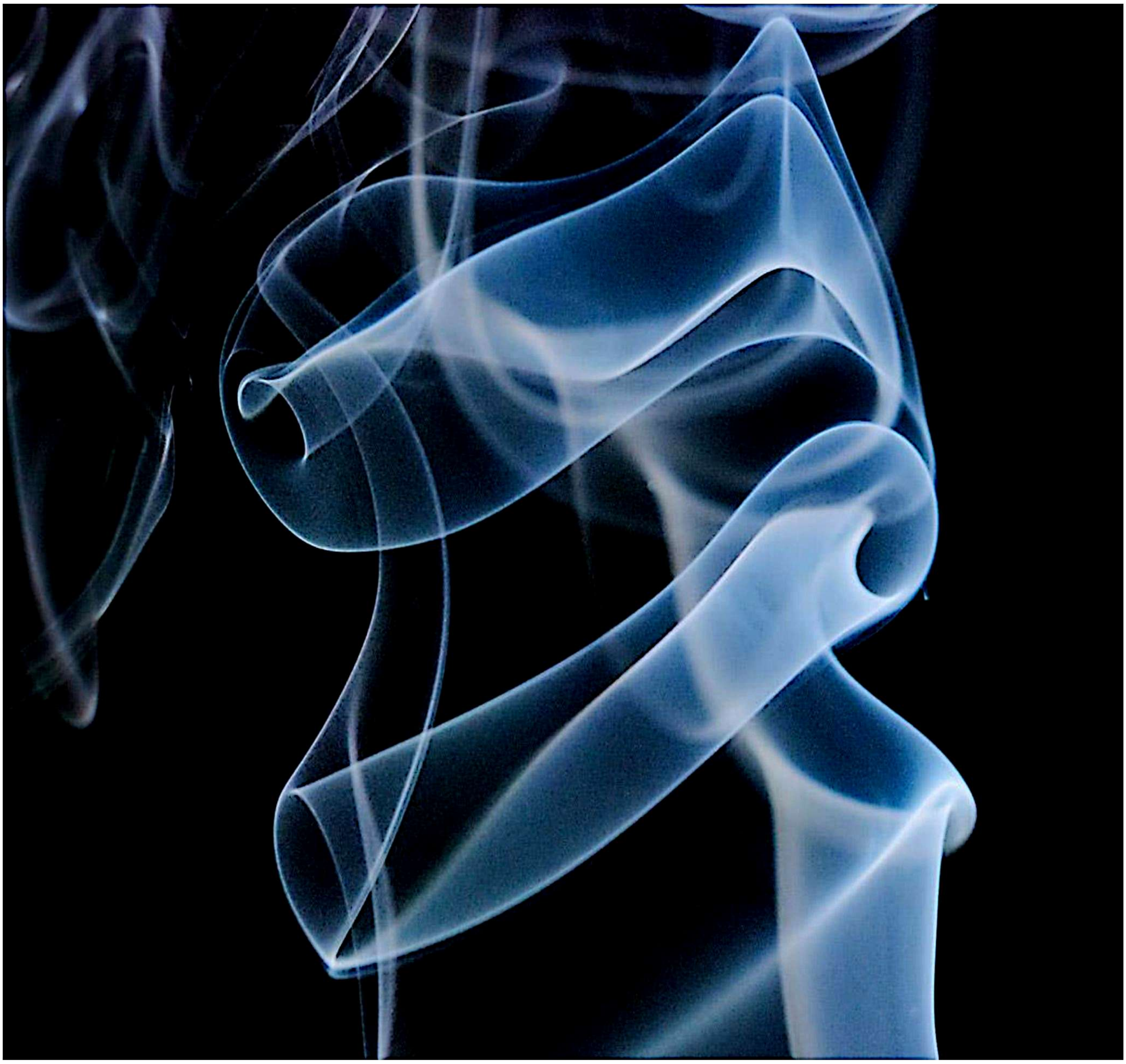
Chapter–13:

Kinetic Theory



CBSE CLASS XI NOTES

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1. **Obtain perfect gas equation?**

According to boyle's law $P \propto \frac{1}{V}$

According to charle's law $P \propto T$

$$P \propto \frac{T}{V}$$

$$PV \propto T$$

$$PV = RT$$

If there are 'n' number of moles

$$PV = nRT$$

Avogadro's Number

Number of molecules in one mole of gas is called avogadro's number ($N = 6.023 \times 10^{23} mol^{-1}$)

2. **State postulates of kinetic theory of gases?**

1. Molecules of gas are hard, smooth and perfectly elastic spheres.
2. The molecules are supposed to be point masses. Size of a molecule is negligible compared to the distance between them.
3. There is no force of attraction or repulsion between them.
4. The molecules are in a state of random motion - moving with all possible velocities in all possible directions
5. During their motion they collide with each other and also with the walls of the container.
6. Between successive collisions, the molecules move in straight lines with uniform velocity the distance travelled between two successive collisions is called free path.
7. Time spent in a collision is negligible compared to the time taken to traverse the mean free path.
8. The mean kinetic energy of the molecule is a constant at a given temperature and is proportional to absolute temperature.

3. **Explain kinetic Interpretation of pressure and temperature?**

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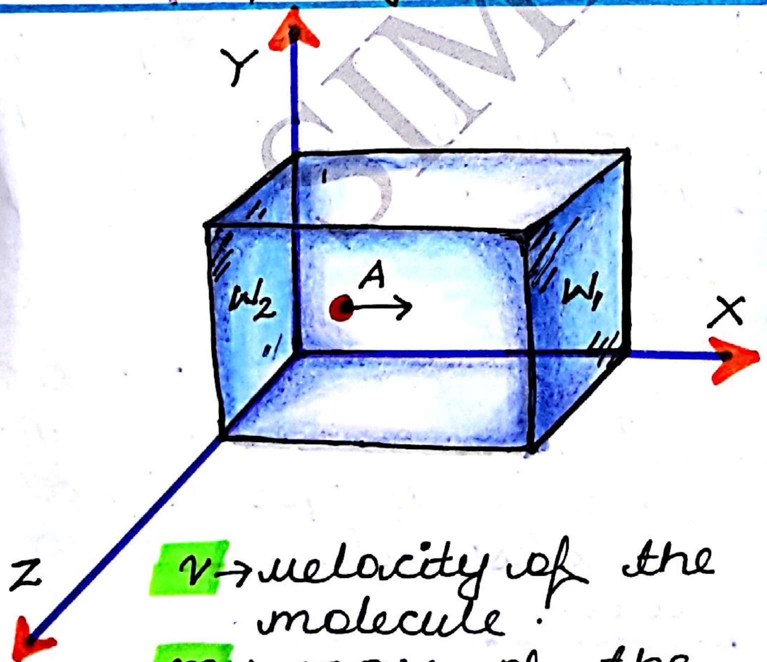
pressure

According to kinetic theory pressure exerted by a gas is defined as the total momentum imparted to unit area of walls of the container per second due to molecular impact on the walls.

Temperature

According to kinetic theory, temperature of a gas is a measure of the average kinetic energy of the molecules of the gas.

4. Derive an expression for pressure exerted by a gas on the basis of kinetic theory.



v → velocity of the molecule.

m → mass of the molecule.

* W_1, W_2 – two opposite walls of the vessel.

A → molecule moving along x-direction.

Consider a gas inside a cubical vessel of unit side. A molecule (A), moving along x-direction hits the wall W_1 and rebounds with same velocity.

Momentum of the molecule before collision

$$= mv$$

momentum of the molecule after collision

$$= -mv$$

change in momentum of the molecule

$$= -mv - mv = -2mv$$

change in momentum of the wall $W_1 = +2mv$

time taken for one collision $= t = \frac{\text{distance}}{\text{velocity}} = \frac{2}{v}$

According to Newton's second law

Force exerted on the wall $F = \frac{dP}{dt}$

$$F = \frac{2mv}{\frac{2}{v}} = mv^2$$

$$F = mv^2$$

If there are 'n' number of molecules. only n/3 molecules will move along X-direction.

Total force exerted on the wall $W_1 = \frac{n}{3} mv^2$

pressure exerted on the wall $= P = \frac{force}{area} = \frac{\frac{n}{3} mv^2}{1}$

$$P = \frac{1}{3} mnv^2$$

substituting $\bar{c}^2$ for v^2

$$P = \frac{1}{3} mn\bar{c}^2$$

$$P = \frac{1}{3} \rho \bar{c}^2$$

$\because mn = \rho$

5, Derive the relationship between kinetic Energy and temperature of a molecule of the gas.?

pressure $P = \frac{1}{3} \rho \bar{c}^2$

$$P = \frac{1}{3} \frac{M}{V} \bar{c}^2$$

$$PV = \frac{1}{3} M\bar{c}^2$$

$$RT = \frac{2}{3} \times \frac{1}{2} M\bar{c}^2$$

$$RT = \frac{2}{3} \overline{KE}$$

$\because \rho = \frac{M}{V}$

$\because PV = RT$

$\because KE = \frac{1}{2} M\bar{c}^2$

average kinetic energy of one mole of gas,

$$\overline{KE} = \frac{3}{2} RT$$

$\overline{KE}$ of one molecules of the gas

$$\overline{KE} = \frac{3}{2} \frac{R}{N} T$$

[N - no of molecules in one mole]

$$\overline{K.E} = \frac{3}{2} kT$$

{$\frac{R}{N} = k$ - boltzman's constant}

$$\overline{KE} \propto T$$

6, Deduce perfect gas equation from kinetic theory of gases:

K.E of one molecule $= \frac{3}{2} kT$

K.E of the gas $= \frac{3}{2} nkT$

$$P = \frac{1}{3} \rho \bar{c}^2 = \frac{1}{3} \frac{M}{V} \bar{c}^2$$

$$PV = \frac{1}{3} M\bar{c}^2 = \frac{2}{3} \times \frac{1}{2} M\bar{c}^2$$

$$PV = \frac{2}{3} \overline{KE}$$

$$PV = \frac{2}{3} \times \frac{3}{2} nkT$$

$$PV = nkT$$

7. Write down the expression for rms velocity, mean free path.

pressure $P = \frac{1}{3} \rho \bar{c}^2$

$$\bar{c} = \sqrt{\frac{3P}{\rho}}$$

$P = \frac{1}{3} \frac{M}{V} \bar{c}^2$, $PV = \frac{1}{3} M \bar{c}^2$

$RT = \frac{1}{3} M \bar{c}^2$

$$\bar{c} = \sqrt{\frac{3RT}{M}}$$

$$\bar{c} \propto \sqrt{T}$$

Mean free path:- Average distance between successive collisions.

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$$

d - diameter of molecule.

n - number of molecules/volume.