MADE EASY

ELECTRICAL ENGINEERING

Material Science

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- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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MATERIAL SCIENCE

TECHNICAL

PAPER - II

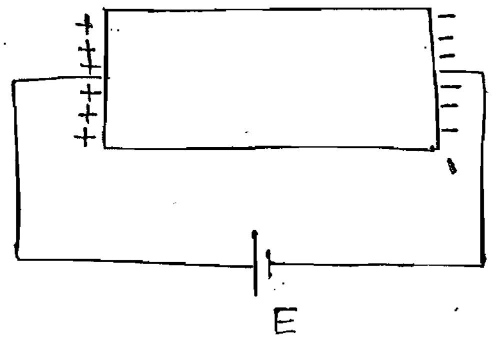
Syllabus.

1. Atomic Structure and Chemical Bonding (GS के Notes page No-3)
2. Crystallography (GS के Notes page No-21)
3. Insulators / Dielectrics
4. Magnetic Properties (GS के Notes page No--82)
5. Conductors (GS के Notes page No - 53)
6. Super Conductors
7. Semiconductors (GS के Notes page No - 60)
8. Ceramics / Composites (GS के Notes page No-97)
9. Nanomaterials.

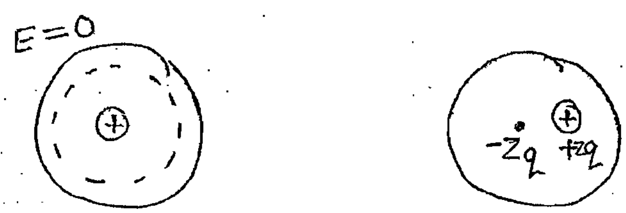
Topics 1, 2, 4, 5, 7, 8 GS- Part मे पढाया है।
Topics 7 (Semiconductors) Electronic वाले बच्चो को पढाया है।
Topics 4, 5 मे कुछ point और Add करवाएगे

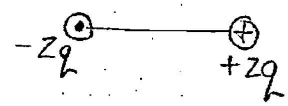
Refer Books
1. Electrical Engineering Materials by S.P. Seth
   ↳ Topic 3, 4, 5, 6

INSULATORS/DIELECTRICS



→ यदि Charge किसी Body पे Uniformly distributed है तो उसका Effect हम Centre पे Consider कर सकते है।





← इस को Polarisation कहते है।

यह Metal मे नही होगा क्योकि वहा पर free Electron होते है।

$$N = \frac{n}{V_c} = \frac{N_A \rho}{A}$$

→ Insulator are generally made of PVC OR Nylon.

→ Insulation और Polarisation मे दोनो एक साथ चाहिए Charge Store करने के लिए Dielectrics की जरूरत होगी।

→ Non-Conducting Material do not have Sufficient free Electron to take part in Electrical Conductivity But these material have abondance of bounded Electrons due to which they get polarised on the application of Electric field.

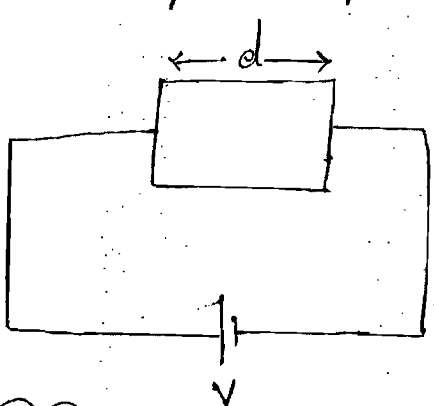
→ The Material which get Easily polarized Under the Influence of Electric field are known as Dielectrics.

→ If the main function of Non-Conducting Material is to provide Electrical Insulation then Material is known as Insulators.

→ If the main function of Non-Conducting Material is Storage Charge then it is known as Dielectrics.

Capacitance

Consider a parallel plate Capacitor.



$$C = \frac{\varepsilon_r \varepsilon_0 A}{d} = \frac{\varepsilon A}{d}$$

C → Capacitance (in Farad)
A → Cross Section area of the plates
d → Distance b/w the plates
ε_0 → Permittivity of free Space or vaccum
$\varepsilon_0 = 8.854 \times 10^{-12}$ F/M

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

ε_r = Relative permittivity OR Dielectric Constant of Material.

ε = Permittivity of Material $\Rightarrow$ $\varepsilon = \varepsilon_r \varepsilon_0$

# Material	ε_r
Vacuum	1
Air	1.0006
Helium	1.0000684
paper	2.0 — 3.0
Teflon	2.1
Fused Quartz	3.8
Nylon	3.5
Bakelite	4.9
Mica	6
Distilled Water	81
TiO_2	100

→ For a Capacitor

$$Q \propto V$$

$$Q = CV$$

→ Energy Stored in a Capacitor

$$W = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}Q \cdot V$$

→ Energy Density

→ Energy Stored per Unit Volume.

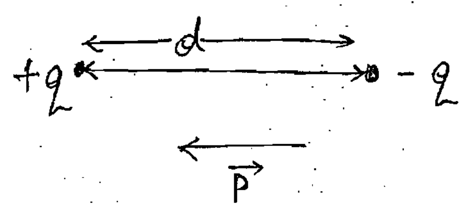
$$D = \varepsilon E$$

D → Electric flux density (C/m^2)
E → Electric field Intensity (V/m)

$$\varepsilon = \frac{D}{E}$$

Electric dipole Moment ($\vec{p}$) (GS के Page 75)

→ Two Equal and opposite charges separated by certain distance constitute an Electric dipole.



Electric dipole Moment ($\vec{p}$)

$$\vec{p} = q \cdot \vec{d}$$

Unit → ① C-m
② Debye

$$1 \text{ Debye} = 3.33 \times 10^{-30} \text{ C-m}$$

$\vec{p}$ → It is a vector Quantity and vector direction is taken from negative charge to positive charge.

→ अगर Atomic no. पे stable है तो Atom
→ अगर Molecule no. पे stable है तो Molecule

Polarisation ($\vec{P}$) (GS के Page-76)

→ It is defined as Electric dipole moment per Unit Volume.

$$\vec{P} = \frac{\text{Electric dipole Moment}}{\text{Volume}}$$

On a Macro-Scopic Scale

N → No. of Electric dipole per Unit Volume.
$\vec{p}$ → Electric dipole moment of Each dipole.

Then

$$\vec{P} = \vec{p} + \vec{p} + \text{---} \quad N \text{ times}$$

$$\vec{P} = N\vec{p}$$

(Acc. to GS part)

N → No. of Molecules per Unit Volume
N·ΔV → No. of Molecules in Volume ΔV.

$$\vec{P} = \frac{1}{\Delta V} \sum_{j=1}^{N \cdot \Delta V} \vec{p_j} = N\vec{p}$$

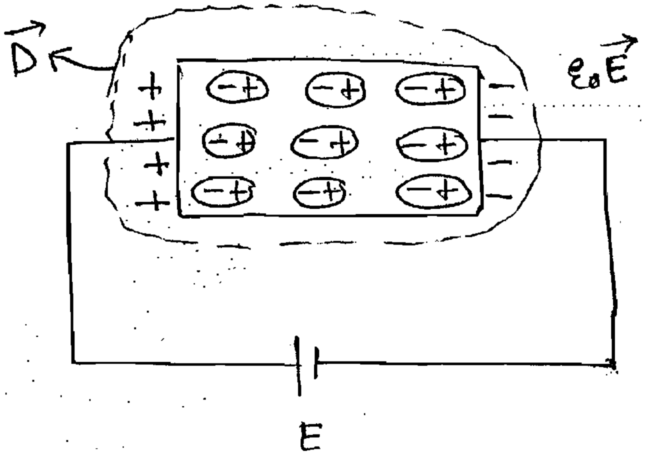
$\vec{p}$ → Electric dipole Moment of Each Molecule

Unit of $\vec{P}$:-

$$= \frac{1}{m^3} \times C\text{-}m$$

$$= \frac{C}{m^2}$$

(8)



→ Total Electric flux density in a dielectric material is due to
  ① → Applied Electric field ($\varepsilon_0 \vec{E}$)
  ② → Polarisation Inside the Material ($\vec{P}$)

i.e., $\vec{D} = \varepsilon_0\vec{E} + \vec{P}$ —① (Acc to Material Science)

but $\vec{D} = \varepsilon_r\varepsilon_0\vec{E}$ —② (Acc. to Physics)

from Eqⁿ(1) & Eqⁿ(2)

$$\vec{P} + \varepsilon_0\vec{E} = \varepsilon_r\varepsilon_0\vec{E}$$

$$P = \varepsilon_r\varepsilon_0\vec{E} - \varepsilon_0\vec{E}$$

$$\vec{P} = \varepsilon_0(\varepsilon_r - 1)\vec{E}$$

$$\vec{P} = \varepsilon_0\chi_e\vec{E}$$

where

$\chi_e = \varepsilon_r - 1$

↳ Electric Susceptibility of Material

$$\chi_e = \frac{P}{\varepsilon_0\vec{E}} = \frac{\text{Bound charge density}}{\text{Free charge density}}$$