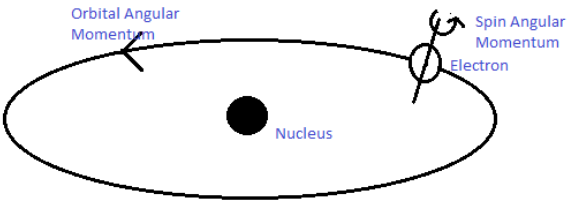
UNIT 3 – MAGNETISM AND DIELECTRIC

Magnetic moment due to orbital angular momentum of electrons :

The orbital motion of electron revolving about a nucleus is equivalent to a tiny current loop. This produces a magnetic field perpendicular to the plane of the orbit as shown in figure below



Let us consider an electron moving with a constant speed '*v*' in a circular orbit of radius r as shown in fig.

Let "T" be the time taken for one revolution and 'e' be the magnitude of charge on the electron.

The current I across any point in the orbit.

Magnetic moment associated with the orbit.

μ_L = current x area covered by the orbital = $IA = -\dfrac{\pi r^2 e}{T}$ ---------------------- (2)

[Therefore, $A = \pi r^2$]

Since T is the time taken for one complete revolution, the angle covered (angular displacement) in time T is 2π.

Angular velocity $\omega = \dfrac{2\pi}{T}$ (or) $T = \dfrac{2\pi}{\omega}$

substituting the value of T in equation, we have

$$\mu_L = -\frac{\pi r^2 e}{\frac{2\pi}{\omega}}$$

$$\mu_L = \frac{-\pi r^2 e\omega}{2\pi}$$

$$\mu_L = -\frac{r^2 e\omega}{2}$$

$$\left[\begin{array}{l} \text{Hence } v = r\omega \\ \dfrac{v}{r} = \omega \end{array}\right]$$

$$\mu_L = -\frac{r^2 e}{2}\frac{v}{r}$$

$$\mu_L = -\left(\frac{evr}{2}\right)$$

dividing and multiplying R.H.S of equation by m (the mass of the electron), we have

$$\mu_L = \frac{-evr}{2} \times \frac{m}{m}$$

$$\mu_L = \frac{-emvr}{2m}$$

$$\boxed{\mu_L = -\left(\frac{eL}{2m}\right)}$$

where L = mvr is the orbital angular momentum of the electron

BOHR MAGNETON

The magnetic moment contributed by an electron with angular momentum quantum number n = 1 is known as Bohr magnetron.

We know that $$\mu_L = \frac{-eL}{2m} \quad \text{-------------------------------------} \quad (1)$$

According to quantum theory, orbital angular momentum

Where $L = n\hbar = \left(\frac{nh}{2\pi}\right)$

substituting the value of L in equation (1), we have

$$\mu_L = -\frac{e}{2m} \cdot \left(\frac{nh}{2\pi}\right)$$

For n = 1, electron is in ground state, (Bohr orbit)

where n is orbital angular momentum quantum number

$$\mu_L = \frac{eh}{4\pi m} \quad \text{--------------------------------} \quad (2)$$

This magnetic moment is defined as one Bohr magnetor (μ_B)

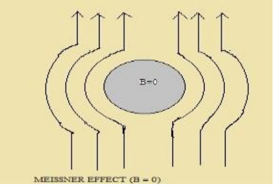
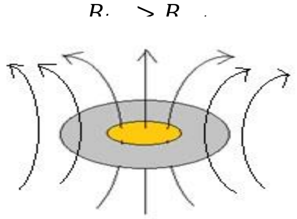
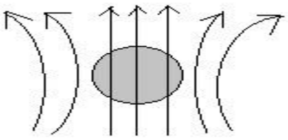
$$\mu_B = \frac{eh}{4\pi m}$$

substituting the values in equation, we have

$$\mu_B = \frac{1.6 \times 10^{-19} \times 6.625 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31}}$$

$$\boxed{\mu_B = 9.274 \times 10^{-24}}$$ **ampere metre² or Am²**

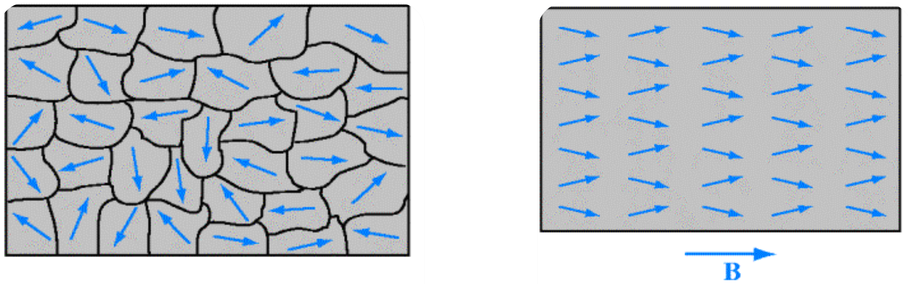
TYPES OF MAGNETIC MATERIALS

CATEGORY	DIAMAGNETIC MATERIALS	PARAMAGNETIC MATERIALS	FERROMMAGNETIC MATERIALS
Definition	These materials have no permanent dipole moment.	These materials have permanent magnetic dipole.	These materials have very large permanent magnetic dipole moment.
Electrons	- They have paired electrons. - The electrons spin in opposite directions. Thus the net magnetic moment is zero.	- They have unpaired electrons. - They give rise to spin magnetic moment. - Thus the net magnetic moment is not zero.	- They have more unpaired electrons. - They give rise to spin magnetic moment. - Thus the net magnetic moment is not zero.
Absence of external magnetic field	- The magnetic dipole moment is zero without external magnetic field. - All electrons have orbital and spin motion in opposite direction. - These orbital and spin motions will be cancelled by other electron.	- The atoms are arranged randomly in the absence of external magnetic field. - They have equal number of $\frac{+1}{2}$ spins and $\frac{-1}{2}$ spins.	- They have spin exchange interaction in the absence of magnetic field. - The magnetic field spreads over the domain.
Presence of external magnetic field	The strength of the magnetic moment = the applied field.	The magnetic dipoles orient in the direction of the applied field.	The domains align parallel to the field and increase in size.
Susceptibility	Always negative	Always positive and small.	Always positive and large.
Temperature dependence	Independent of temperature	Inversely proportional to the temperature of material	Complex dependence on temperature
Magnetic lines of force	Magnetic lines of force are repelled away from the material. $B_{out} > B_{in}$  	Magnetic lines of force are attracted towards the center of the material. 	Magnetic lines of force are highly attracted towards the center of the material. $B_{in} >> B_{out}$ 
Permeability	Less than 1.	Greater than 1.	Very much greater than 1.
Examples	Water, Bismuth and Gold.	Aluminium and Platinum.	Iron, Nickel and Cobalt.

DOMAIN THEORY OF FERROMAGNETISM

Principle

The group of atomic dipoles (atoms with permanent magnetic moment) organised into tiny bounded regions in the ferromagnetic materials are called magnetic domains.



(a) Unmagnetized domains (b) Magnetized domains

When a magnetic field is applied externally to a ferromagnetic material, the domains align themselves with field as shown in fig. This results in a large net magnetization of the material.

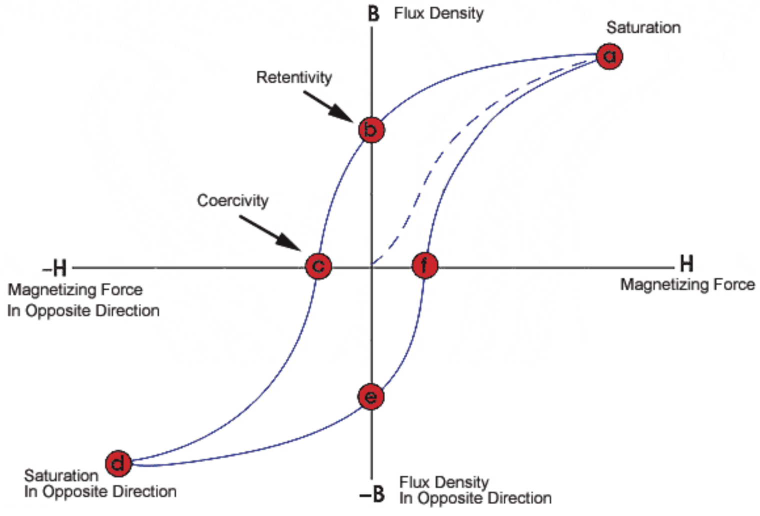
Process of Domain Magnetisation

When the external magnetic field is applied, domains align with the direction of field resulting in large net magnetisation of a material. There are two possible ways to align the domains by applying an external magnetic field.

(a) By the motion of domain walls & (b) By rotation of domains

HYSTERESIS LOOP

A hysteresis loop shows the relationship between the induced magnetic flux density (**B)** and the magnetizing force **(H).** It is often referred to as the B-H loop.



- A magnetizing field ‘H’ is applied to a ferromagnetic material.
- If ‘H’ is increased to H_{max}, the material acquires magnetism and the magnetic induction ‘B’ increases. It is represented as –OA.
- If H_{max} is dereased to zero, the magnetic induction ‘B’ will not fall to zero.
- Instead magnetic induction falls to ‘B’.

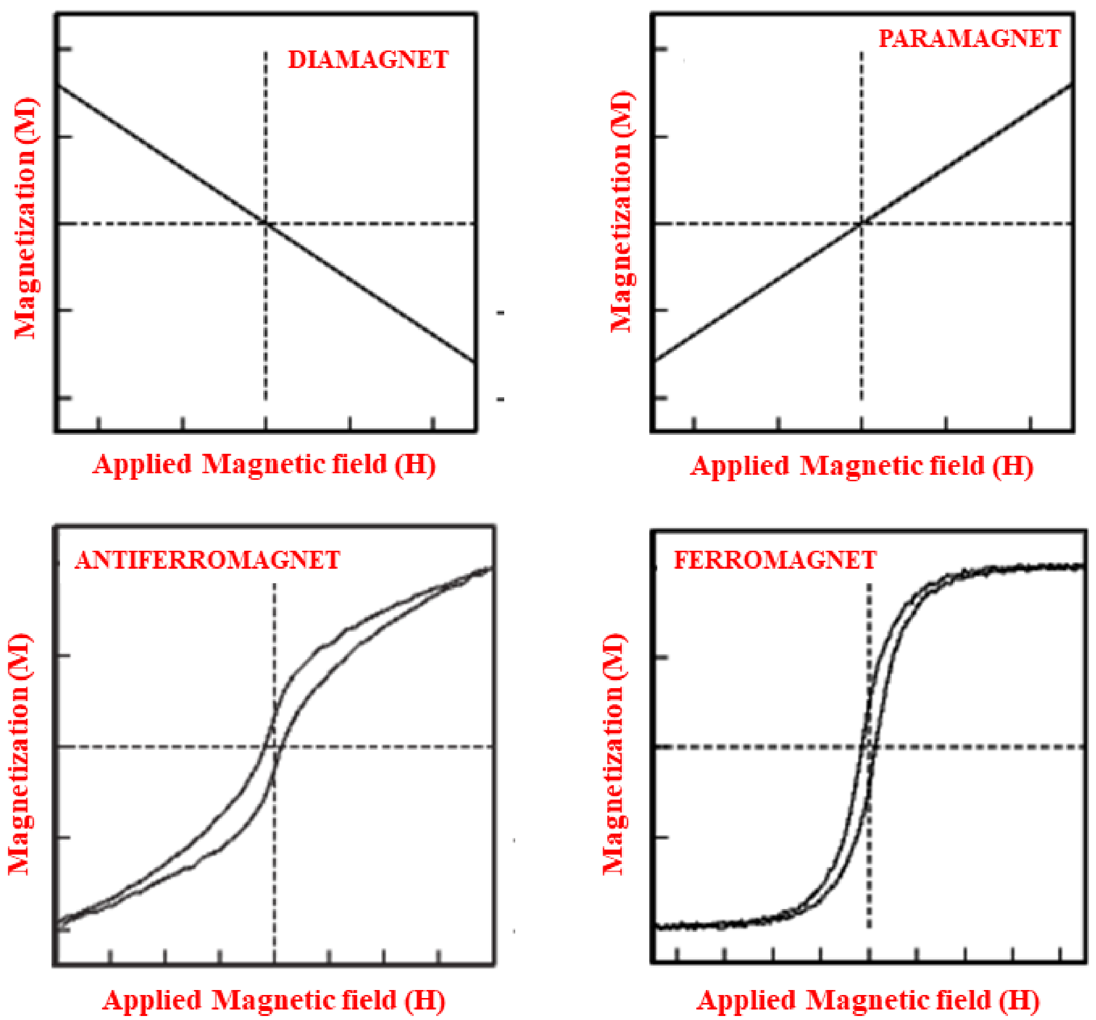
Retentivity: -

- When the applied field is zero (Or) removed, the material acquires some magnetic induction called as residual magnetism or retentivity.

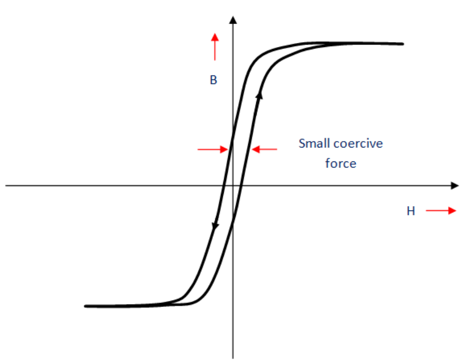
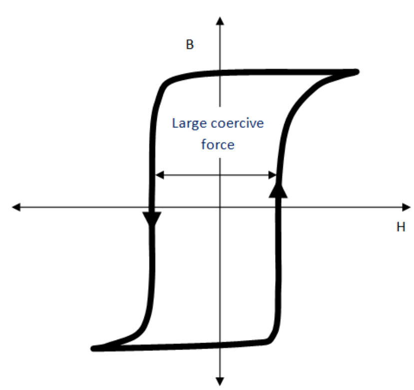
Coercivity: -

- To remove the residual magnetism, the magnetic field is reversed and increased to - H_{max}, represented as OC. This is called as Coercivity.
- We get the curve BCD.
- The ‘– H’ is reduced to zero, then DE curve is formed.
- When still increasing from zero to H_{max} EFA curve is obtained.

Hysteresis curve for various magnetic materials



Hard and Soft magnetic materials

S.No.	Soft magnetic materials	Hard magnetic materials
1.	These magnetic materials can be easily magnetised and demagnetized	These magnetic materials can not be easily magnetised and Demagnetized.
2.	They have high permeability	They have low permeability
3.	Magnetic energy stored is not high.	Magnetic energy stored is high
4.	Low hysteresis losses due to small hysteresis loop area.	Low hysteresis losses due to large hysteresis loop area.
5.	Coercivity and retentivity are small.	Coercivity and retentivity are large
6.	The eddy current loss is small due to its high resistivity	The eddy current loss is more due to its small resistivity
7.	The domain walls are easy to move.	The movement of domain wall must be prevented.
8.	Examples : Iron silicon alloy, Nickel iron alloy, silicon steels and ferrities.	Examples : Tungsten steel, Cobalt steel, Alini, Alnico and Cunife.
9.	They are used in electric motor, generators, transformers, relays, telephone receivers, radar and Sonar equipment's. 	They are used in loud speakers and electrical measuring instruments. 

DIELECTRIC MATERIALS

Dielectric are electrically non conducting materials. Basic difference between a dielectric and insulator is,

* Both are electrically non conducting
* Insulator cannot store charges whereas a dielectric material can store charges.
* All dielectric materials are insulators.

Eg: mica, glass, porcelain, glass, plastics and oxides of various metals.

PROPERTIES OF DIELECTRIC MATERIALS

* Dielectrics are non-metallic materials of high resistivity.
* They have large energy gap (> 3eV)
* All electrons in dielectrics are tightly bound their parent nucleus.
* They have negative temperature coefficient of resistance
* High insulation resistance.

DIELECTRIC CONSTANT ε_r

It is measure of polarization in the dielectrics. It is defined as ratio between absolute permittivity of medium (ε) and permittivity of free space (ε_0)

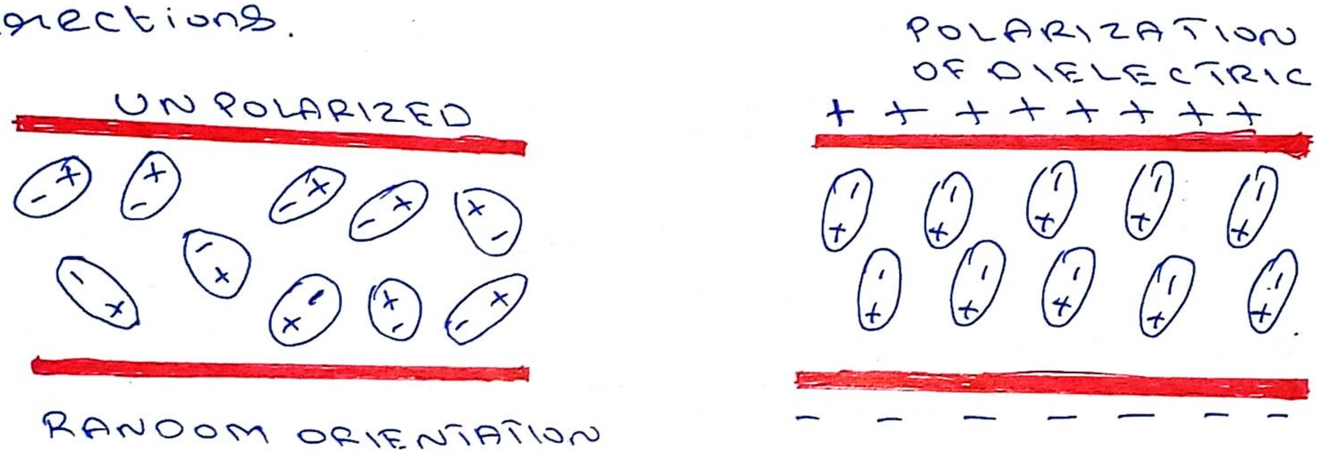
$$\boxed{\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}}$$

$$\text{Dielectric constant, } \varepsilon_r = \frac{\text{Absolute permittivity } (\varepsilon)}{\text{permittivity of free space } (\varepsilon_0)}$$

POLARIZATION

The electrical behaviour of a dielectric material can be changed by application of external field.

When an external field is applied to a dielectric, it exerts force on both positive and negative charged particles of each atom present in the dielectric material. The positive charges are pushed in same direction of applied electric field while negative charges are pushed in opposite directions.



RANDOM ORIENTATION OF DIPOLES (ELECTRIC)

The process of producing electrical dipoles inside the dielectric by application of external field is called polarization in dielectrics.

POLARIZABILITY

It is the ratio of average dipole moment of applied electric field. unit is Fm^2

$$\mu \propto E$$

$$\mu = \alpha E$$

$$\boxed{\alpha = \frac{\mu}{E}}$$

VARIOUS POLARIZATION MECHANISMS IN DIELECTRICS

The four polarization mechanisms which occur in a dielectric material is,

* Electronic polarization
* Ionic polarization
* Orientational polarization
* Space charge polarization

ELECTRONIC POLARIZATION

It is due to the displacement of positively charged nucleus and negatively charged electrons of an atom in opposite directions on application of electrical field.

Dipole moment (μ) is proportional to electric field strength

$$\boxed{\mu \propto E}$$

$$\mu = \alpha_e E$$

α_e - electronic polarizability

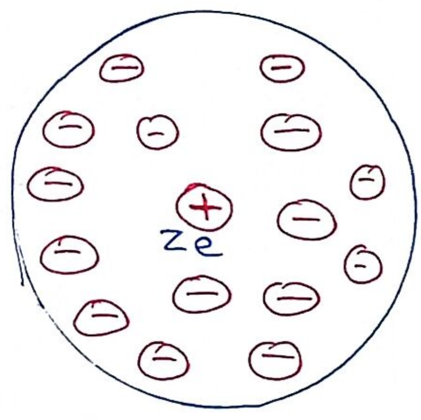
(i) without electric field

Consider an atom of dielectric material of nuclear charge $+Ze$ at centre

Z - atomic number

Electrons are distributed uniformly throughout the atom of radius R

Charge of an electron = $-Ze$



IN THE ABSENSE OF FIELD

when no electric field is applied the centres of electron cloud and the positive nucleus are at same point and hence there is no dipole moment.

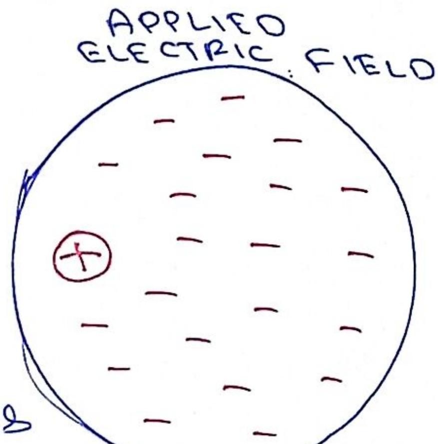
Negative charge density of an atom of radius R is given by

$$\rho = \frac{\text{Total negative charge}}{\text{volume of atom}} = \frac{-Ze}{\frac{4}{3}\pi R^3}$$

$$\boxed{\rho = \frac{-3Ze}{4\pi R^3}} \longrightarrow (1)$$

(ii) when electric field applied

when the dielectric is placed in an electric field of strength, E two phenomena occur.



a) Lorentz force

tends to move the positive nucleus and electron cloud of that atom from their positions. positive nucleus will move towards the field direction and electron cloud move in opposite direction.

b) Attractive coulomb force

arises between nucleus and electron cloud which tends to maintain the equilibrium position.

On application of electric field the electron cloud and nucleus move in opposite directions and they are separated by a distance x where there is a formation of electric dipole in the atom.

When these two forces are equal & opposite, there will be a equilibrium between nucleus & electron cloud in an atom.

Lorentz force, F_L = Charge × Electric Field

$$\boxed{F_L = ZeE} \longrightarrow (2)$$

Consider a sphere of radius x which encloses the +ve nucleus & -ve electrons.

Coloumb force, $F_C = \frac{1}{4\pi\varepsilon_0} \frac{Q_p Q_e}{x^2}$

$$\boxed{Q_p = Ze}$$

Q_e = Total number of negative charges enclosed in sphere of radius x

= charge density (ρ) × volume of sphere

$$= -\frac{3}{4}\frac{Ze}{\pi R^3} \times \frac{4}{3}\pi x^3$$ [Substituting ρ from equation (1)]

$$\boxed{Q_e = -Ze\left(\frac{x^3}{R^3}\right)}$$

$$F_C = \frac{1}{4\pi\varepsilon_0} \times \frac{Ze \times -Ze\left(\frac{x^3}{R^3}\right)}{x^2}$$

$$= \frac{-(Ze)^2 x}{4\pi\varepsilon_0 R^3} \Rightarrow \boxed{F_C = \frac{-Z^2e^2 x}{4\pi\varepsilon_0 R^3}} \rightarrow (3)$$

At equilibrium, coloumb force & Lorentz force is equal & opposite,

$$F_L = -F_C$$

Substituting for F_L & F_C from equation (2) & (3)

$$ZeE = -\left(-\frac{Z^2e^2x}{4\pi\varepsilon_0 R^3}\right)$$

$$\cancel{Z}\cancel{e}E = \frac{xZ^{\cancel{2}}e^{\cancel{2}}}{4\pi\varepsilon_0 R^3}$$

$$x = \frac{4\pi\varepsilon_0 R^3}{Ze} \Rightarrow \boxed{x = \frac{4\pi\varepsilon_0 R^3 E}{Ze}}$$

The induced dipole moment

$$\mu_{ind} = \text{magnitude of charge} \times \text{displacement}$$

$$\mu_{ind} = Zex$$

Interms of polarizability

$$\mu_{ind} = \alpha_e E$$

$$\mu_{ind} = \cancel{Ze} \times \frac{4\pi\varepsilon_0 R^3 E}{\cancel{Ze}}$$

$$\alpha_e \cancel{E} = 4\pi\varepsilon_0 R^3 \cancel{E}$$

$$\boxed{\alpha_e = 4\pi\varepsilon_0 R^3}$$

* Electronic polarization is independent of temperature
* It is proportional to volume of atoms in the material
* Electronic polarization occurs in all dielectric materials.

IONIC POLARIZATION

* It occurs in ionic crystals

eg:- NaCl , KCl, KF, NaI

* It occurs due to the displacement of cations and anions in opposite directions.

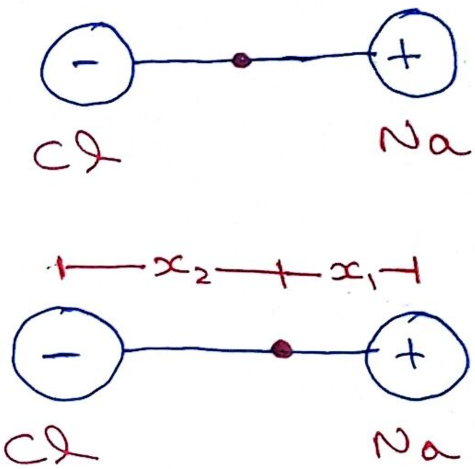
when an electric field is applied on an ionic dielectric, there is a shift of one ion with respect to another from their mean positions.

Positive ions displace through a distance x_1

negative ions displace through a distance x_2

net distance between two ions $\quad x = x_1 + x_2 \longrightarrow (1)$

when the ions are displaced from their mean positions in their respective directions the restoring forces appear which tend to move the ions back to their mean position.



For +ve ions restoring force, $F \propto x_1$

For -ve ions " " , $F \propto x_2$

$\longrightarrow (2)$

$\boxed{F = x_1 \beta_1}$

$\boxed{F = \beta_2 x_2}$

β_1 & β_2 are restoring force constant

$\longrightarrow (3)$

m - mass of positive ion

M - mass of negative ion

ω_0 - angular frequency

$$\beta_1 = m\omega_0^2 \rightarrow (4)$$

$$\beta_2 = M\omega_0^2 \rightarrow (5)$$

Substituting β_1 & β_2 values in equation (2) & (3)

$$F = m\omega_0^2 x_1$$

$$F = M\omega_0^2 x_2$$

Force, $F = eE$

$$eE = m\omega_0^2 x_1$$

$$x_1 = \frac{eE}{m\omega_0^2} \; ; \; x_2 = \frac{eE}{M\omega_0^2}$$

$$x = x_1 + x_2$$

$$x = \frac{eE}{m\omega_0^2} + \frac{eE}{M\omega_0^2} \Rightarrow \frac{eE}{\omega_0^2}\left(\frac{1}{m} + \frac{1}{M}\right) \rightarrow (6)$$

Dipole moment, $\boxed{\mu = e \times x}$

Substituting value of x from equation (6)

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

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

But $\boxed{\mu = \alpha_i E}$ α_i - ionic polarizability

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

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

(8)

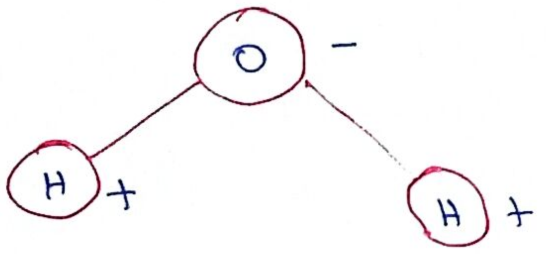
POLAR MOLECULE

A polar molecule is one in which the centre of gravity of positive charges is separated from the centre of gravity of negative charges by a finite distance.

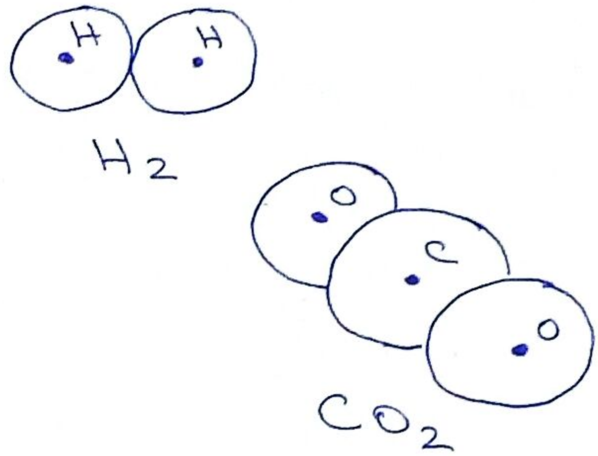
Eg: H_2O, HCl, N_2O

NON POLAR MOLECULE

A non polar molecule is one in which the centre of gravity of the positive charges coincides with centre of gravity of negative electrons. Eg: H_2, CO_2



POLAR MOLECULE



CO_2

NON-POLAR MOLECULE

ORIENTATION POLARIZATION

* It takes place only in polar dielectrics
* Polar dielectrics have molecules with permanent dipole moments even in the absence of electrical field.

When the polar dielectrics are subjected to an electrical field, the molecules dipoles are oriented in direction of electric field.

The Polarization due to orientation of molecular dipoles is called orientational polarization.

Orientational polarization depends on temperature. When temperature is increased, thermal energy tends to disturb the alignment.

From Langevin's theory of paramagnetism,

net intensity of magnetization $= \frac{N\mu^2 B}{3kT}$

Same principle is applied here,

Orientational polarization $\boxed{P_o = \frac{N\mu^2 E}{3kT}}$

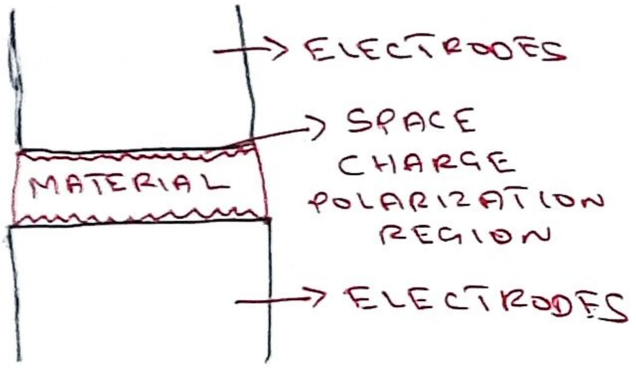
$$\boxed{P_o = N\alpha_o E}$$

α_o - orientational polarizability

$$\boxed{\alpha_o = \frac{\mu^2}{3kT}}$$

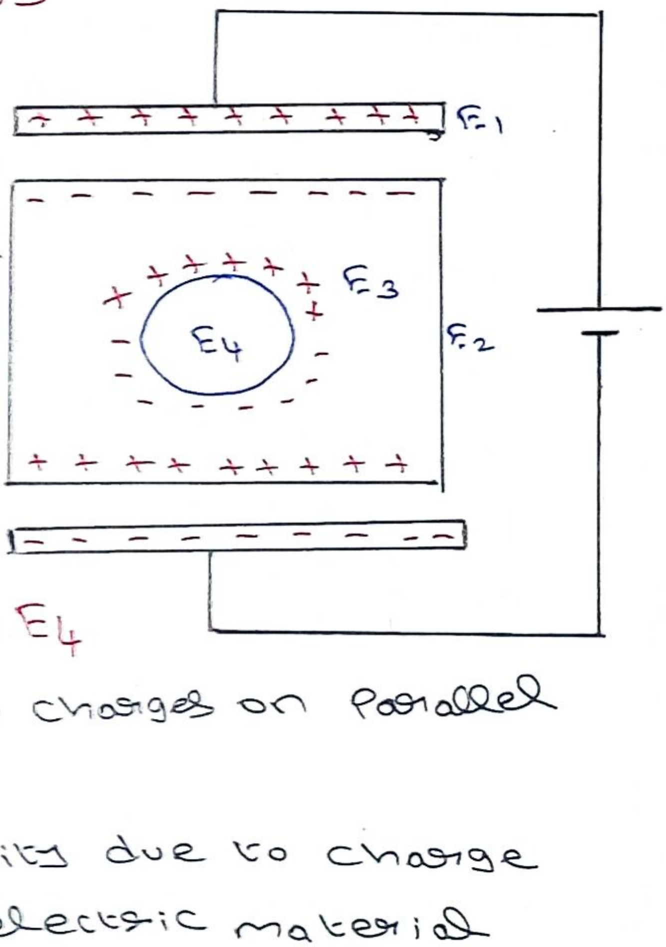
SPACE CHARGE POLARIZATION

Space charge polarization occurs due to the accumulation of charges at the electrodes or at the interfaces of multiphase dielectric materials.



INTERNAL FIELD OF SOLIDS

When a dielectric material is placed between two parallel plate capacitors. The internal field of solid consitutes of four components.



$$E_{int} = E_1 + E_2 + E_3 + E_4$$

E_1 - Electric field intensity due to charges on parallel plate capacitor

E_2 - Electric field intensity due to charge density on side of dielectric material

E_3 - Electric field intensity due to other atoms in dielectric material

E_4 - Electric field intensity due to charge density on surface of cavity.

The electric field intensity due to charges on the plates,

$$E_1 = \frac{D}{\varepsilon_0}$$

D - Displacement current which relates the electric field & polarization

$$D = \varepsilon_0 E + P$$

$$E_1 = \frac{\varepsilon_0 E + P}{\varepsilon_0}$$

$$\boxed{E_1 = E + \frac{P}{\varepsilon_0}}$$

E_2 - Field intensity due to charge density on either side of dielectric

$$\boxed{E_2 = \frac{-P}{\varepsilon_0}}$$

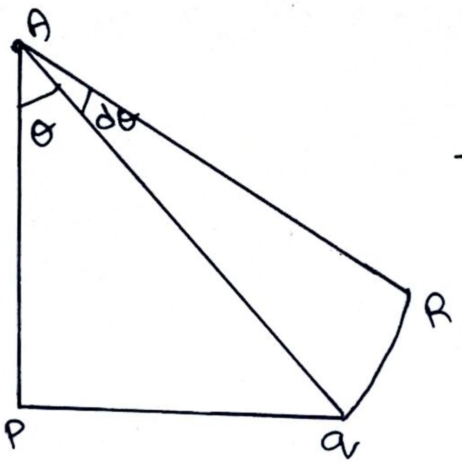
E_3 - consider the dielectric material to have cubic structure where the dipole moments cancel eachother.

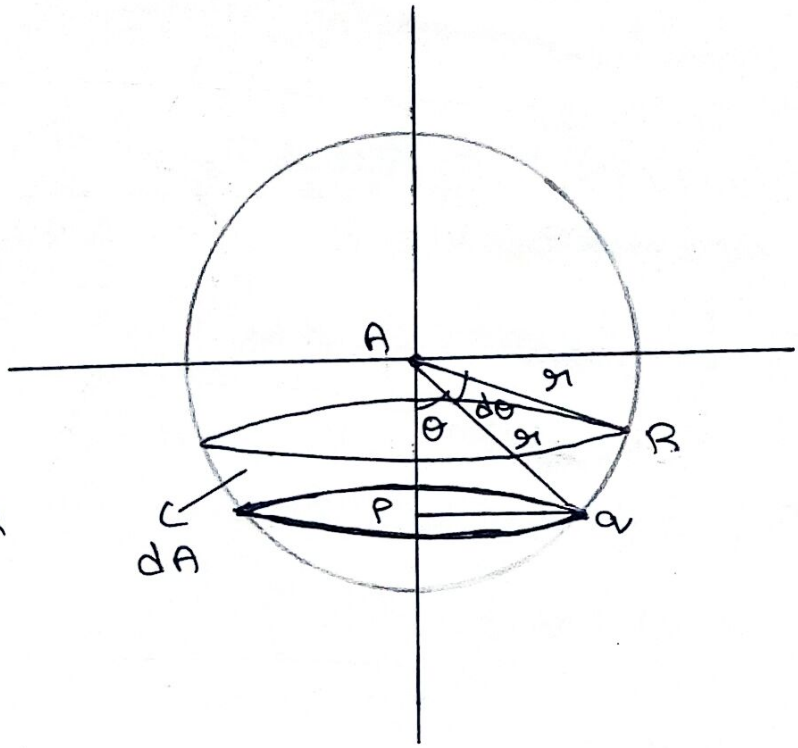
$$\boxed{E_3 = 0}$$

consider a cavity in the dielectric material with a spherical shape of radius r.

Let us assume two small surface areas whose area is dA

$$dA = 2\pi PQ \times QR$$





By trignometric identities

ΔAPQ

$$\sin\theta = \frac{PQ}{r} \qquad \sin\theta = \frac{opp}{hyp}$$

$$PQ = r\sin\theta$$

ΔAQR

$$\sin d\theta = \frac{QR}{r}$$

by small angle approximation

$$\sin d\theta = d\theta$$

$$\therefore d\theta = \frac{QR}{r}$$

$$QR = r\,d\theta$$

$$dA = 2\pi \times r\sin\theta \times r\,d\theta$$

$$dA = 2\pi r^2 \sin\theta\, d\theta \longrightarrow (1)$$

charges dq present in surface area dA

$$\boxed{dq = \rho \cos\theta \, dA}$$

dA from equation (1)

$$\boxed{dq = \rho \cos\theta \, (2\pi r^2 \sin\theta \, d\theta)} \longrightarrow (2)$$

Electric field at centre point A is,

$$dE_4 = \frac{dq}{4\pi\varepsilon_0 r^2}$$

$\theta = 0$, normal electric field intensity

$$dE_4 = \frac{dq \cos\theta}{4\pi\varepsilon_0 r^2}$$

substitute dq from equation (2)

$$dE_4 = \frac{\rho \cos\theta \, (\cancel{2}\cancel{\pi}\cancel{r^2} \sin\theta \, d\theta) \times \cos\theta}{{}_{2}\cancel{4}\cancel{\pi}\varepsilon_0 \cancel{r^2}}$$

$$dE_4 = \frac{\rho \cos^2\theta \sin\theta \, d\theta}{2\varepsilon_0}$$

$$E_4 = \int_0^{\pi} dE_4$$

$$\therefore E_4 = \int_0^{\pi} \frac{\rho \cos^2\theta \sin\theta \, d\theta}{2\varepsilon_0}$$

$$E_4 = \frac{\rho}{2\varepsilon_0} \int_0^{\pi} \cos^2\theta \sin\theta \, d\theta$$

$\cos\theta = x$

$dx = -\sin\theta \, d\theta$

Substituting the limits

$\cos 0 = 1 \qquad \cos\pi = -1$

$$E_4 = \frac{P}{2\varepsilon_0} \int_{1}^{-1} x^2 (-dx)$$

$$E_4 = \frac{P}{2\varepsilon_0} \left. \frac{x^3}{3} \right]_{-1}^{1}$$

$$E_4 = \frac{P}{2\varepsilon_0} \left[\frac{1}{3} + \frac{1}{3} \right]$$

$$\boxed{E_4 = \frac{P}{3\varepsilon_0}}$$

Total internal field

$$E_{int} = E_1 + E_2 + E_3 + E_4$$

$$\boxed{E_1 = E + \frac{P}{\varepsilon_0}} , \quad \boxed{E_2 = -\frac{P}{\varepsilon_0}} \quad \boxed{E_3 = 0}$$

$$\boxed{E_4 = \frac{P}{3\varepsilon_0}}$$

$$E_{int} = E + \frac{P}{\varepsilon_0} - \frac{P}{\varepsilon_0} + 0 + \frac{P}{3\varepsilon_0}$$

$$\boxed{E_{int} = E + \frac{P}{3\varepsilon_0}}$$

CLAUSIUS MOSSOTTI EQUATION

Clausius mossotti relates the electronic polarizability and the dielectric constant of a dilelectric material.

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} \begin{array}{l} \rightarrow \text{Material} \\ \rightarrow \text{Vacuum} \end{array}$$

ε_r - dielectric constant

ε - Material permittivity

ε_0 - Vacuum permittivity

Let N - number of molecules in the medium

α - electronic polarizability

P - Total polarization

E_{int} - Total internal field of a solid

$$P = N\alpha E_{int}$$

current density

$$D = \varepsilon_0 E + P = \varepsilon E$$

$$E = \frac{P}{\varepsilon - \varepsilon_0}$$

$$E_{int} = E + \frac{P}{3\varepsilon_0}$$

$$E_{int} = \frac{P}{\varepsilon - \varepsilon_0} + \frac{P}{3\varepsilon_0}$$

$$E_{int} = P\left(\frac{1}{\varepsilon-\varepsilon_0} + \frac{1}{3\varepsilon_0}\right)$$

$$E_{int} = P\left(\frac{3\varepsilon_0 + \varepsilon - \varepsilon_0}{3\varepsilon_0(\varepsilon-\varepsilon_0)}\right)$$

$$E_{int} = \frac{P}{3\varepsilon_0}\left(\frac{2\varepsilon_0 + \varepsilon}{\varepsilon - \varepsilon_0}\right)$$

$$E_{int} = \frac{P}{N\alpha}$$

$$\frac{\cancel{P}}{N\alpha} = \frac{\cancel{P}}{3\varepsilon_0}\left(\frac{2\varepsilon_0 + \varepsilon}{\varepsilon - \varepsilon_0}\right)$$

$$\frac{N\alpha}{3\varepsilon_0} = \left(\frac{\varepsilon - \varepsilon_0}{2\varepsilon_0 + \varepsilon}\right)$$

$$\frac{N\alpha}{3\varepsilon_0} = \frac{\cancel{\varepsilon_0}}{\cancel{\varepsilon_0}}\left(\frac{\frac{\varepsilon}{\varepsilon_0} - 1}{\frac{2\cancel{\varepsilon_0}}{\cancel{\varepsilon_0}} + \frac{\varepsilon}{\varepsilon_0}}\right)$$

ε_r

$$\frac{N\alpha}{3\varepsilon_0} = \frac{\frac{\varepsilon}{\varepsilon_0} - 1}{2 + \frac{\varepsilon}{\varepsilon_0}} \Rightarrow \boxed{\frac{N\alpha}{3\varepsilon_0} = \frac{\varepsilon_r - 1}{\varepsilon_r + 2}}$$

The above relation is Clausius Mossotti relation.

DIELECTRIC LOSS

When a dielectric material is applied with AC voltage, the electrical energy is absorbed by the dielectric and certain quantity of electrical energy is dissipated in the form of heat energy is termed as dielectric loss.