DIELECTRICS

→ The dielectrics are non-conductors of electricity (electrical insulators) ∵ they don't possess free charges.

→ The electrical conductivity of the dielectrics is either very small or zero.

→ They don't conduct any current at ordinary temp.

→ The −ve & +ve charges in each part of the crystal can be considered to be centered at the same pt. & no conductivity is possible, the localized charges remain practically undisturbed.

→ When an E.F. of sufficient magnitude is applied to the crystal, the centers of +ve charges are displaced slightly in one dirⁿ i.e. the dirⁿ of the field & that of the −ve charges in opp dirⁿ. This produces local electric dipole throughout the crystal.

DIELECTRIC PARAMETERS

(i) Dielectric Constt: Dielectric constt (ε_r) of a material is defined as the ratio of the permitivity of the medium (ε) to the permitivity of free space (ε_0);

$$\Rightarrow \boxed{\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}}$$ → Dielectric Constt (Dimensionless qty).

$\varepsilon_r = 1$ (air)

* The measure of D.C. gives the properties of a dielectric material.

APRIL 2012

WK	M	T	W	T	F	S	S
13	30						1
14	2	3	4	5	6	7	8
15	9	10	11	12	13	14	15
16	16	17	18	19	20	21	22
17	23	24	25	26	27	28	29

Scanned with CamScanner

(ii) Electric Dipole Moment:- An electric dipole is made up of two equal +ve & -ve charges, separated by a small distance. If q is the magnitude of charge & dl is the sepa^n, then the electric dipole moment:-

$$\boxed{P = q\,dl.} \rightarrow \text{vector qty. (cm)}$$

* If each of the particles in a solid possesses a dipole moment then total dipole moment will be the sum of moments of all dipoles.

$$P_{total} = \sum_{i=1}^{n} q_i\, dl_i$$

Where $q_1, q_2 - - - q_n$ are pt. charges & $dl_1, - - dl_n$ are distances of sepr^n.

(iii) Polarization Vector:- The dielectric becomes polarized in the presence of E.F.

→ The effect of E.F. is to separate +ve & -ve charges of the entire vol. of the dielectric, +ve charges are displaced in one dir^n & -ve charges are displaced in opp. dir^n. The displacement of +ve & -ve charges create electric dipoles, this effect is called Polarz^n of Dielectric.

→ The polar^n P in a solid is defined as the dipole moment per unit vol i.e.

$$P = \frac{p}{V} \quad (C\text{-}m^{-2})$$

(iv) Polarizability:- when a dielectric material is placed in an E.F the displacement of electric charges gives rise to the creation of dipole in the material. The polar^n p of an elementary particle is directly prop. to the electric ~~E~~ field strength E i.e. $P \propto E$

$$\Rightarrow P = \alpha E.$$

$\alpha \rightarrow$ prop. Const ($F m^2$)

MAY 2012

WK	M	T	W	T	F	S	S
18		1	2	3	4	5	6
19	7	8	9	10	11	12	13
20	14	15	16	17	18	19	20
21	21	22	23	24	25	26	27
22	28	29	30	31			

Scanned with CamScanner

→ If the solid material contains N no. of particles per unit vol, then polar :- $P = N\alpha E$.

$\alpha = \alpha_e + \alpha_i + \alpha_d$ polarizabilities.
↓ Electronic, ↓ ionic, ↓ dipolar

TYPES OF DIELETRICS :

Dielectrics are of two types :—

(i) Non-polar (ii) Polar.

(i) Non-polar Dielectrics :- In a molecule there is a distribution of protons & electrons. The protons can be considered as the equivalent +ve electric charge at some specific pt. in the molecule called the centre of gravity of protons.
Illy, there is a pt., at which −ve charge is equivalent to the distributed electrons called the centre of e^-.

* A molecule in which the centres of +ve & −ve charges coincide, is called non-polar molecule and don't possess any electric dipole moment.

Ex :- CO_2, CCl_4, H_2, N_2, O_2 etc.

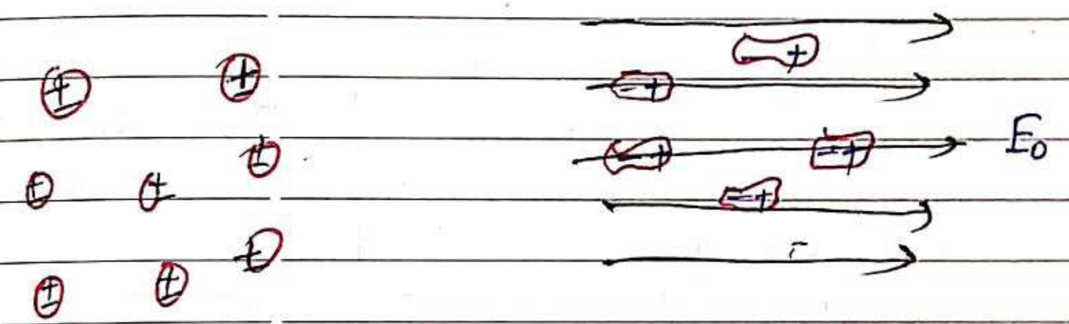
APRIL							2012
WK	M	T	W	T	F	S	S
13	30						1
14	2	3	4	5	6	7	8
15	9	10	11	12	13	14	15
16	16	17	18	19	20	21	22
17	23	24	25	26	27	28	29

Scanned with CamScanner

(ii) Polar Dielectric :- A molecule in which centres of +ve & -ve charges don't coincide but separated by a small distance, is called polar molecule.
Polar molecules work as electric dipoles and have dipole moment.
HCl, H_2O, $CHCl_3$ are polar molecules.

POLARIZATION IN DIELECTRICS

→ When a dielectric (polar or non-polar) is placed in an E.F., the charge centres of non-polar molecules displaced and the molecules become induced dipoles.



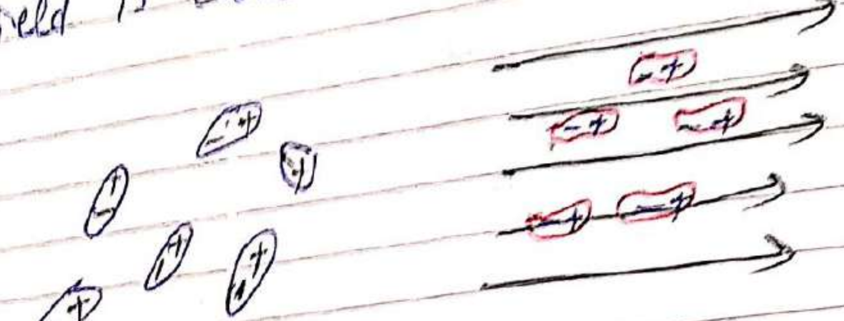
→ For polar molecules, which already have randomly oriented permanent dipoles, the effect of E.F. is to orient the dipoles along the dir^n of E.F. & ↑ their dipole moment. The stronger the field, the greater is the aligning effect.

Scanned with CamScanner

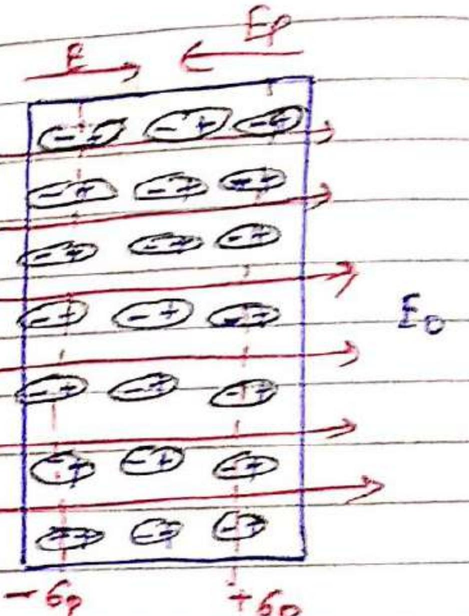
2012

Important Notes

→ The phenomenon of orientation of the induced dipoles or the permanent dipoles in an external E.F. to set the axis of the dipoles along the field is called electric polarⁿ.



Behaviour of Dielectric in E.F.



→ If a thin slab of dielectric (polar or non-polar) is placed in an E.F, the slab as a whole becomes polarized.

→ Due to polarⁿ, molecules are oriented so that the -ve charges are on the left & +ve charges on the right.

→ Thus leaving the net +ve charge at the right surface & net -ve charge ~~charge~~ at the left surface.

→ Inside the medium there is no excess charge in any given vol. element

→ The ~~xxx~~ medium as a whole remains electrically neutral & +ve charge on the right is equal in magnitude to the -ve charge on the left.

→ Charges so obtained on the surfaces are known as polarⁿ charges.

APRIL 2012

WK	M	T	W	T	F	S	S
13	30						1
14	2	3	4	5	6	7	8
15	9	10	11	12	13	14	15
16	16	17	18	19	20	21	22
17	23	24	25	26	27	28	29

→ These charges are not free but each is bound to a molecule lying in or near surface, ∴ they are named as bound charges or fictitious charges.

→ These charges create their own E.F. E_p which is directed to the left and oppose the external applied field E_0.

⇒ When we add $E_0 + E_p = E < E_0$

⇒ Polaⁿ of dielectric reduces the E.F. in its interior.

TYPES OF POLARIZATION

→ Dielectric polaⁿ is a consequence of the fact that when an E.F. acts on a molecule its +ve charges (nuclei) are displaced along the field while the -ve charges (e^-) in a dirⁿ opp. to the field.

→ Displacement of electric charges results in the formation of electric dipole moment in atoms, ions or molecules of the material.

Three imp types of polaⁿs :-

(i) Electronic polaⁿ

(ii) Ionic polaⁿ

(iii) Orientational polaⁿ.

MAY 2012

WK	M	T	W	T	F	S	S
18		1	2	3	4	5	6
19	7	8	9	10	11	12	13
20	14	15	16	17	18	19	20
21	21	22	23	24	25	26	27
22	28	29	30	31			

Scanned with CamScanner

(α_e)
(i) Electronic Polarⁿ :- When the e^- in its various shells are displaced relative to the nucleus by the E.F., an induced electric dipole moment is produced. This is called electronic polarⁿ.

(α_i)
(ii) Ionic polarⁿ :- If a molecule contains ions, then the applied field tends to displace the +ve & -ve ions in opp. dirⁿ, causing a change in length of the ionic bond. Polaⁿ due to relative displacement of ions, it is called Ionic or atomic polarⁿ.

(α_d)
(iii) Orientational Polarⁿ :- If the molecule has permanent dipoles, these are oriented randomly in the absence of an external field & result in a complete cancellation of the polarⁿ. But when an external field is applied these dipoles tend to orient & align with the field, giving an effective polarⁿ, called dipolar or orientational polarⁿ.

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

Total polarizibility α is defined as the dipole moment p, that an atom or molecule acquires in a local E.F. E_{loc}.

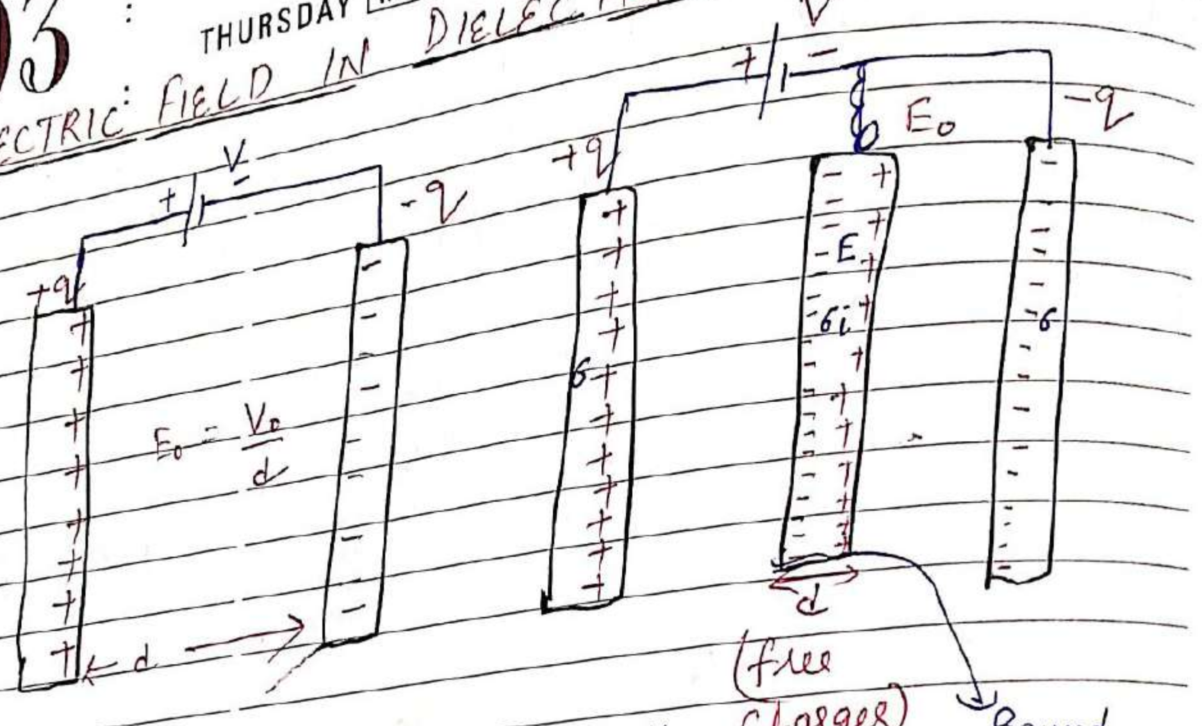
$$\boxed{\alpha = \frac{p}{E_{loc}}}$$

Local field E_{loc} is the field that is actually effective in polarizing the atoms in a solid & is also called molecular field in the dielectric

JUNE 2012							
WK	M	T	W	T	F	S	S
22					1	2	3
23	4	5	6	7	8	9	10
24	11	12	13	14	15	16	17
25	18	19	20	21	22	23	24
26	25	26	27	28	29	30	

Scanned with CamScanner

ELECTRIC FIELD IN DIELECTRIC



(i) If two capacitors are charged to the same potential, the charge on the one containing the dielectric is greater than that of the other.

(ii) If the Capacitors are given the same charge, the pot. difference b/w the plates with dielectric is smaller than that without the dielectric.

$\Rightarrow$ C ↑s when filled with dielectric material.

→ When a Voltage V is applied across ∥ plates of capacitor, Let the charges on one plate be q and on other -q.

$$C = \frac{q}{V}.$$

MAY 2012

WK	M	T	W	T	F	S	S
18		1	2	3	4	5	6
19	7	8	9	10	11	12	13
20	14	15	16	17	18	19	20
21	21	22	23	24	25	26	27
22	28	29	30	31			

→ Consider a $\parallel$ plate capacitor with vaccum in b/w :

$$C_0 = \frac{\epsilon_0 A}{d} = \frac{q}{V_0} \quad ; \quad -(1)$$

A : Area of the plate
d : distance b/w them
ϵ_0 : permitivity of vaccum
V_0 : Pot. diff. b/w plates without dielectric.

If a dielectric material is inserted into the region within the plates, $C_d = \frac{\epsilon A}{d} = \frac{q}{V_d}$. $-(2)$

ϵ → Permitivity of dielectric material, $\epsilon > \epsilon_0$
V_d → Pot. diff. b/w the plates.
C_d → Capacitance with dielectric.

From (1) & (2)

$$\boxed{\frac{C_d}{C_0} = \frac{V_0}{V_d} = K = \frac{\epsilon}{\epsilon_0} = \epsilon_r} \rightarrow \text{Dielectric constt.}$$

→ K is defined as ratio of ~~Cap~~ capacitance of capacitor with dielectric to the ~~capacit~~ capacitance of the same capacitor without dielectric

→ Also the ratio of permitivity of the medium to the permitivity of the vaccum.

→ With vaccum (or air) b/w its plates, E.F. intensity E_0 in the region b/w the plates of a $\parallel$ plate capacitor,

$$E_0 = \frac{V_0}{d} = \frac{\sigma}{\epsilon_0}.$$

8

JUNE 2012

WK	M	T	W	T	F	S	S
22					1	2	3
23	4	5	6	7	8	9	10
24	11	12	13	14	15	16	17
25	18	19	20	21	22	23	24
26	25	26	27	28	29	30	

Scanned with CamScanner

Reduction in pot. diff, when a dielectric is inserted b/w the plates ⇒ Red^n in E.F. ⇒ Redu^n in charge per unit area.

* Redu^n could be caused only by charge of opp. sign appearing on the two surfaces of the dielectric.

Dielectric surface adjacent to the +ve plate must have an induced −ve charge & that adjacent to the −ve plate an induced +ve charge of equal magnitude.

If σ_i is the magnitude of induced charge per unit area on the surfaces of the dielectric,

E.F. with dielectric, $E = \frac{V_d}{d} = \frac{\sigma - \sigma_i}{\varepsilon_0}$

$$K = \frac{C_d}{C_0} = \frac{q/V_d}{q/V_0} = \frac{V_0}{V_d}$$

$$K = \frac{E_0}{E} = \frac{\sigma}{\sigma - \sigma_i}$$

$$\Rightarrow \sigma - \sigma_i = \frac{\sigma}{K}$$

$$\Rightarrow \boxed{E = \frac{\sigma}{\underbrace{K\varepsilon_0}_{\varepsilon}} = \frac{\sigma}{\varepsilon}.}$$

MAY 2012

WK	M	T	W	T	F	S	S
18		1	2	3	4	5	6
19	7	8	9	10	11	12	13
20	14	15	16	17	18	19	20
21	21	22	23	24	25	26	27
22	28	29	30	31			

Scanned with CamScanner