HSST PHYSICS

MODULE 7 : SOLID STATE PHYSICS PART 2

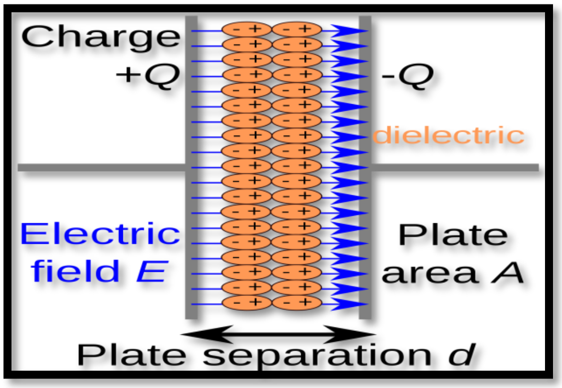
Dielectric constant

- A dielectric is a material which has poor electrical conductivity but inherits an ability to store an electrical charge. Thus exhibiting only displacement current making it ideal to build a capacitor to store and return electrical energy.
- Dielectric materials include some solids such as glass, porcelain etc, liquids such as chemically pure water, methyl chloride etc, and gases such as hydrogen, nitrogen, ammonia etc..
- A dielectric is called homogeneous and isotropic if all its properties are the same at any point and in all directions inside it.
- The dielectric constant of a substance can be defined as the ratio of the permittivity of the substance to the permittivity of the free space.
- If in the absence of an external electric field the centres of mass of the positive and negative charges in a molecule of a dielectric coincide, it is called **non-polar**. On the other hand, the nuclei and electrons in the molecules of polar dielectrics are arranged in such a way that the centres of mass of the positive and negative charges do not coincide, such molecules, regardless of the external electric field behave like **rigid dipoles**.

Dielectric constant and its measurement

Dielectric constant also known as permittivity of the medium is a measure of the degree to which a medium can resist the flow of charge. It is defined as the ratio for the electric displacement D to the electric field intensity E. $\varepsilon = \frac{D}{E} = \varepsilon_r \varepsilon_0$

ε_r is the relative permittivity of the medium ε_0 : Permittivity of free space.



The above Figure shows a simple experiment setup for measuring dielectric constant. The plates of a capacitor are connected to a battery which charges them. In the absence of a dielectric inside the capacitor, the field produced by the charges is E_0 which can be determined by measuring the potential difference V_0 across the capacitor using the relation,

$E_0 = \frac{V0}{L}$ …………(1)

where L is the distance between the plates.

When a dielectric slab is introduced between the plates, the field E_0 polarizes the medium, which in turn modifies the field to a new value E. Like wise, this field can be determined by measuring the new potential difference V across the capacitor using the relation ;

$E = \frac{V}{L}$……………(2)

The dielectric constant in terms of the fields E_0 and E is given by the relation

$\varepsilon_r = \frac{E0}{E}$

From eqn 1 and 2 $\varepsilon_r = \frac{V0}{V}$…………(3)

We can thus obtain the dielectric constant by measuring the potential differences across the capacitor with and without a dielectric and taking their ratio as in eqn (3)

Similarly, it can be shown that the dielectric constant can also be obtained by measuring the capacities of condenser with and without a dielectric and taking their ratio as ;

$$\varepsilon_r = \frac{C}{C0}$$

Where C_0 and C are the capacities in the absence and presence of a dielectric respectively.

Further, we know that the capacity of a parallel plate condenser is defined as the ratio for the charge Q on either plate to the potential difference between the plates as:

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

Or

Q = CV