UNIT 5 | CHAPTER 19-21

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Electricity :-

Electrostatic :-

↳ The branch of physics which deals with electricity at rest is called electrostatic.

Electric Charge :-

↳ The physical property of matter which causes it to experience a force when placed in an electromagnetic field is called electric charge. It's SI unit is Coulomb.

★ properties of Charge :-

i) like charges repel where as unlike charges attract each other.

ii) Electric charge are quantized.

i.e. $q = ne$

Where, $n = 1, 2, 3, \cdots$

$e = 1.6 \times 10^{-19} C$ (charge of electron)

iii) Electric charge is a scalar quantity.

iv) Electric charge is a conserved quantity.

v) The magnitude of charge on a body is not affected by the speed of the body.

Electrostatic Induction :-

↳ When a charge body is brought near uncharged body equal and opposite charged induced at near ends but similar charge induced at far end such a process is known as electrostatic induction. Charge at near end are bound charge and charge at free end are called free charge.

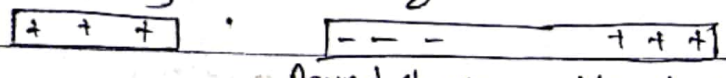
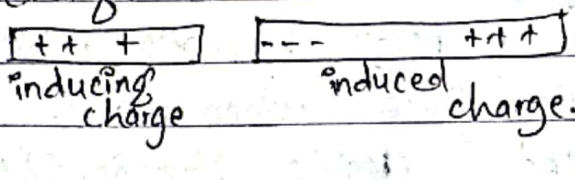


Fig :- Electrostatic induction

Induced Charge and inducing Charge:-

↳ Two kinds of charge that appears on two ends of Conductors due to induction are called induced charge but the charge present in charge body which causes the other body to be changed are called inducing charge.



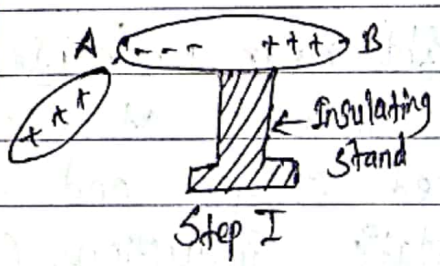
Note:⇒ positive charge can be developed when glass rod rubbed with silk.

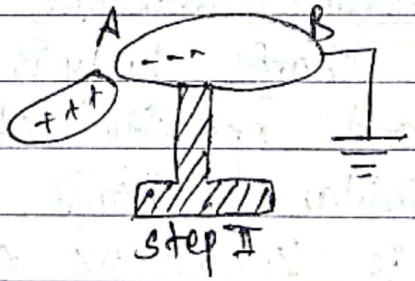
⇒ Negative charge can be developed when rubber rod rubbed with cloth or wool.

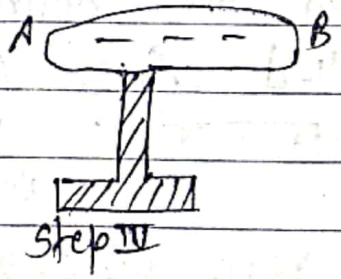
Charging of a body by electrostatic induction:-

@ Charging of a body negatively by induction:-

↳ To change a body negatively by induction a glass rod rubbed with silk brought near to it. During the charging of a body negatively by induction following steps should be done.







Step I:-

↳ Suppose an uncharged body AB is is fitted on an insulating stand. If a positively charged glass rod brought near to uncharged body AB then end A acquires negative charge. while end B acquires positive charges as shown in figure. (a).

Step II:-

↳ Now end B of the uncharged body AB is earthed with the help of metal wire. Hence charge at B are moves to earth as shown in figure (b).

Step III:-

↳ Now the earthing is removed keeping glass rod still ing initial position then only negative charge remains on a Conductor as shown in figure. (c).

Step IV:-

↳ Finally, the positively charge glass rod removed away from AB and negatively charge spread over the Conductor as shown in figure.

In this way, we can charge a body negatively by induction.

(b) Charging of a body positively by induction:-

↳ To charge a body positively by induction a rubber rod rubbed with cloth or wool brought near to it. During the charging of a body positively by induction following steps should be done.

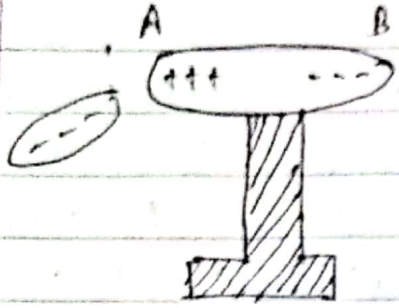
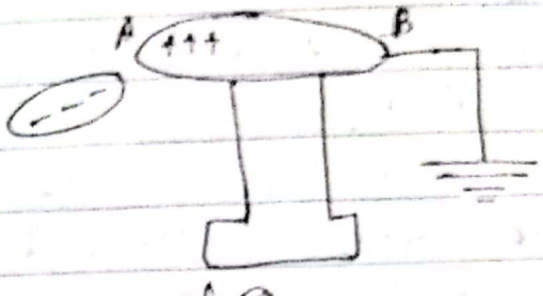


fig ⓐ



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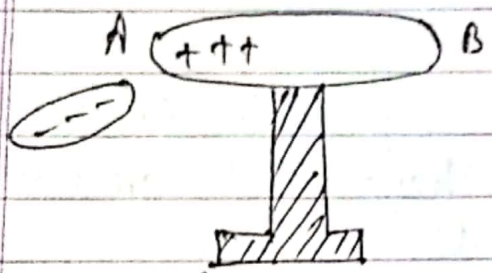

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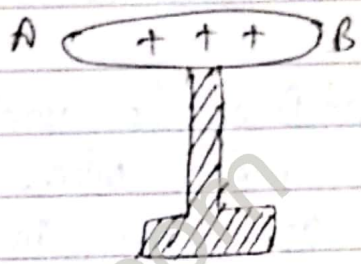

fig ⓓ

Step I:-

↳ Suppose an uncharged body AB is fitted on an insulating stand. If a negatively charged rubber rod brought near to uncharged body AB then end A acquires positive charge while end B acquires negative charge as shown in fig ⓐ.

Step II:-

↳ Now end B of the uncharged body AB is earthed with the help of metal wire. Hence charge at end B are moves to earth as shown in figure ⓑ.

Step III:-

↳ Now, the earthing is removed keeping rubber rod still in initial position taken only positive charge remains on conductor AB as shown in fig ⓒ.

Step IV:-

↳ Finally, the negatively charged rubber rod removed away

from AB and positive charge spread over the conductor as shown in figure ④.

In this way, we can charge a body positively by induction.

Coulomb's Law:-

The force of attraction or repulsion between two electric charge is,

i) directly proportional to the product of their magnitude & ii) inversely proportional to the square of the distance between them.

* derivation:-

↳ Let us consider two charges q_1 & q_2 are separated by distance 'r' as shown in figure. Then according to Coulomb's law, the force experienced by them is given by:

fig: Coulomb's law.

$$F \propto q_1 q_2 \quad \text{---(i)}$$

$$F \propto \frac{1}{r^2} \quad \text{---(ii)}$$

Combining eq^n(i) & eq^n(ii)

$$\Rightarrow F \propto \frac{q_1 q_2}{r^2}$$

$$\therefore F = \frac{K q_1 q_2}{r^2} \quad \text{---(iii)}$$

Where, K is a proportionality Constant, Whose Value depends on the nature of the medium and the system of unit chosen.

* Special Cases:-

Case(a): In SI System:-

i) For air medium: $K = \frac{1}{4\pi\epsilon_0} = 9\times10^9\ Nm^2/C^2$

Where, $\epsilon_0 = 8.85\times10^{-12}\ C^2/Nm^2$ is called the permittivity of free space or vaccum.

With this value eqn (iii) becomes;

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2} \quad \text{---(iv)}$$

ii) For medium (other than air):-

$$K = \frac{1}{4\pi\epsilon}$$

Where, ϵ is permittivity of the medium.

With this value eqn (iii) becomes

$$F = \frac{1}{4\pi\epsilon}\frac{q_1q_2}{r^2} \quad \text{---(v)}$$

Case(b):-

↳ In CGS system and air medium, $K = 1$ with this value eqn (iii) becomes,

$$F = \frac{q_1q_2}{r^2} \quad \text{---(vi)}$$

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Relative permittivity:-

↳ The permittivity of any medium with respect to permittivity of the free space (or vaccum) is called relative permittivity of that medium. It is denoted by ϵ_r and is given by;

$$\epsilon_r = \frac{\text{permittivity of medium}}{\text{permittivity of free space}}$$

$$\therefore \epsilon_r = \frac{\epsilon}{\epsilon_0}$$

The relative permittivity of the medium is also known as the dielectric Constant of the medium. It is denoted by K.

$$K = \epsilon_r = \frac{\epsilon}{\epsilon_0}$$

Thus, For S.I. System and in the medium other than air

$$F = \frac{1}{4\pi\epsilon_0\epsilon_r}\frac{q_1 q_2}{r^2}$$

or,
$$\boxed{F = \frac{1}{4\pi\epsilon_0 K}\frac{q_1 q_2}{r^2}}$$

permittivity:-

↳ The ability of a medium to pass the electric charge through that medium is called permittivity of that medium.

Electric field:-

↳ The space around the electric charge where the electric force of attraction or repulsion exists is called electric field.

Test Charge:-

↳ The positive charge having unit magnitude is taken as test charge in electrostatics. It is denoted by q_0.

i.e. $\boxed{q_0 = \pm 1\ C}$