# Electric CHARGE

chapter - 19,

Electrostatics → Electro (charge)
→ Statics (Rest)

* Electrostatics is the branch of physics that deals with the study of charge at rest, the force, electrifield, the potential due to the charge.

* Electric charge :- Electric charge is the properties associated with matter due to which it produces an expirences electrical & magnetic effects.
  - The concept of charge is due to the transfer of electron.

It is given by Benjamin franklin
  - There are two types of charge

(i) Positive charge :- It is dificency of electron as campared to protons in an atoms.

(ii) Negative charge :- It is excess of electron as campared to protons in an atoms.

⇒ The S.I unit of charge is Coulomb (C) & C.G.S unit is stat. Coulomb / e.s.u / franklin.

⇒ 1 coulomb = $3 \times 10^9$ e.s.u
1 faraday = 96500 coulomb.

$M_p = 1837 \, m_e$

* Dimension of charge

$$(I) \text{ current} = \frac{d(q) \text{ charge}}{d(t) \text{ time}}$$

$$\text{or } [A] = \frac{[Q]}{[t]}$$

$$\text{or } [Q] = [At]$$

# Properties of charge :-

(i) charge is the Scalar quantity.
(ii) Charge is transferable.
(iii) Like charges repeal while unlike charges attract eachothers.
(iv) Charge at rest produces electric field, At uniform motion produces electric field & magnetic field, At non-uniform motion electric field & magnetic field & electromagnetic radaition.
(v) charges is always conserve
(vi) Quantization of charge :-

It State that "The total amount of charge on any objects is integral multiple of an electronic charge."

Mathmatically,

$q = \pm ne$ where, n = (+ve integers for ex 1,2,3....

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

vii Charge is always associated with mass

mass of 1 charge $M_e = 9 \times 10^{-31}$ kg.



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Q which of the chare isn't possible.

(a) $1.6 \times 10^{-19}$ C

$q = \pm ne$

$1.6 \times 10^{-19} = \pm n \times 1.6 \times 10^{-19}$

n=1 possible

(b) $1.6 \times 10^{-18}$ C

$q = \pm ne$

$1.6 \times 10^{-18} = \pm n \times 1.6 \times 10^{-19}$

n=10 possible

(c) $1.6 \times 10^{-21}$ C

Soln

$q = \pm ne$

$1.6 \times 10^{-21} = \pm n \times 1.6 \times 10^{-19}$

n = 0.01 Impossible X

⇒ Charging / Electrification

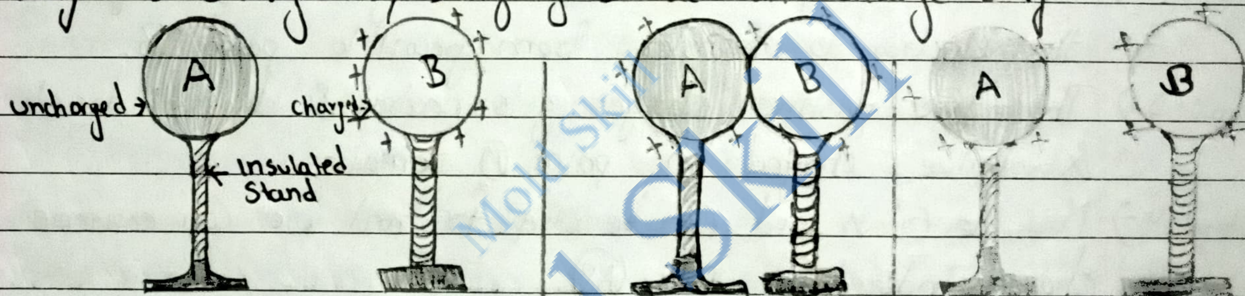
It is the process in which charge is developed in any neutral body.

- This process can be done by 3 ways:

① Charging by frication:- In friction when two bodies are rubbed then the ~~electron~~ transfer of electron from one body to another.

- The body having low value of work ~~friction~~ function becomes positively charge while body having high value of work function becomes negitively charge.

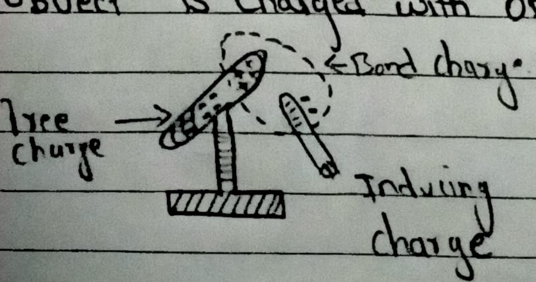
⑪ Charging by Contact :- It is the process In which an uncharged body is charged by bringing contact with charge body.




Step-I Step-II Step-III

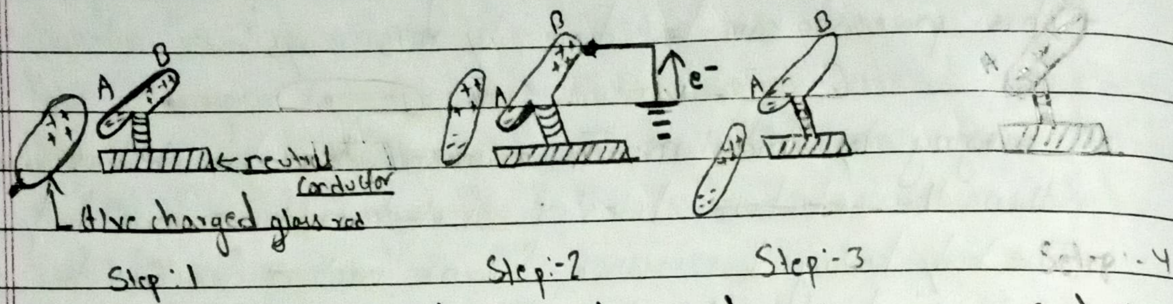
⇒ Let us consider two body A & B In Isolated location. where A is uncharged & B is positively charged. to prove Charging by Contact lets make contact between A & B as shown in the figure (step-II) after all if we Separte both from physical Contact we can observe that now, both are positively Charged with equal value.

⑪ Charging by Induction:- It is the process In which an uncharged object is charged with opposite charge without any actual contact.




N.P.--

- Charging a conductor Negatively. ($\bar{}$ ve)



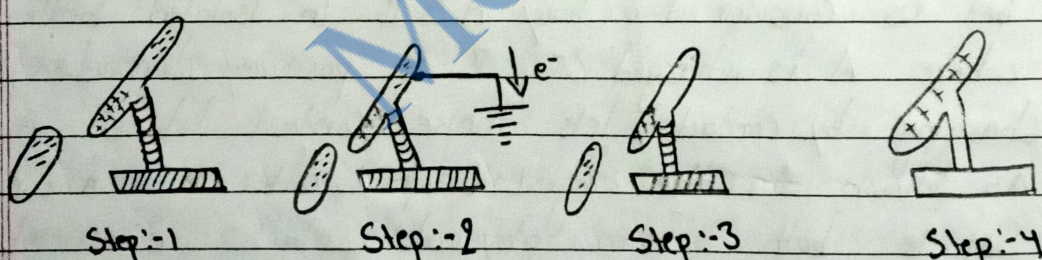

Step-1 ⇒ Take a positively charged glass rod and bring it near a Conducting material isolated from the earth. (AB) after that, Point Ⓐ of the body acquires bond negatively charged & end of point B acquired free positive charge.

Step:-2 ⇒ The end of point B needs to be grounded (earthing). which tends the electron to transfer from ground to point B.

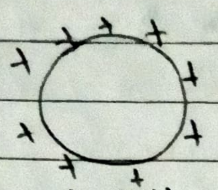
Step:-3 ⇒ The free positive charge gets neutral & disapper due to electron. & Induce charged in point Ⓐ remains.

Step:-4 ⇒ Now, Glass rod can be kept for and we can expirence negative charge induced in Body (AB)

- Charging a conductor positively (+ ve)



# Distribution of charge:- One of the main properties of the charge is that it residue (stay) on the outersurface of a charged conductor. This is due to fact that the charges on a conductor always tries to minimize the force of repulsion. It is only possible at the farthest distance (i.e outersurface)



uniform distribution of charge.

# charge density. It is the accumlation of charge on a particular surface of a conductor. there are three types of charge density

(i) linear charge density :- ($\lambda$) It is the total number of charge per unit by lenth. It means $\lambda = \frac{q\,(\text{colomb})}{l\,(\text{lenth})}$ = SI = C/m

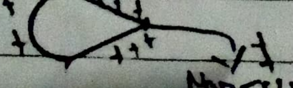
(ii) Surface charge density ($\sigma$) :- It is the total number of charge per unit by surface area $\sigma = \frac{q\,(\text{colomb})}{A\,(\text{Area})}$ = S.I = $C/m^2$

(iii) Volume charge density ($\rho$) = It is the total number of charge per unit by Volume $\rho = \frac{q\,(\text{coulomb})}{V\,(\text{Volume})}$ = $C/m^3$

# Action of points :-

for spherical conductor: $\sigma = \frac{q}{A} = \frac{q}{4\pi r^2}$ ---- (1)

from eqn (1) $\sigma \propto \frac{1}{r^2}$ :- More charge is concentrated at the pointed end of a charged conductor. because of having small value of radius of curvature the charged is leaked from the pointed ends as a result. the action of loosing of charge from a pointed end of a charged conductors is known as action of point.



leaking of charge

action point.

Non-unifor distribution of charge.

Epsilon not $\epsilon^{\circ}$

classmate

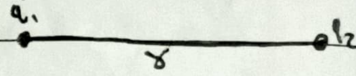
Date

Page

# Columb's law :- It state that the force of attraction or repulsion between any two rest charged seperateds at a finite distance is ① directly proportion to the product of the charges

$F \propto q_1 q_2$ —— ①


⑪ Inversly proportion to the square of between the distance of charges $F \propto 1/r^2$ —— ⑪




Combinging eqⁿ ① & ⑪

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

or, $F = K \frac{q_1 q_2}{r^2}$ wher K is constant (colomb's constant) (iii)

Effect of medium

① For air / vaccum

from eqⁿ (iii)

$F = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2}$ where Epsilon-not is the permitivity of air/vaccum which is $8.85 \times 10^{-12}\ N^{-1} m^{-2} C^{+2}$

then, $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\ Nm^2 C^{-2}$ therfore, $F_{air} = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2}$ —— (iv)



⑪ For any medium

$F_{medium} = \frac{1}{4\pi\epsilon} \times \frac{q_1 q_2}{r^2}$ where Epsilon is the permitivity of medium

The relative permitivy of a medium ($\epsilon_r$) of a melium is defined as the ratio of permitivity of medium to the permitivity of air. It is also known as dielectric Constant (K)

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

Then force becomes $F_{medium} = \frac{1}{4\pi\epsilon} \times \frac{q_1 q_2}{r^2}$ —— (v)

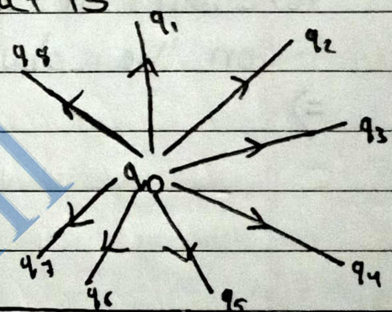
Dividing eq^n ① by iv.

$$\frac{F_{medium}}{F_{air}} = \frac{1}{\varepsilon_r}$$

$$\varepsilon_r = \frac{F_{air}}{F_{medium}}$$

The relative permitivity of a medium is also defined as the ratio of force expirenced by charge in air to the force experinced in a medium. The value of Epsilon (n) ($\varepsilon_r$/(K)) is 1 for air & 80 for water.

# Superposition Principle :- It states that "The force expirenced by a given charge is the vector sum of the forces exerted on it due to all the other charges that is




$$\vec{F_0} = \vec{F_{01}} + \vec{F_{02}} + \vec{F_{03}} + \dots F_{08}$$ where,

$\vec{F_0}$ is the force expirenced by $q_0$.

if there is 'n' of charges, $\vec{F_0} = \vec{F_{01}} + \vec{F_{02}} + \dots \vec{F_{0n}}$

⇒ if there are two vectors $\vec{A}$ & $\vec{B}$ Inclined at angle θ then resultant $\vec{R} = \sqrt{\vec{A}^2 + \vec{B}^2 + 2\vec{A}\vec{B}.\cos\theta}$

$F_{01}$ → force expirenced by $q_0$ due to $q_1$

of less than $10^{-15}$ m

only valid for inverse square.

Concept Based problems.

19.20

(a) Define quantization of charge?

=> The total number of charge on any object is integral multiple of an electronic charge.

(b) Can a body have a chargeless than $1.6 \times 10^{-19}$ C?

=> Yes, A body can have a chargeless than $1.6 \times 10^{-19}$ because ~~these~~

(c) when an object is rubbed with another object the charge developed on the object is 32 μC. Calculate the no. of electron transferred.

=> Here,

Charge developed $Q = 32\ \mu C = 32 \times 10^{-6}$ C

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

no. of electron (n) = ?

from quantization of charge $Q = \pm ne$,

or $32 \times 10^{-6} = \pm n \times 1.6 \times 10^{-19}$

or $\frac{32 \times 10^{-6}}{1.6 \times 10^{-19}} = \pm n$

or, $20 \times 10^{13} = n$

$\therefore n = 2 \times 10^{14}$



9.21 (a) write down the different method charging a body?

=> Some method of charging a body are:-

(i) By friction

(ii) By physical Contact

(iii) By Induction

(b) Repulsion is sure test for testing the electric charge. Explain.
⇒ Repulsion is sure test for testing the electric charge because repulsion can be observed only when two bodies have like charge & which assure that body is charged.

(c) What are the difference between the method of charging by conduction & induction.
⇒ The differences between method of charging by conduction & induction :-

| | Conduction | Induction. |
|---|---|---|
| (i) | For the eletrification bodies should must be in physical contact | For the electrification bodies aren't kept in physical contact |
| (ii) | Like charge are ~~taken~~ ~~to~~ & can be expirenced | Like charge isn't possible in both bodies, for ex:- Positive body should be taken to charg body negative |
| (iii) | Amount of charges decreases due to distribution of charge | Amount of charge remain constant. |



19.22 (a) Distinguish between banded charge & free charge.
→ The Differences between bounded charge & free charge.

| Comparison | Banded charge | Free charge. |
|---|---|---|
| Defination | The charge which are induced in a body closed to the inducing charge are called banded charge. | The charges which are induced in the body far from the inducing charge are called free charge |
| Energy. | Energy possed by a bounded charge are both potential & kinetic energy | Energy posse by a free charge is kinetic energy. |

(b) How should you charge a body positively by the method of induction
=> we can charge a body positively by the method of induction by inducing negatively charged body to another conductor.

.23 (a) Define linear charge density, Surface charge density & Volume charge density.
=> Linear charge density ($\lambda$):- It is the quantity of charge per unit by length $\lambda = \frac{q}{l} = Cm^{-1}$

Surface charge density ($\sigma$): It is the quantity of charge per unit by Surface area $\sigma = \frac{q}{l^2} = Cm^{-2}$

Volume charge density ($\rho$): It is the quantity of charge per unit by Volume by Volume $\rho = \frac{q}{l^3} = Cm^{-3}$.

(b) why pointed end are avoided in electrical machine?
=> Pointed end are avoided in a electrical machine because more electric charge is concentrated at the corner (point which have small value of radius of curvature since $\sigma \propto r^2$,



19.24 (a) Define Surface density & and write down its unit
=> Surface density $\sigma$ is the quantity of charge per unit by surface area. it unit $\sigma = \frac{q}{l^2} = Cm^{-2}$,,

(b) More charge can be stored on metal if it is highly polished Then when its Surface is rough?
=> As we know chance of leakage of charges (Action of point) is highly at sharp edge & there are number of sharp edge on rough surface but if metal is highly polished it doesn't have sharp edge to leak charge. Hence more charge can be stored on metal if it is highly polished.

© Define the term action of point
=) The point from which charge can easily leak from the Conductor due to high Concentration of electric charge is called action of point. It basically occur at sharp edges.

19.25 ⓐ State Coulomb's law in electrostatics.
=) Coulomb's law state that the force of attraction or repulsion between two charged seprated at a fine distance is directly proportional to product of their charges & inversely proportional to the square of the distance of charges.

ⓑ Differentiate between electrostatic force & gravitational force.
=) Differences between electrostatic force & gravitational force.

| Comparison | Electrostatic force | Gravitational Force. |
|---|---|---|
| Statement | The force of attraction or repulsion between two charges separated at a fine distance is directly proportional to product of their charges & inversely proportional to the square of their distances. | The force of attraction of any two bodies having mass is directly proportional to the product of their masses & inversely proportional to the square of the distances between their centre. |
| Constant | Electrostatic force depends upon as Coulomb's constant $\frac{1}{4\pi\epsilon_0}$ | Gravitational force depends on Gravitational Constant $G = 6.67 \times 10^{-11}$. |
| Unit | The unit of electrostatic force. B | The unit of Gravitational force. |