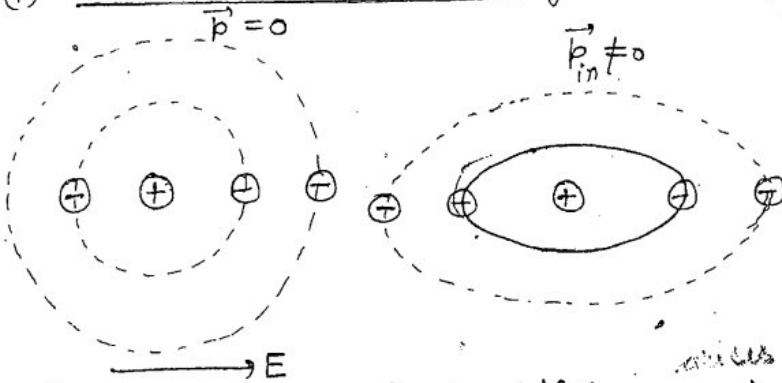


For Pollo

Types of polarisability :-

$$\alpha = \underbrace{\alpha_e + \alpha_i}_{\text{induced}} + \underbrace{\alpha_d}_{\text{Permanent}}$$

(i) Electronic Polarisability :- (α_e)



Unit of α

C.G.S. \Rightarrow volume \rightarrow cm^3

M.K.S. \Rightarrow $\text{F} \cdot \text{m}^2$

This type of polarisability arises due to displacement of e^- cloud of an atom relative to its nucleus in the presence of applied electric field

$$\alpha_e = 4\pi \epsilon_0 R^3$$

$R \rightarrow$ radius of the atom

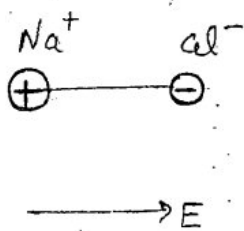
This type of polarisability is independent of temp. but depend on the freq. of applied electric field.

$$\alpha_e = \frac{e^2}{m(\omega_0^2 - \omega^2)}$$

This is the freq. dependence of α_e

- $m \rightarrow$ mass of the e^- . & $e \rightarrow e^-$ charge
- $\omega_0 \rightarrow$ Natural freq. of oscillation of atom.
- $\omega \rightarrow$ freq. of applied electric field.

(ii) Ionic Polarisability :- (α_i)



This type of polarisability arises due to increase of or decrease in the bond length of a ions.

This type of polarisability is independent of temp. but depends on the freq. of applied field.

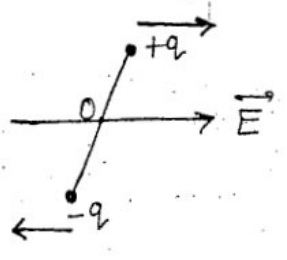
$$\alpha_i = \frac{e^2}{\omega_0^2} \left(\frac{1}{m} + \frac{1}{M} \right)$$

$m \rightarrow$ mass of 1 ion (Na^+)
 $M \rightarrow$ " " another ion (Cl^-)
 $\omega_0 \rightarrow$ natural freq. of the vibration of molecule (Nace)

$$\alpha_i \approx \frac{\alpha_e}{10} \quad (\text{in general})$$

(iii) Dipolar Polarizability - (α_d)

This type of polarizability arises due to the permanent dipole mom. of the molecule.



$$\alpha_d = \frac{p_p^2}{3k_B T}$$

$p_p \rightarrow$ permanent dipole mom. of the molecule
 α_d depends on both temp. & freq. of the field.

Hence total polarizability,

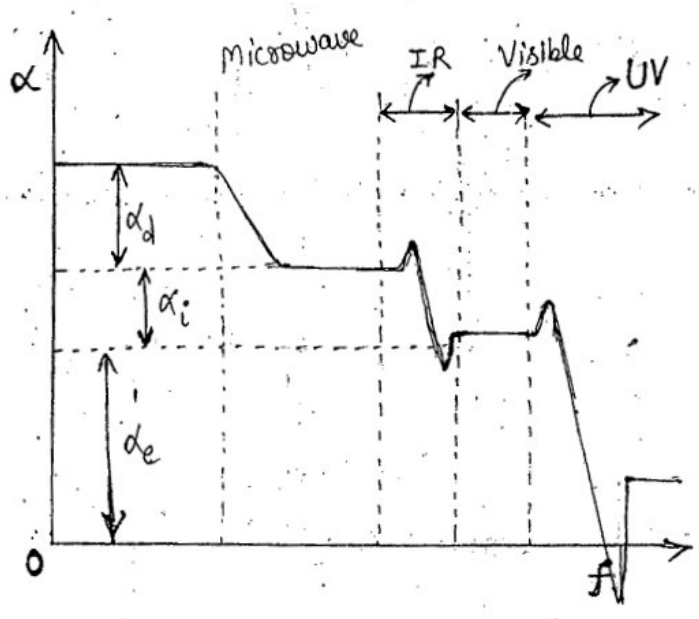
$$\alpha = \alpha_e + \alpha_i + \alpha_d$$

$$\alpha = \alpha_0 + \frac{p_p^2}{3k_B T}$$

\Rightarrow Langevin - Debye Equation.

This is valid for polar molecules.

Frequency Dependence of Total Polarizability:-



In visible region, Total polarisation is electronic polarisation (α_e) $\alpha = \alpha_e$

\rightarrow Existence of α_i , α_d , α_e depends upon the Relaxation time (τ)

\rightarrow lesser the τ , faster the response.

$$f \propto \frac{1}{\tau}$$

$$\tau_e < \tau_i < \tau_d$$

• At optical freq. or visible freq. :-

$$\alpha = \alpha_e$$

We have $\epsilon_r = n^2$

$$\frac{n^2 - 1}{n^2 + 2} = \frac{N \alpha_e}{3 \epsilon_0} \Rightarrow \text{Lorentz-Lorentz Relation}$$

Static Dielectric Constant from Langevin-Debye Equation :-

Total polarisability $\alpha = \alpha_e + \alpha_i + \alpha_d$
 $= \alpha_e + \alpha_i + \frac{p_p^2}{3 k_B T}$

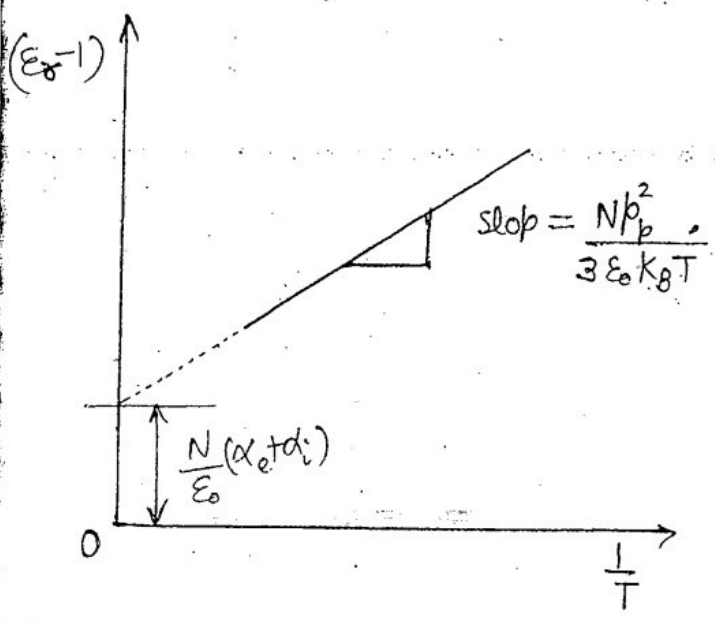
$$\Rightarrow \vec{P} = \epsilon_0 (\epsilon_r - 1) E_m = N \alpha E_{loc}$$

if $E_{loc} = E_m$

This is possible if separation b/w atoms & molecules is so large that there is no interaction b/w the dipoles like in liquid or gasses.

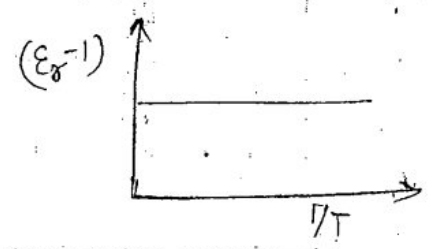
$$\text{so } \vec{P} = \epsilon_0 (\epsilon_r - 1) E_m = N \alpha E_{loc}$$

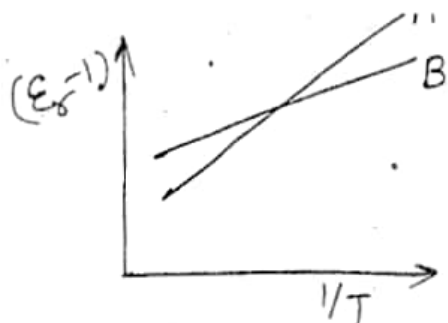
$$(\epsilon_r - 1) = \frac{N}{\epsilon_0} (\alpha_e + \alpha_i) + \frac{N p_p^2}{3 \epsilon_0 k_B T}$$



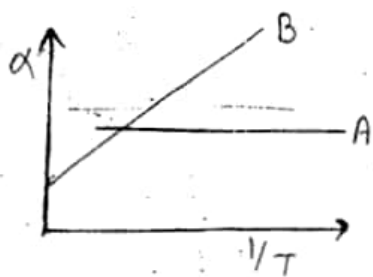
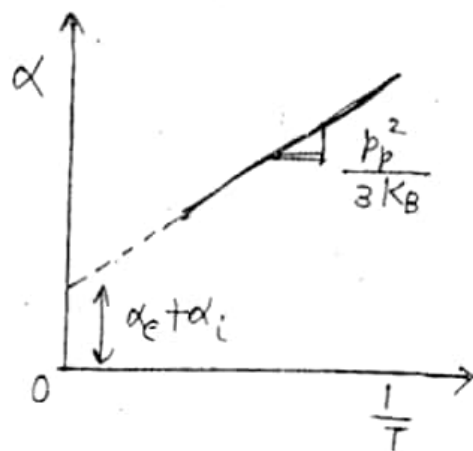
More slope \Rightarrow More polar
 More intercept \Rightarrow More electronic & ionic polarisabilities

If graph is flat \rightarrow means molecule is Non-pola





A is more polar
 beoz more slop \rightarrow more polar.



- (i) $\text{CH}_4 \rightarrow A$
- (ii) $\text{CO}_2 \rightarrow A$
- (iii) $\text{H}_2\text{O} \rightarrow B$
- (iv) $\text{HCl} \rightarrow B$
- (v) $\text{CO} \rightarrow B$
- (vi) $\text{CS}_2 \rightarrow A$
- (vii) $\text{SO}_2 \rightarrow B$
- (viii) $\text{NO}_2 \rightarrow B$

These have permanent dipole mom. $\rightarrow B$