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Changing your Tomorrow

DIELECTRICS AND ELECTRIC POLARIZATION,

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 02
CHAPTER NAME : ELECTROSTATIC POTENTIAL AND CAPACITANCE

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LEARNING OUTCOME

After this lesson, students will be able:

- To understand that all sources of charge create an influence or action upon other objects some distance away and that the electric field concept is used to describe that influence.
- To state the mathematical definition of the di electric medium and to describe the dependence of the electric field strength upon the variables that affect it.
- To construct and to interpret electric field line diagrams for charged plates with and without dielectrics.
- To use the electric field equation, Polarisation equation, to analyze physical situations that involve electric fields and to solve physics word problems associated with such situations.

Slide 2

1	@Format for content and slide heading is missing? Just like you have mentioned in DOC., We need to specify, for each slide's heading and text content, what will be the font style +amanrouniyar@odmegroup.org _Assigned to you_ -Swoyan Satyendu , 6/17/2020

REVIEW

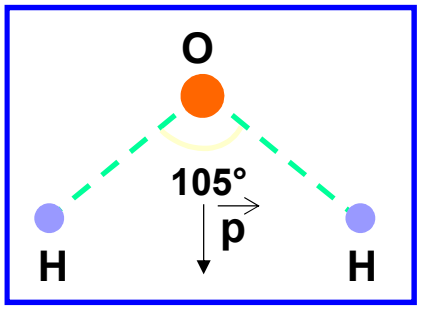
1. What are conductors ?
2. What surface charge density?
3. What is the volume charge?
4. What are charges?

POLAR MOLECULES:

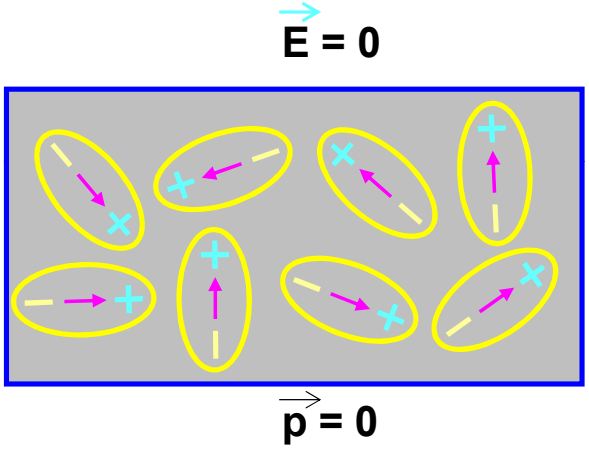
A molecule in which the centre of positive charges does not coincide with the centre of negative charges is called a polar molecule.

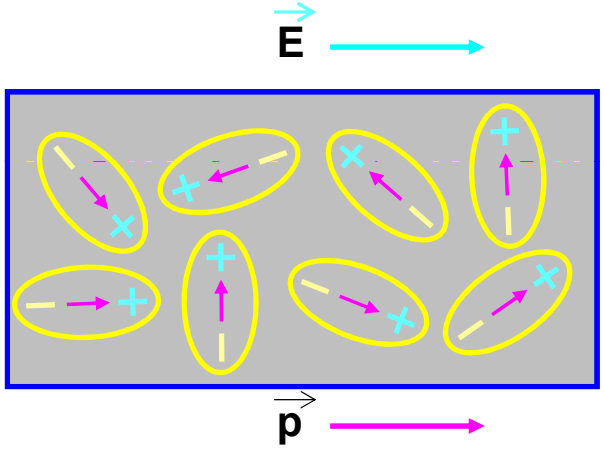
Polar molecule does not have symmetrical shape.

Eg. H Cl, H_2 O, N H_3, C O_2, alcohol, etc.



Effect of Electric Field on Polar Molecules:





NON - POLAR MOLECULES:

A molecule in which the centre of positive charges coincides with the centre of negative charges is called a non-polar molecule.

Non-polar molecule has symmetrical shape.

Eg. N_2 , C H_4, O_2, C_6 H_6, etc.

Effect of Electric Field on Non-polar Molecules:

DIELECTRICS:

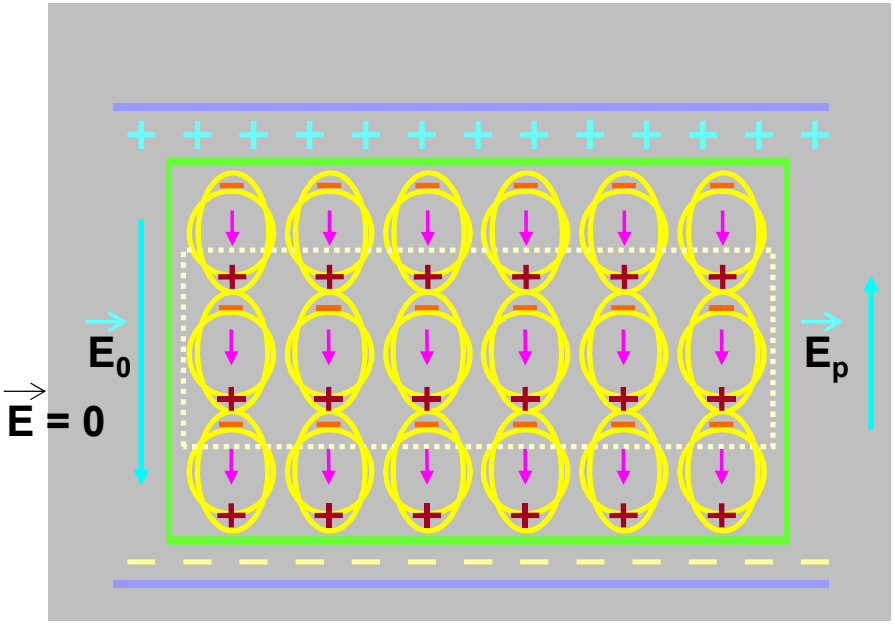
Generally, a non-conducting medium or insulator is called a 'dielectric'.

Precisely, the non-conducting materials in which induced charges are produced on their faces on the application of electric fields are called dielectrics.

Eg. Air, H_2, glass, mica, paraffin wax, transformer oil, etc.

Polarization of Dielectrics:

$$K = \frac{E_0}{E_0 - E_p}$$



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POLARIZATION VECTOR:

$$\vec{P} = n\,\vec{p}$$

SI unit of polarization vector is C m^{-2}.

Dielectric Strength:

Dielectric	Dielectric strength (kV / mm)
Vacuum	∞
Air	0.8 – 1
Porcelain	4 – 8
Pyrex	14
Paper	14 – 16
Rubber	21
Mica	160 – 200

POLARISATION VECTOR OR POLARISATION DENSITY

- Polarisation vector $\vec{P}$ is defined as the total dipole moment induced per unit volume.

  i.e. $\vec{P} = \frac{\vec{P}_{net}}{V}$

- The direction of 'P' is the same as that of the external field.
- Its S.I. unit is Cm^{-2}.

POLARISATION DENSITY AND SURFACE CHARGE DENSITY

The relation between polarization density and induced surface charge density

Suppose a dielectric slab of surface area 'A' and thickness 'd' acquires a surface charge density $\pm\sigma_P$ due to polarization in the electric field and its two faces acquire charges $\pm Q_P$. Then

$\sigma_P = \frac{Q_P}{A}$

We can consider the whole dielectric slab as a large dipole having a dipole moment $Q_P d$. The dipole moment per unit volume or the polarization density will be:-

$$\mathrm{P} = \frac{\text{dipole moment of dielectric}}{\text{volume of dielectric}} = \frac{\mathrm{Q_P d}}{\mathrm{Ad}} = \frac{\mathrm{Q_P}}{\mathrm{A}} = \sigma_P$$

ELECTRIC SUSCEPTIBILITY

- The ratio of the polarization to ϵ_0 times the electric field is called the electric susceptibility of the dielectric.

  i.e. $\chi_e = \frac{P}{\epsilon_0 E}$

- It is a unitless and dimensionless quantity.
- **Physical Significance**

  It describes the electrical behavior of dielectric. The dielectrics with constant χ_e are called linear dielectric.

For vacuum:

Polarisation = 0

Thus $\chi = 0$

DIELECTRIC STRENGTH

The maximum electric field that can exist in a dielectric without causing the breakdown of its insulating property is called the dielectric strength of the material.

Unit:- Vm^{-1}. But the more common practical unit is $(kV)(mm^{-1})$

Note:- For air it is about $3 \text{ x } 10^{6} \text{ Vm}^{-1}$

DIELECTRIC STRENGTH

The relation between dielectric constant and electric susceptibility of the material

$$\Rightarrow K = 1 + \chi_e$$

HOME ASSIGNMENT

1. The dielectric strength of air is 3 x 10^6 V/m. The maximum charge that can be given to a copper sphere of radius 10 cm, placed in air is

   (a) 10/3 μC (b) 10/3 m C (c) 10/3 C (d) 1/3 C

2. If a charge +q is kept in a medium of dielectric constant K, then the charge induced on the surface of cavity of the medium enclosing the charged body is

   (a) $\frac{q}{K}$ (b) $-\frac{q}{K}$ (c) $q\left(1-\frac{1}{K}\right)$ (d) $-q\left(1-\frac{1}{K}\right)$

3. Charges are induced in dielectrics due to

   (a) flow of free electrons from one end to another (b) flow of protons from one end to another

   (c) shift of electrons bound to the nuclii (d) shift of protons bound to the nuclii

4. Define electrical susceptibility . What is its unit ?

5. The dipole moment induced per unit volume in a dielectric is called as .....

THANKING YOU

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