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Electricity

Electricity :- It is the branch of Physics that deals with the study of electric charge and its relative properties like electric force, electric field, electric potential, electric flux.

Study of charge → electricity.

Charge at rest.

Static electricity
Electrostatics
- Coulomb's law
Electric field
Electric Potential
Electric flux & Gauss law.
Capacitor

Charge in motion
Current electricity

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- It is measured by a device called physical balance.

Charge (q) → Scalar quantity.

- S.I. unit is coulomb (C).
- C.G.S. unit is stat coulomb (stat C)
- ∴ $1C = 3 \times 10^9$ stat C

→ (i) Positive charge ($q > 0$) → electron dificiency (ecp)

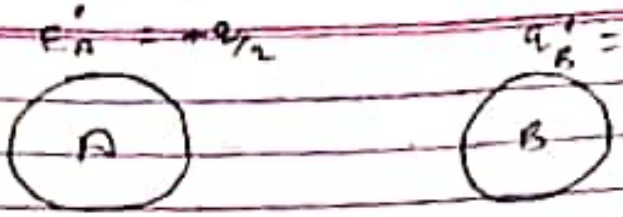
(ii) Negative charge ($q < 0$) → electron sufficient. ($e > p$)

* Electronic charge (e) :- It is the smallest unit of the electric charge.

$$1e = 1.6 \times 10^{-19} C$$

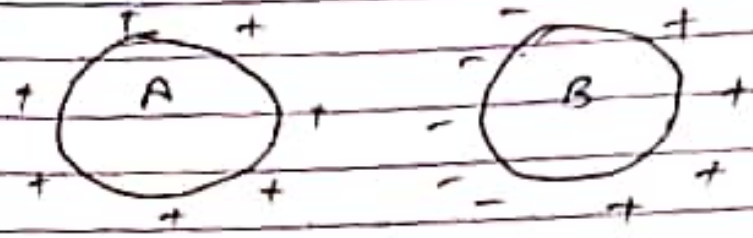
Properties of electric charge

- 2 like charges generally repel each other while 2 unlike charges always attract each other.



conduction

(2)



induction.

*Coulomb's law :- By using a torsion balance Coulomb measured the electric force that exist b/w 2 electric charges kept at a separation either in a medium or, in the free space (air, or vacuum).

Coulomb's law state that b/w 2 static charges (q_1 & q_2) kept at a seperation (x) in a medium the electric force (F).

$F \propto (q_1 . q_2)$ F is directly proportional to the magnitude of the 2 charges and

$F \propto \frac{1}{x^2}$ inversely proportional to sq. of the dist. x.

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Positive charge	negative charge.
Glass rod	Silk cloth
Flannel or catskin	Ebonite rod
Wollen cloth	Amber rod
woollen coat	& Plastic seat
woollen carpet	Rubber shoes.

Q. When a glass rod rubbed againt silk both aquire equal & opposite charge of magnitude ~~10~~ 10μC.

(a) State which body aquire +ve & -ve charge.

(b) State the direction of transfer of electron and also calculate the no. of electron that get transfered.

Ans. (a) glass rod aquire +10 μC charge while silk aquire -10μC charge.

(b) Electron get transfer from the glass rod to the silk.

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

$$q_{glass} = +10\mu C$$

$$= 10 \times 10^{-6} C = 10^{-5} C$$

$$= \frac{10^{-5}}{1.6 \times 10^{-19}} = \frac{1}{16} \times 10^{15} e$$

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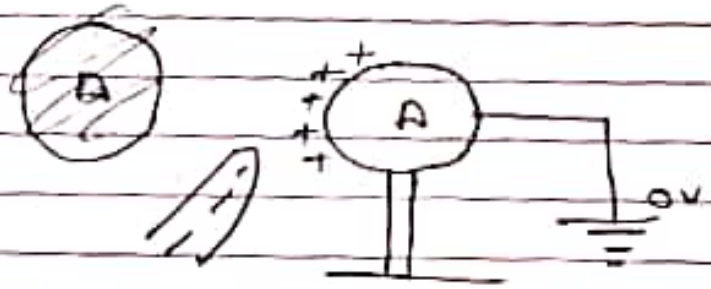
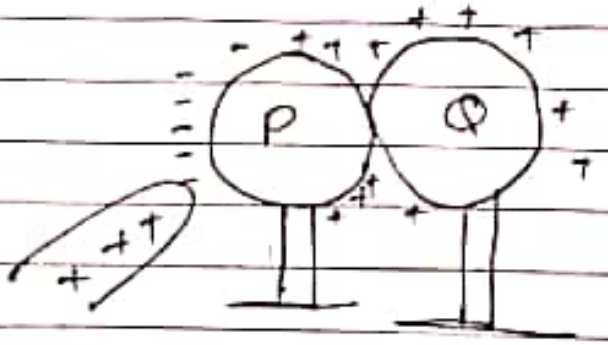
$= 0.96 \times 10^{15}$ e (appox) 15/100(0.06

$= 6 \times 10^{13}$ electrons.

Conduction & induction only possible in metallic bod





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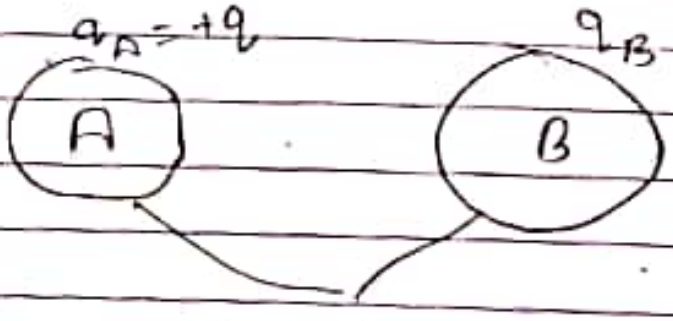
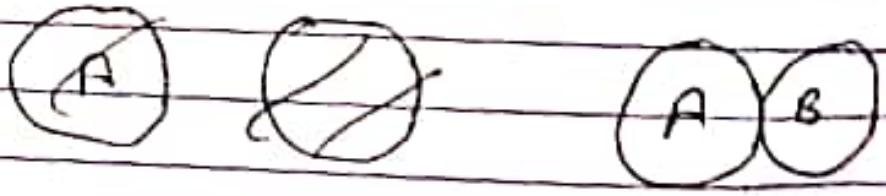


Metallic sphere



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$F \propto |q_1||q_2|$

$F \propto \frac{1}{r^2}$

i.e It is also known as called inverse square law in electrostatics

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

(i) In the free space (air / vacuum)

$K = \frac{1}{4\pi\varepsilon_0} \approx 9 \times 10^9 \, N m^2 C^{-2}$

$\varepsilon_0 \rightarrow$ a constant for the free space called absolute permittivity

$\approx 8.854 \times 10^{-12} \, C^2 N^{-1} m^{-2}$

$F_{air} = F_0 = \left(\frac{1}{4\pi\varepsilon_0}\right) \frac{q_1 q_2}{r^2}$

↳ Absolute electric force.

(ii) In a medium

$K = \left(\frac{1}{4\pi\varepsilon}\right)$

$\varepsilon \rightarrow$ permittivity of the medium.

Principle of superposition:- In a system of n charges $q_1, q_2, q_3 \ldots q_n$ The net coulomb force at a particular charge (let on q_1) is given as :-

$$\vec{F_1} = \vec{F_{12}} + \vec{F_{13}} + \vec{F_{14}} + \ldots + \vec{F_{1n}}$$

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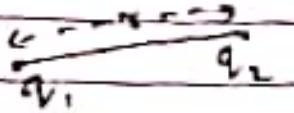
For a medium, the relative permittivity (ε_r) or dielectric constant (K) is defined as.



$$\varepsilon_r \text{ (or } k) = \frac{F_0}{F_m} = \frac{F_{air}}{F_{medium}} = \text{No unit.}$$

$$= \frac{\left(\frac{1}{4\pi\varepsilon_0}\right)\frac{q_1 q_2}{r^2}}{\left(\frac{1}{4\pi\varepsilon}\right)\frac{q_1 q_2}{r^2}}$$

$$\boxed{\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} > 1} \quad \text{---(1a)}$$

$$\varepsilon = \varepsilon_0 \varepsilon_r$$

$$F_{med} = F_m = \left(\frac{1}{4\pi\varepsilon}\right)\frac{q_1 q_2}{r^2}$$

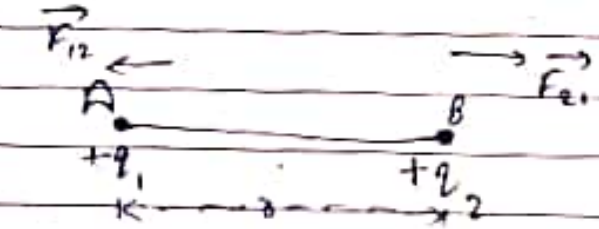
$$= \frac{1}{\varepsilon_r}\left(\frac{1}{4\pi\varepsilon_0}\right)\frac{q_1 q_2}{r^2}$$

$$F_{med} = \frac{F_{air}}{\varepsilon_r} \quad \text{where, } \varepsilon_r > 1$$

hence $F_{med} < F_{air}$

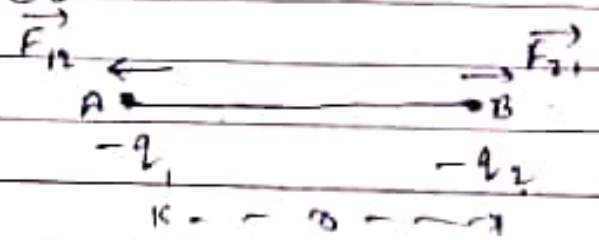
Nature of coulomb's force.

- It is either attractive or repulsive.
- 2 like charges or 2 unlike charges respectively repel or attract each other with equal and opposite force and follow law of action & reaction.
- It is a central force as it acts along the line joining the centre of 2 static point charges.
- It is a conservative force.



$$F_{12} = F_{21} = F = \frac{K q_1 q_2}{r^2}$$

OR



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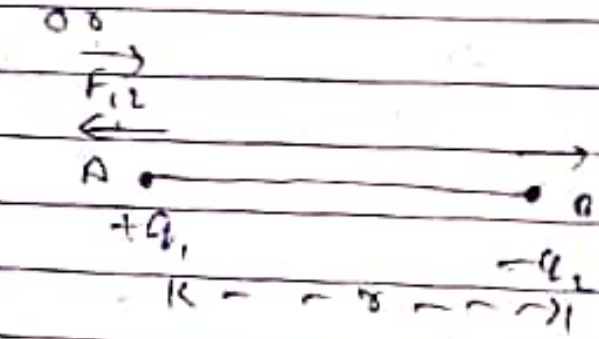

For

i.e. $\vec{F}_{net} = \vec{F}_{12} + \vec{F}_{21} = 0$

$\vec{F}_{12}$

$\vec{F}_{12} = -\vec{F}_{21}$

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- The electric charge is additive in nature as it is a scalar quantity.

* Net force = Resultant force
  ↓
  vector sum

Net work = total work
  ↓
  algebraic sum.

- The th. total charge of a body is quantized
- The total charge of a body is conserved.

* Priciple of quantisation of the electric charge states that for a body :-

$$q_{total} = \pm ne$$

where = n = 1, 2, 3, 4...
e = electronic charge
= $1.6 \times 10^{-19} C$

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

↓
eq. no. of electrons lost or gained by a body.

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* Principle of conservation of charge :

The charge can neither be created nor be destroyed but it can be transfered from 1 body to another. However.

- The total charge of a body or a system always remains conserved.

* Different methods of a charging a body physical are :-

(i) by friction
(ii) by conduction
(iii) by induction

(i) by friction :- When 2 body of different material are rubbed against each other equal & opposite charges develop on either of the 2 bodies due to transfer of electron from 1 body (aquiring +ve charge) to other body (aquiring -ve charge). The electricity so produced on 2 bodies is known as the frictional electricity. which remains on the body temporarily.

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Q. Distinguish b/w mass & electric charge.

Electric charge :-

- It is the fundmental property of a body that determines the electrical properties that electric force, electric field, electric potential etc. associated with the body.
- It is denoted by 'q' and as a quantity it is scalar derived quantity as $q = it$.
- It can be either 0 or +ve or -ve or fractional value.
- It is measured by a device called electroscope.

Mass :-

- It is the fundamental property of a body that determines its mechanical properties like force, momentum, work, energy etc.
- It is denoted by 'm'.
- It is a scalar fundamental quantity. It can neither be 0 nor be -ve nor be fractional value. It is always a +ve whole no.

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