CL53_Q1: Establish a relation between electric field E, polarization P and susceptibility χ.

If $\boldsymbol{E_o}$ is the electric field applied to a parallel plate capacitor the surface charge density on the plates of the capacitor $\boldsymbol{\sigma = \varepsilon_o E_o}$

If a dielectric material is placed between the plates of the capacitor, then the surface density of charge due to polarization $\boldsymbol{\sigma_p = \varepsilon_o E'}$ where $\boldsymbol{E'}$ is called the depolarization field.

The net electric field E between the plates is reduced by a factor which is the dielectric constant ε_r of the material ie., $\boldsymbol{E = \frac{E_o}{\varepsilon_r}}$ $\boldsymbol{or}$ $\boldsymbol{E_o = \varepsilon_r E}$

The net electric field $\boldsymbol{E = E_o - E' = \varepsilon_r E - \frac{\sigma_p}{\varepsilon_o}}$

Simplifying $\boldsymbol{\sigma_p = \varepsilon_o \varepsilon_r E - \varepsilon_o E = \varepsilon_o(\varepsilon_r - 1)E}$

Hence the polarization in the material due to a net electric field is given by

$\boldsymbol{P = \sigma_p = \varepsilon_o(\varepsilon_r - 1)E}$

The polarization of the material can also be written as $\boldsymbol{P = \varepsilon_o \chi E}$ where $\boldsymbol{\chi}$ is the dielectric susceptibility of the material.

CL53_Q2. What is meant by dielectric polarization? List the various kinds of polarization mechanism that prevail in dielectric materials and how do those polarization mechanism vary with temperature?

Ans:

Dipole moment per unit volume is called polarization $P = \frac{\sum \mu}{V}$

Electronic polarization, Ionic Polarisation, Orientation polarization and space charge polarization.

Electronic polarization and ionic polarisation is independent of temperature.

Orientation polarization- Increase in temperature increases the random motion of the dipoles and hence the orientation polarization decreases with increase in temperature

CL53_Q3. A dielectric slab of constant 6 is kept between the plates of a parallel plate capacitor. If the charge on the plates is 10μC and the area of the plates is 1cm^2 what is the polarization induced in the specimen?

Answer

Solution : Given $\varepsilon_r = 12, Q = 10\ \mu C, A = 1cm^2 = 10^{-4}m^2$

$$P = \varepsilon_o(\varepsilon_r - 1)\frac{V}{d}$$

$$C = \frac{\varepsilon_o \varepsilon_r A}{d} = 1.062x10^{-12}F$$

$$V = \frac{Q}{C} = 9.4\ MV$$

Therefore, $P = \varepsilon_o(\varepsilon_r - 1)\frac{V}{d} = 0.09\ Cm^{-2}$