(7) The press exerted by the gaseous molecules is due to the collision b/w the molecules & also upon the walls of the container per unit area.

(8) The gaseous molecules are moving with different velocities. They possess different kinetics energy. However the average kinetic energy of gaseous molecule is directly proportional to the absolute temperature of the gas.

(9) The effect of gravitational force upon the motion of gaseous molecule is negligible.

Derivation of Kinetic gas-Equation

To derive $PV = \frac{1}{3} mnc^2$

A gas enclosed in a cubical vessel.

mass of a single molecule $= m$

Total number of molecules $= n$

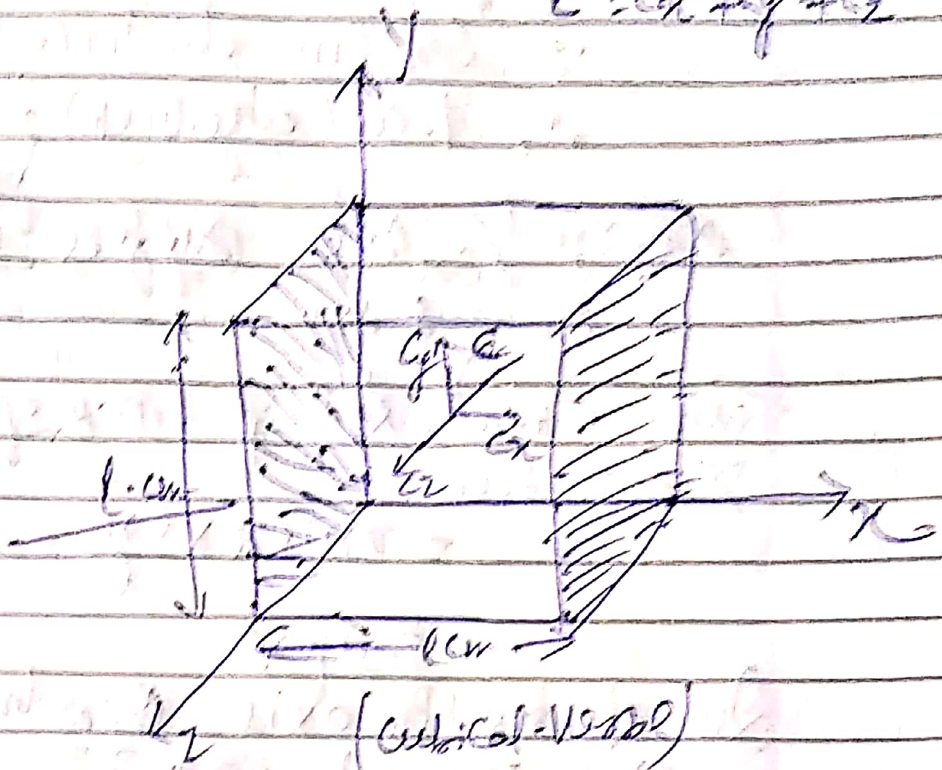
length of each side (Edge-length) $= l$

Any one molecule of gas moving in any direction of different velocities. Velocity $= c$ cm/sec

That velocity can be resolve into three mutually perpendicular component

C_x, C_y & C_z.

$c^2 = C_x^2 + C_y^2 + C_z^2$

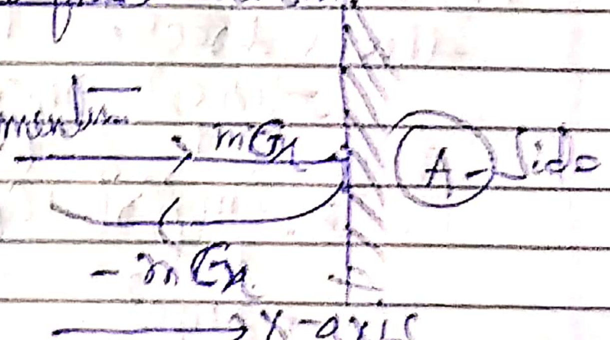


(Cubical vessel)

Momentum of molecules along x-direction of face-A strike before collision.

$= m \times C_x$

$= mC_x$



After colliding with face-A, it will return with same velocity, as only direction can change. Thus momentum after collision

$= m \times -C_x$

$= -mC_x$

Change in momentum =

$= mC_x - (-mC_x)$

$= 2mC_x$

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Number of Collision Per sec.

∵ C_x cm distance travel in one sec.

∴ 1 cm (edge length) of face in ——— $1/C_x$ sec.

Along: $1/C_x$ sec. suffers one collision

∴ 1 sec ——— C_x/l collision

Thus, Total Rate of change of momentum in X-direction.

$$= 2mC_x \times \frac{C_x}{l}$$

$$= \frac{2mC_x^2}{l}$$

By all possible axis, similarly for Y & Z axis, $\frac{2mC_y^2}{l}$ & $\frac{2mC_z^2}{l}$ respectively

Thus, Rate of change of momentum in all the three direction.

$$= \frac{2mC_x^2}{l} + \frac{2mC_y^2}{l} + \frac{2mC_z^2}{l}$$

$$= \frac{2m}{l}(C_x^2 + C_y^2 + C_z^2)$$

$$= \frac{2mC^2}{l}$$

For n molecule, it become, $\frac{2mnC^2}{l}$.

According to Newton's 2nd law of motion

Rate of change of momentum ∝ Applied Force

Thus,

$$F = \frac{2mnC^2}{l}$$

$$P \times A = \frac{2mnC^2}{l}$$

$$P = \frac{2mnC^2}{A \times l}$$

$$P = \frac{2mnC^2}{6V}$$

$A \times l = 6V$

Thus

$$PV = \frac{1}{3}mnC^2$$

$P = F/A$

A = area

l = edge length

$A \times l$ = Volume of box (V)