ECE-305

$P \propto E$

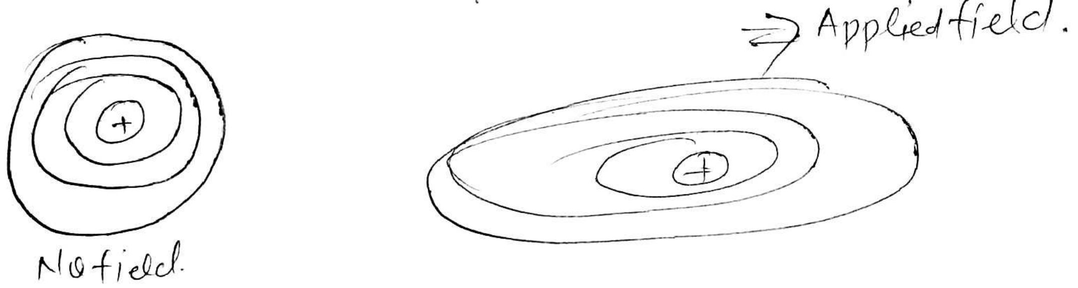
$P = \epsilon_0 \chi_e E$

$P = P_e + P_i + P_o + P_s$

Electronic Polarisation:- The electronic polarisation is occure due ^displacement of^ to negatively charged electron cloud & possitive Nucleas during the application of external field. Actually when we applied external electric field then negative charged electron cloud & possitively charged nucleaus shifted from their equilibrium position, this shifting of electron clouds results in a dipole moment. The ~~dip~~ polarisation of charge in shown in following figure-

$$\vec{p} = \alpha_e \vec{E}$$

α_e = Electronic Polarizibility, & it is independent of Temperature.



The mono-atomic Gases Exhibits only this kind of polarisation, so- electronic polarisation is given by- (occurs only mono-atomic gases.)

$$\vec{P}_e = n\alpha_e \vec{E}$$

The contribution of P_e to the dielectric constant may be given as:-

$$\epsilon_r = 1 + \chi$$

$$= 1 + \frac{P_e}{\epsilon_0 E}$$

$$= 1 + \frac{n\alpha_e E}{\epsilon_0 E}$$

$$\boxed{\epsilon_r = 1 + \frac{n\alpha_e}{\epsilon_0}}$$

In case of mono-atomic gas it is found that the electronic polarization is given by:- $\alpha_e = 4\pi\epsilon_0 R^3$ / $\epsilon_r = 1 + 4\pi n R^3$ .... (*)

where R = Radius of atom.

② **Ionic Polarisation:-** Ionic polarisation is occurs ~~only~~ in Ionic materials. In Ionic materials when external field is applied then cations and anions get displaced in opposite directions which gives a net dipole moment. The magnitude of ionic polarisation is product of relative displacement d_i & the charge on each ion.

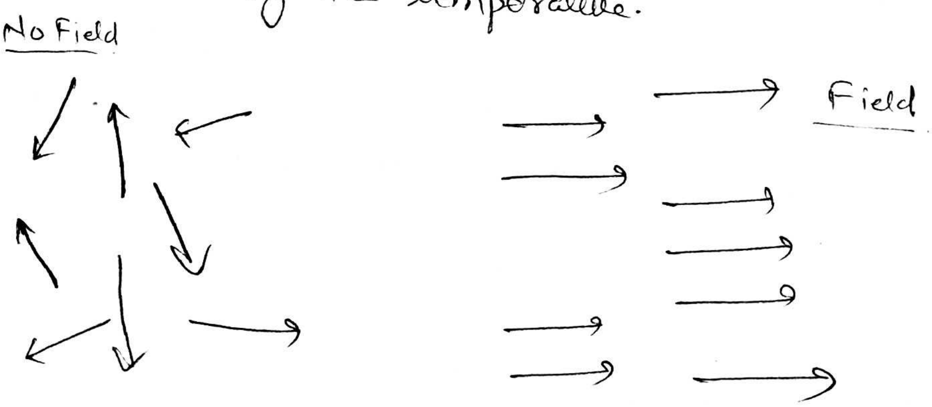
$$P_i = q d_i \qquad \alpha_i = \text{Ionic Polarizability.}$$

$$P_i = n \alpha_i E \qquad n = \text{No. of Ions.}$$

The Ionic & electronic polarisations are ~~also~~ independent of Temperature.

$$\alpha_i = \frac{1}{10}\alpha_e$$

Orientational Polarisation:- Orientational polarisation occurs only in those type materials or substances which have permanent dipole moment. for example CH_3Cl (Methylchloride). When external electric field is applied then all the dipole tends themselves in the direction of applied field. The polarisation is temperature dependent. Orientational polarisation decreases with increasing the temperature. The orientational



Hence Total polarisation

$$P = P_e + P_i + P_o + P_s$$

for a single phase dielectric.

$$P = P_e + P_i + P_o$$

$$P = n\alpha_e E + n\alpha_i E + \frac{n p^2 E}{3K_B T}$$

$$P = n\left[\alpha_e + \alpha_i + \frac{p^2}{3K_B T}\right]E \quad \text{—— (i)}$$

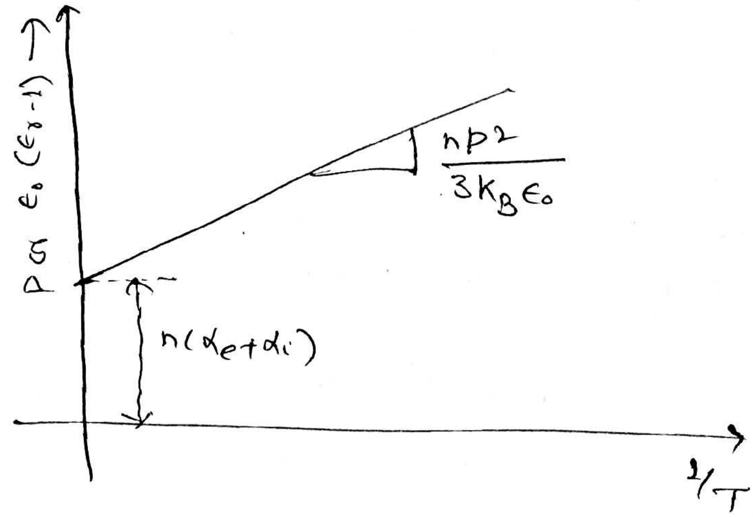
$$P = \epsilon_0 (\epsilon_r - 1) E \quad \text{—— (ii)}$$

compare (i) & (ii)

$$\epsilon_0(\epsilon_r - 1)E = n\left[\alpha_e + \alpha_i + \frac{p^2}{3K_BT}\right]E$$

$$\therefore \epsilon_0(\epsilon_r - 1) = n\left[\alpha_e + \alpha_i + \frac{p^2}{3K_BT}\right]$$

if either polarisation P or dielectric constant ϵ_r is plotted as a function of $1/T$ Then we get a straight line. ~~atlt~~ in The intercept of the line with y axis is at $1/T = 0$ gives the value $n(\alpha_e + \alpha_i)$ from which $(\alpha_e + \alpha_i)$ can be evaluated. The dipole moment p can be calculated by knowing the value of n, the number of molecules per m3.



Prob (1):- Calculate electronic polarizibility of Argon atom. Given $\epsilon_r = 1.0024$ at NTP

$n = 2.7 \times 10^{25}$ atoms/m³

$\epsilon_0 = 8.85 \times 10^{-12}$ F/m

$$P = \epsilon_0(\epsilon_r - 1)\vec{E}$$

$$P = n\alpha_e\vec{E}$$

$$\alpha_e = \frac{\epsilon_0(\epsilon_r - 1)}{n} = 7.9 \times 10^{-40} \text{ F/m}^2$$