

1 SAQ = 4 MARKS

13. KINETIC THEORY

- Mean free path • Gas laws • Pressure of an Ideal gas
- Law of Equipartition of Energy

SMART SYNOPSIS

- Kinetic theory** of gases deals with the behaviour (Speed, KE, Degrees of freedom) of rapidly moving atoms or molecules under various pressures and temperatures.
- Mean free path** is the average distance covered by a molecule between two successive collisions.

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

- Gas Laws** establish various relations between Pressure(P), Volume (V), Temperature (T) and number of moles (n) under certain conditions.

- Boyle's law** "At **constant temperature**, the **volume** of a given mass of a gas is **inversely** proportional to the **pressure** of the gas". $V \propto \frac{1}{P} \Leftrightarrow PV = k$

Isotherms: The curves of graphs, plotted between V and P of a gas, at constant temperature.

- Charles' law** "At **constant pressure**, the **volume** of a given mass of gas is **directly** proportional to its absolute **temperature**". $V \propto T \Leftrightarrow \frac{V}{T} = k$

- Dalton's law of partial pressures** states that total pressure of a mixture of ideal gases is sum of partial pressures.

$P = P_1 + P_2 + P_3 + \dots$ where $P_1, P_2, P_3, \dots$ are partial pressures.

- Avogadro's law:** "Under the same conditions of temperature and pressure, equal volumes of all gases contain equal number of molecules (or) moles". $V \propto n \Leftrightarrow \frac{V}{n} = k$

- Ideal gas** is a gas which obeys, all gas laws at all temperatures and pressures.

- At low pressure and high temperature a real gas behaves like an ideal gas.

- Ideal gas equation :** $PV = nRT \Leftrightarrow \frac{PV}{T} = k$. **R** is called **Universal gas constant**

- **Boltzman constant (K_B)** is the gas constant per molecule $K_B = \frac{R}{N_A}$

4.3 Pressure exerted by an ideal gas is $P = \frac{1}{3} n m \bar{v}^2$ (or) $P = \frac{1}{3} \frac{N}{V} m V_{rms}^2$

Here n is number density of molecules,

m is the mass of the molecule and $\bar{v}^2$ is the mean of square speed.

5. **RMS Speed** is the square root of the mean of the squares of the speeds of all molecules of a gas.

RMS Speed : $C = \sqrt{\frac{C_1^2 + C_2^2 + \dots + C_n^2}{n}}$ (or) $C = \sqrt{\frac{3RT}{M}}$

6. **Degrees of Freedom (f) :**

Degrees of freedom (f) represents the independent ways a molecule can move and store energy.

Types & number of degrees of freedom (f) :

(i) Translational (along x,y,z axes ; 3 f) (ii) Rotational (spinning; 2f for linear, 3f for non-linear)

(iii) Vibrational (to and fro; f depends on the type of molecule)

Degree of freedom of molecules depends on atomicity (monoatomic, diatomic, polyatomic)

7. **Law of Equipartition of Energy** states that each translational and rotational degree of freedom of molecule contributes an average energy of $\frac{1}{2} K_B T$ to its system.

• Translational kinetic energy $E = \frac{3}{2} K_B N T$

8. If a gas has 'f' degrees of freedom then $\gamma = 1 + \frac{2}{f}$

• Number of degrees of freedom (f) for monoatomic gas $f=3$

• Number of degrees of freedom (f) for diatomic gas $f=5$

• Number of degrees of freedom (f) for tri (or) poly atomic gas $f=6$

For better concept clarity refer **PHYSI BEATS P.No: 273**

Imp. Formulae

1. $P = \frac{1}{3} n m \bar{v}^2$

2. $PV = \frac{2}{3} E$; $PV = \frac{2}{3} K$

3. Average energy contributed by one molecule = $\frac{1}{2} K_B T$

4. Translational kinetic energy $E = \frac{3}{2} K_B N T$

5. The average kinetic energy of one gas molecule is $\frac{1}{2} m \bar{v}^2 = \frac{3}{2} K_B T$

6. Mean free path = $l = \frac{1}{\sqrt{2} n \pi d^2}$

