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CLASS 11&12th

CLASS 11th

Kinetic Theory of Gases

01. Kinetic Theory of Gases

Rudolph Clausius (1822-88) and James Clark Maxwell (1831-75) developed the kinetic theory of gases in order to explain gas laws in terms of the motion of the gas molecules. The theory is based on the following assumptions as regards to the motion of molecules and the nature of the gases :

Assumptions

(i) All gases consist of molecules. The molecules of a gas are all alike and differ from those of other gases.

(ii) The molecules of a gas are very small in size as compared to the distance between them.

(iii) The molecules of a gas behave as perfect elastic spheres.

(iv) The molecules are always in random motion. They have velocities in all directions ranging from zero to infinity.

(v) During their random motion, the molecules collide against one another and the walls of the containing vessel. The collisions of the molecules with one another and with the walls of the vessel are perfectly elastic.

(vi) Between two collisions, a molecule moves along a straight line and the distance covered between two successive collisions is called the ***free path*** of the molecule.

(vii) The collisions are almost instantaneous *i.e.* the time during which a collision takes place is negligible as compared to the time taken by the molecule to cover the free path.

(viii) The molecules do not exert andy force on each other except during collisions.

02. Pressure Exerted by a Gas

The molecule moves with momentum mv_x along X-axis and strikes against the face ABGF. Since the collision is perfectly elastic in nature, the molecule rebounds back with same speed v_x. As the direction of motion is reversed, the momentum of the molecule after the rebound becomes $-mv_x$.

Therefore, change in momentum of the molecule along X-axis

$$= (-mv_x) - mv_x = -2\ mv_x$$

Let us find the change in momentum of the gas molecules hitting the area A of the face ABGF in time Δt. Now, in time Δt, all those molecules will hit the area A of the face ABGF, which lie in a cylinder of length $v_x\Delta t$ and area of cross-section A. Therefore, such molecules lie in volume $A \times v_x \Delta t$. Since the number of molecules per unit volume is n, the number of such molecules is $n\ Av_x\Delta t$. In fact, on the average, half of this number is expected to move along negative X-axis and the other half towards the face ABGF along positive X-axis. Therefore,

the number of molecules hitting the area A in time Δt along positive X-axis

$$= \frac{1}{2} n\ A\ v_x\ \Delta t$$

Therefore, the total change in momentum of molecules in time Δt along X-axis,

$$\Delta p_x = (-2\ m\ v_x) \times \frac{1}{2}\ n\ A\ v_x\ \Delta t = -\text{m}\ n\ A\ v_x^{\ 2} \Delta t$$