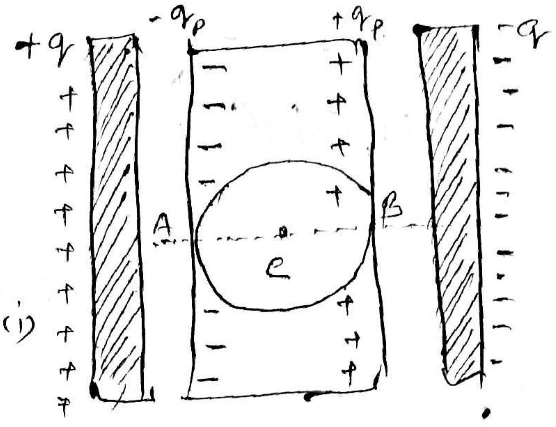
~~Clasius~~ Clausius - Mossotti Relation:-

Let us consider a parallel plate capacitor and a dielectric is placed b/n plates of capacitor. Now dielectric is polarised and net effect of polarisation reduces the electric field. The resultant electric field is

~~[struck out]~~: Consider a Molecule C at the Centre of dielectric. Then the field experience -



$$E_{in} = E_1 + E_2 + E_3 + E_4 \quad \text{------(i)}$$

where E_1 = Field between the plates, when no dielectric,

$= \frac{\sigma}{\epsilon_0}$, σ = charge density, & ϵ_0 = Permittivity of free space.

E_2 = Field at C due to polarisation of dielectric.

$= -\frac{\sigma_p}{\epsilon_0}$

E_3 = Field at C due to polarised charge on the surface of cavity, which is to be calculated

E_4 = Field at C due to Permanent dipoles, which is zero in case of nonpolar isotropic dielectric

Hence if dielectric is non-polar isotropic then -

$$E_{in} = E_1 + E_2 + E_3 \quad \text{---------(ii)}$$

$$= \left(\frac{\sigma}{\epsilon_0} - \frac{\sigma_p}{\epsilon_0}\right) + E_3$$

$$E_{in} = E + E_3 \quad \text{-----------(iii)}$$

where E = Resultant Electric field.

The value of E_3 can be given by -

$$E_3 = \frac{P}{3\epsilon_0} \qquad \therefore E_{in} = E + \frac{P}{3\epsilon_0} \quad \text{--------(iv)}$$

Hence Equation (iii) becomes

$$E_{in} = E + \frac{P}{3\epsilon_0} \quad \cdots\cdots\cdots (iv)$$

But we already know that:

$$\vec{D} = \epsilon_0 \vec{E} + \vec{P} = \epsilon E$$

$$E = \frac{P}{(\epsilon - \epsilon_0)}$$

Put the value of E in the equation (iv)

$$E_{in} = \frac{P}{(\epsilon - \epsilon_0)} + \frac{P}{3\epsilon_0}$$

$$E_{in} = P\left[\frac{\epsilon + 2\epsilon_0}{3\epsilon_0(\epsilon - \epsilon_0)}\right]$$

If n is the number of molecules per unit volume and α is molecular Polarizibility then Polarisation P is given by.

$$P = n\alpha E_{in}$$

$$P = n\alpha P\left[\frac{\epsilon + 2\epsilon_0}{3\epsilon_0(\epsilon - \epsilon_0)}\right]$$

$$\frac{n\alpha}{3\epsilon_0} = \frac{\epsilon - \epsilon_0}{\epsilon + 2\epsilon_0} = \frac{\epsilon/\epsilon_0 - 1}{\epsilon/\epsilon_0 + 2}$$

$$\frac{n\alpha}{3\epsilon_0} = \frac{(\epsilon_r - 1)}{(\epsilon_r + 2)}$$

$$\frac{\epsilon_r - 1}{\epsilon_r + 2} = \frac{n\alpha}{3\epsilon_0}$$

$$\frac{\epsilon_r - 1}{\epsilon_r + 2} = \frac{1}{3\epsilon_0}\left[n_e\alpha_e + n_i\alpha_i + n_o\alpha_o\right]$$

↓

Relation called Clausius Mossoti relation