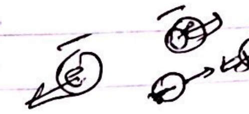
Electrostatics

Friday
1 May 2020

The branch of Physics which deals with the study of static charges (charges at rest), force, electric field, potentials due to these charges is called Electrostatics.

When these charges moves then electricity produces which is called frictional or static electricity.

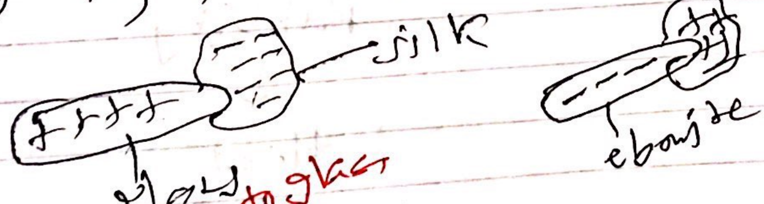
History



charge:— It is intrinsic or inherent property of elementary particles which gives rise to electric force b/w them.

600 BC, Thales of Miletus

Amber — yellow resinous sap
attract dry leaves, ~~dust~~ dust



Pertaining to glass
H.W.

glass ⊕ vitreous	⊖ Amber (resinous)
glass	Amber
Fur	silk
	ebonite

(Du-fay) kinds

Benjamin Franklin American

⊕, ⊖

Properties of charges

1. like charges repel each other.
2. unlike " attracts
3. charges are additive in nature.

Net charge

$= 10 - 7$

$= +3$

4. charges are conserved.
5. charges are quantized

Nature = (Discrete)

Why transfer of charges

Rubbing

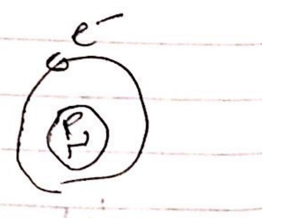
↓

Heat

↓

Energy

↓



Transfer of e^-

work function (ϕ_0, W_0)

The minimum amount of energy needed to liberate or emits out an e^- from a body is called work function.

$E = h\nu$ → freq.
↓ Planck's constant

∴ work function,

$$\phi_0 = W_0 = h\nu_0 = \frac{hc}{\lambda_0} \quad [c = \nu\lambda]$$

ν_0 → Threshold freq.
λ_0 → Threshold wavelength (max.)

① $\phi_0 \propto \nu_0$ (min.)

② $\phi_0 \propto \frac{1}{\lambda_0}$ (max.)

unit — Joules (J)
(electrovolt)

$1\,eV = \frac{J}{e} = \frac{J}{1.6 \times 10^{-19}\,C}$

$J = eV \times 1.6 \times 10^{-19}\,C$

Q6

	metal A	metal B
ϕ_0	2 eV	5 eV

where Threshold freq. and wavelength is max.,

① Th. freq.

$\phi_0 = h\nu_0$
$\phi_0 \propto \nu_0$
$\phi_{0B} > \phi_{0A}$
∴ $\nu_{0B} > \nu_{0A}$
or metal B.

λ_0

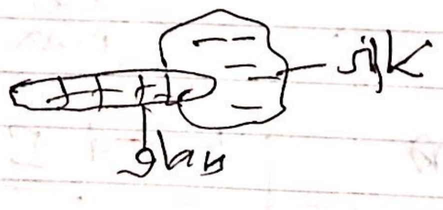
$\phi_0 \propto \frac{1}{\lambda_0}$
$\phi_{0A} < \phi_{0B}$
∴ $\lambda_{0A} > \lambda_{0B}$
or metal A

Applications of electrostatics (H.W.)

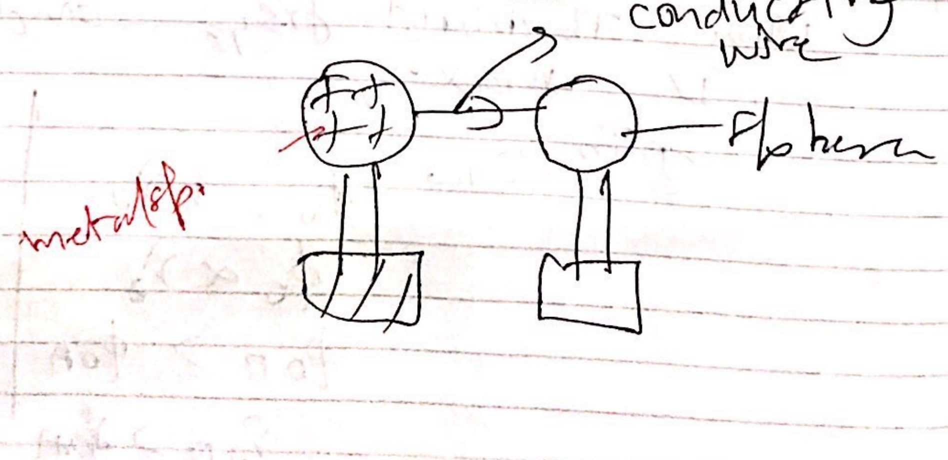
1. capacitors.
2. Van-de graff generator
   accelerates charge particles.
3. Polution control by electrostatic precipitation of fly ash
4. spray painting.
5. Photo copy machine.

Methods of charging

1. friction

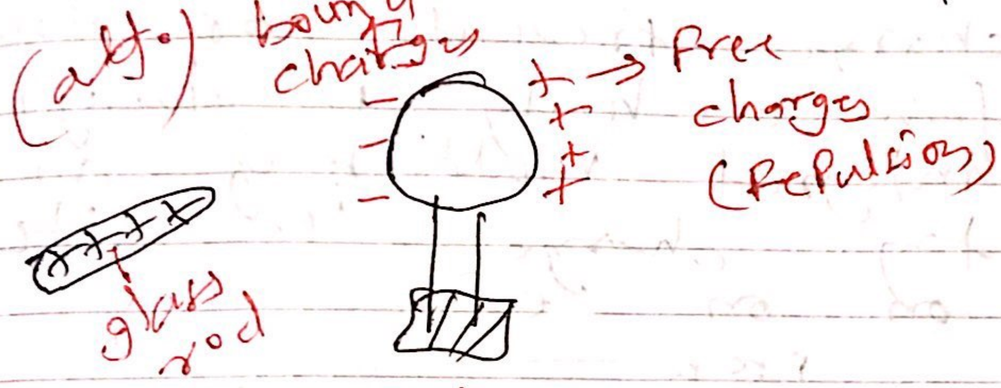


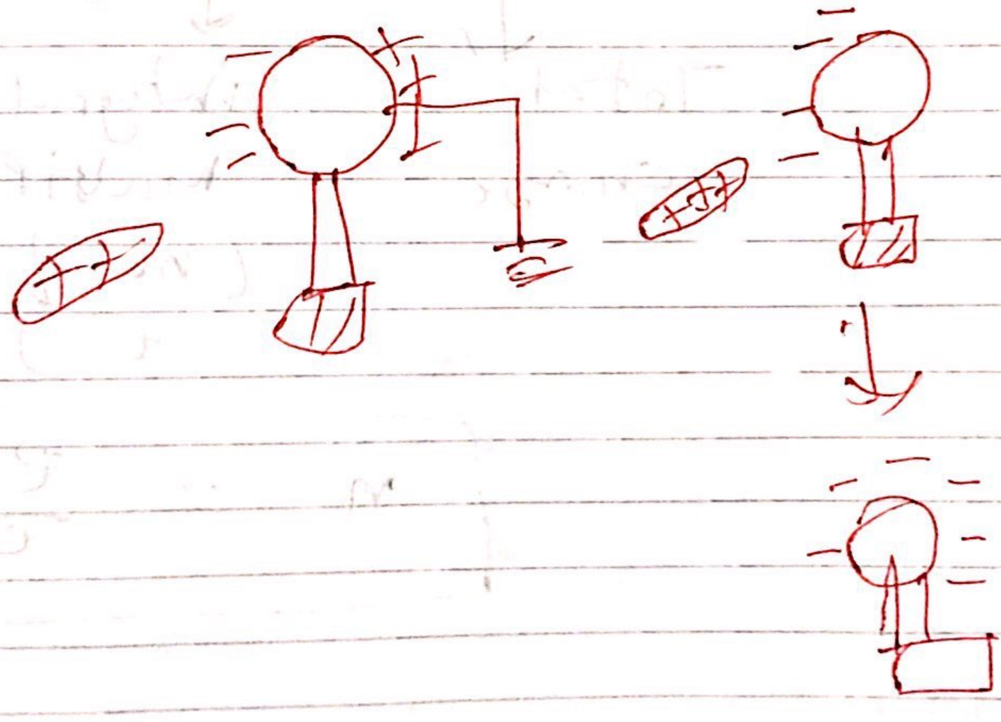
2. conduction



③ Induction

charging a body without actual direct Physical contact is called induction.





Scanned with CamScanner

quantisation Principle

It tells us about the discrete nature of charge. It states that, the total charge present or transferred from a body is always an integral multiple of an elementary charge i.e. the charge on an e^-.

i.e.

$$Q = \pm ne$$

Q → Total charge

n → integral multiple (no. of e^-)

e → charge on an e^-

$$n = \frac{Q}{e}$$

Nature of charge

(1) Microscopic view

(Discrete)

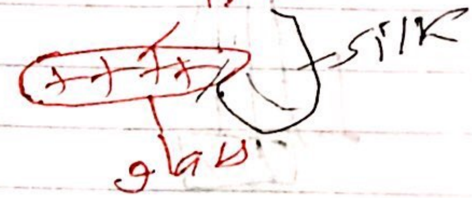
quantisation principle

$q = \pm ne$

(2) Macroscopic view

(continuous)

$1\mu C$



$q = ne$

$n = \frac{q}{e}$

$n = \frac{1\mu C}{e}$

$= \frac{1\times10^{-6}\,C}{1.6\times10^{-19}\,C}$

$n = 6.25 \times 10^{12}\ e^-$

Charge density

① 1-Dimensional

Linear charge distribution

Linear charge density $= \frac{\text{charge}}{\text{length}}$

$\lambda = \frac{q}{L}$, $\frac{C}{m}$, $C\text{-}m^{-1}$

Ex:—

① Rod

② Ring

$L = 2\pi R$

$\lambda = \frac{q}{2\pi R}$

② 2-D

Surface or area charge density

$= \frac{\text{charge}}{\text{area}}$

$\sigma = \frac{q}{S} = \frac{q}{A}$

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

$= C\text{-}m^{-2}$

Ex:—

① sp. shell

② Hollow sp.

cone

cylinder

$\sigma = \frac{q}{4\pi R^2}$

③ 3-D

Vol. charge density

$= \frac{q}{\text{vol.}}$

$\rho = \frac{q}{V}$

$= C\text{-}m^{-3}$

Solid sp.

" " cone

cylinder

cube

cuboid

$\rho = \frac{q}{\frac{4}{3}\pi R^3}$

H.W.: Quantisation Nums

Electric charges, Force — quantisation

1 – Which is bigger – a coulomb or a charge on an electron? How many electronic charges form one coulomb of charge? [$n = 6.25 \times 10^{18}$]

2 – A comb drawn through person's hair on a dry day causes $10^{22}\, e^-$ to leave the person's hair and stick to the comb. Calculate the charge carried by the comb. [-1.6×10^{3} C]

3 – If a body gives out $10^9\, e^-$ per second, how much time is required to get a total charge of 1 C from it? [$q = ne$ (in 1 sec.), 6.25×10^{9} s, 198.18 years]

4 – How much positive and negative charge is there in a cup of water? [Let, $m = 250$ g; molecular mass $(M) = 18$ g, $n = \frac{N_A}{M} \times m = 8.36 \times 10^{24}$; one molecule of H_2O contains $= 2 + 8 = 10\, e^-$ or 10 protons, ∴ Total no. of e^- $n' = n \times 10$, $q = n'e = 1.33 \times 10^{7}$ C]

5 – How many e^- would be removed from a copper penny to leave it with a +ive charge of 10^{-7} C? [$6.25 \times 10^{11}\, e^-$]

6 – Calculate the charge on (i) alpha particle (ii) ${}^{56}_{26}Fe$ nucleus
[(i) $q = +2e$; 3.2×10^{-19} C (ii) 4.16×10^{-18} C]

7 – Determine total charge on 75 kg of e^-. [$n = \frac{\text{Total mass}}{\text{mass of one } e^-} = \frac{25}{3} \times 10^{31}$ & $q = -1.33 \times 10^{13}$ C]

8 – How many mega coulombs of positive (or negative) charge are present in 2 mole of neutral H_2 gas. [No. of molecules in 2 mole of H_2 gas $= 2 \times N_A = 2 \times 6.02 \times 10^{23}$, as each H_2 molecule contains $2\, e^-$/protons ∴ $n = 2 \times 2 \times 6.02 \times 10^{23}$; $q = ne = 0.3853 \times 10^{6}$ C $= 0.3853$ MC]

9 – Two bodies A and B carry charges $-3\,\mu C$ and $-0.44\,\mu C$. How many e^- should be transferred from A to B so that they acquire equal charges? [$q_A = q_B$; $-3 + ne = -0.44 - ne$, $n = 0.8 \times 10^{13} = 8 \times 10^{12}$]

10 – A copper sphere of mass 2 g contains nearly 2×10^{22} atoms. The charge on the nucleus of each atom is $29\,e$. What fraction of the e^- must be removed from the sphere to give it a charge of $2\,\mu C$? [Total no. of $e^- = 29 \times 2 \times 10^{22}$, no. of e^- removed $= \frac{q}{e} = 1.25 \times 10^{13}$, fraction $= \frac{n}{\text{Total no. of } e^-}$; fraction $= 2.16 \times 10^{-11}$]

11 – Two pieces of Cu, each weighing 0.01 kg are placed at a distance of 0.1 m from each other. One e^- per 1000 atoms of one piece is transferred to other piece of Cu. What will be the coulomb force between two pieces after the transfer of e^-s. Atomic wt. of Cu is 63.5 g/g mole. Avogadro's No. $= 6.02 \times 10^{23}$/g mole. [No. of atoms $= \frac{N_A \times 10}{At. wt.} = 9.45 \times 10^{22}$; $n = 9.45 \times 10^{22}/1000$, $q_1 = q_2 = \pm ne$, $F = 2.06 \times 10^{14}$ N]