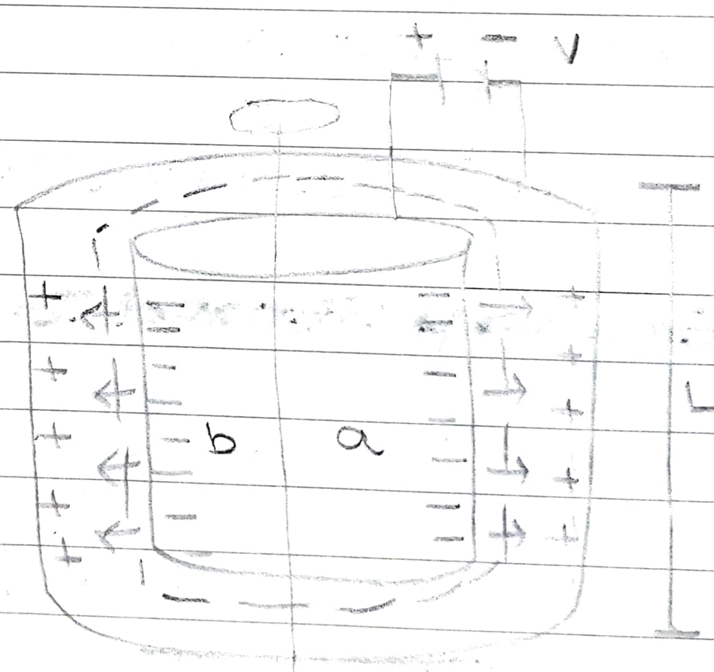
Cylindrical Capacitor

Assume that we have two coaxis cylinders one has a radius (a) and other has radius (b) (b>a) length of both cylinders is (L). We have connected both cylinders with battery of potential (V). +ve charge appears on another cylinder. -ve charge appears on outer cylinder. Because of the charges there is a strong electric field E between the cylinders where we assume a gaussian surface.



According to the Gauss's law,

$$\Rightarrow \oint \vec{E} \cdot \vec{d}A = \frac{q}{\epsilon_0}$$

$$\Rightarrow \oint E\,dA = \frac{q}{\epsilon_0}$$

$$\Rightarrow E \oint_{cylinder} dA = \frac{q}{\epsilon_0}$$

$$\Rightarrow E\,(2\pi r L) = \frac{q}{\epsilon_0}$$

$$\Rightarrow \boxed{E = \frac{q}{2\pi r l \epsilon_0}}$$

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$$\Rightarrow V = \int_a^b \vec{E} \cdot \vec{dr}$$

$$= \int_a^b E \, dr$$

$$\Rightarrow V = \int_a^b \frac{q}{2\pi r l \epsilon_0} \, dr$$

$$\Rightarrow V = \frac{q}{2\pi \epsilon_0 l} \int_a^b \frac{dr}{r}$$

$$= \frac{q}{2\pi \epsilon_0 l} \ln r \Big|_a^b$$

$$\Rightarrow V = \frac{q}{2\pi \epsilon_0 l} \ln\left(\frac{b}{a}\right)$$

$$q = CV$$

$$\Rightarrow C = \frac{q}{V}$$

$$= \frac{\cancel{q}}{\frac{\cancel{q}}{2\pi \epsilon_0 l} \ln\left(\frac{b}{a}\right)}$$

$$\Rightarrow \boxed{C = \frac{2\pi \epsilon_0 l}{\ln\left(\frac{b}{a}\right)}}$$

The capacitance of capacitor depends upon geometrical values and medium between two cylinders.

Spherical Capacitor

Assume that we have two co-axis spheres. One has a radius (a) and the other has radius (b) (b > a). We have connected both spheres with battery of potential (V). +ve charge appears on another shphere, -ve charge appears on outer sphere. Because of the charges there is a strong electric field between the cylindrs where we assume a gaussian surface.

{ Capacitor Numerical Question

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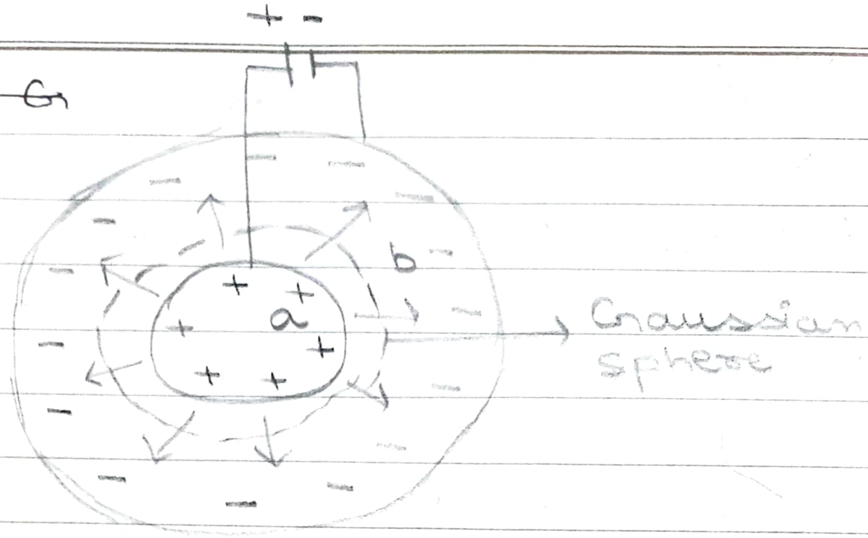
~~According to G~~



According to Gauss's law.

$$\Rightarrow \oint \vec{E} \cdot \vec{d}A = \frac{q}{\varepsilon_0}$$

$$\Rightarrow \cancel{E \oint dA} \oint E dA = \frac{q}{\varepsilon_0}$$

$$\Rightarrow E \oint_{\text{sphere}} dA = \frac{q}{\varepsilon_0}$$

$$\Rightarrow E \cdot 4\pi r^2 = \frac{q}{\varepsilon_0}$$

$$\Rightarrow \boxed{E = \frac{q}{4\pi\varepsilon_0 r^2}}$$

$$\Rightarrow V = \int_a^b \vec{E} \cdot \vec{dr}$$

$$\Rightarrow V = \int_a^b E\, dr$$

It also depends upon geometrical parameter & medium between two spheres.

$$\Rightarrow V = \int_a^b \frac{q}{4\pi\varepsilon_0 r^2} dr$$

$$\Rightarrow V = \frac{q}{4\pi\varepsilon_0} \int_a^b \frac{dr}{r^2}$$

$$\Rightarrow = \frac{q}{4\pi\varepsilon_0} \left| -\frac{1}{r} \right|_a^b$$

$$\Rightarrow V = \frac{q}{4\pi\varepsilon_0} \left[\frac{1}{a} - \frac{1}{b} \right]$$

$$\Rightarrow \boxed{V = \frac{q}{4\pi\varepsilon_0} \left(\frac{b-a}{ab} \right)}$$

$$\Rightarrow C = \frac{q}{V} = \frac{\cancel{q}}{\frac{\cancel{q}}{4\pi\varepsilon_0} \left(\frac{b-a}{ab} \right)}$$

$$\Rightarrow \boxed{C = 4\pi\varepsilon_0 \left(\frac{ab}{b-a} \right)}$$

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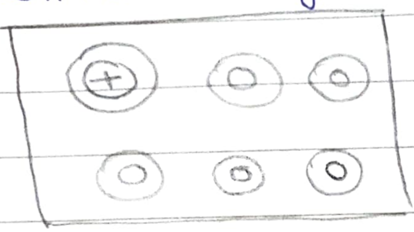
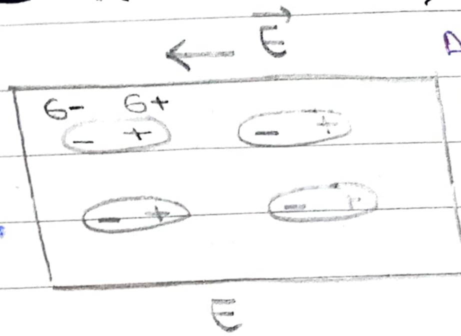
DIELECTRIC (Insulator)

when not charged



Apply electric field

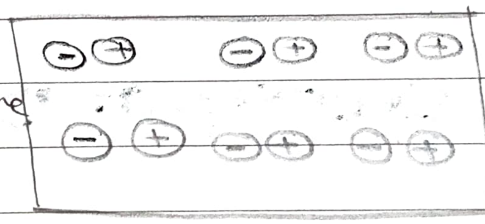


→ Used to increase capacitance.

→ They are in circular shape. When electrical field is induced (smaller ~~than~~ but opposite in direction) then atoms shape become spherical {orbits shape become spherical} so they move away from each other and partial polarization occurs.

Induced Electric Field: Direct apply electric field opposite in direction

→ When electric field more increased it will become ions.



→ Capacitence increased by introducing dielectric in between.

→ Strength of dielectric depends on nature of material.

$$C' > C_o$$

$$C = \mu_E C$$

$$\boxed{\varepsilon < \varepsilon_o}$$ Induced

OHM'S LAW

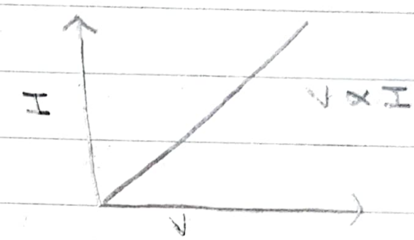
"The amount of resistance ~~opposed~~ offered by a material is independent of the applied potential difference and the current which is flowing through it."

→ Semiconductors, dielectric etc are non-ohmic.

Mathematically,

$\Rightarrow V \propto I$

$\Rightarrow \boxed{V = IR}$



⇒ Current is a scalar quantity.

~~di~~ angle doesn't effect on amount of current

It ~~att~~ always arithmetically add.

They don't follow vector rules.

Current Density ($\vec{J}$)

$$\Rightarrow J = \frac{i}{A} = \frac{A}{m^2}$$

$$\boxed{i = \int \vec{J} \cdot \vec{dA}}$$

Current density is the amount of charge per unit time that flows through a unit area of a chosen cross section.

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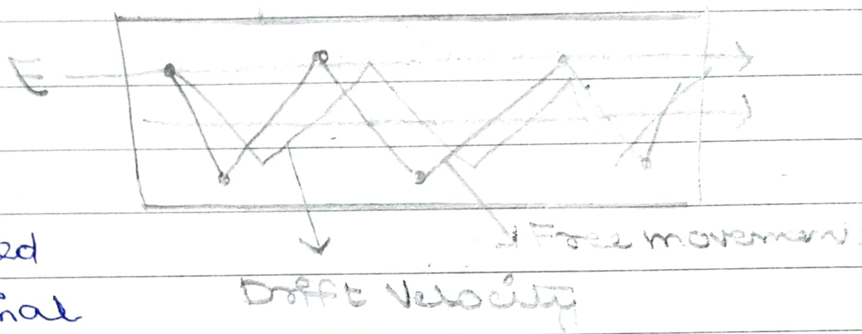
Drift Velocity (V_d)

When electric field is applied, electrons change their velocity. The velocity they obtain will be influenced velocity. This velocity is called drift velocity.

definition:

* Drift velocity is the average velocity attained by charged particles in a material due to an electric field."



Assume the piece of conductor of length L and cross section area A. So volume of material is A×L. Total number of electrons present is N then total charge will be Ne

length = L
Area = A
Volume of material = A×L
Total No. of electron = e
Total charge = Ne

According to the definition of current density.

$$J = \frac{i}{A}$$

where $= \frac{q}{t} = \frac{Ne}{t}$

$$\Rightarrow J = \frac{Ne}{A \times t}$$

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$$\Rightarrow J = \frac{Ne}{\frac{A \times L}{V_d}}$$

$$\boxed{V_d = \frac{L}{t} \; ; \; t = \frac{L}{V_d}}$$

$$\Rightarrow J = enV_d$$

$$\boxed{J = -enV_d}$$

$$n = \boxed{\frac{N}{V}}$$

$$\boxed{V_d = A \times L \qquad \frac{N}{V} = eV_d}$$

The -ve sign shows that the direction of moving electron is opposite of current density.

Resistivity ρ

→ Resistivity depends upon temperature.

→ Resistance does not depends on material size.

$$\Rightarrow R \propto L$$

$$\Rightarrow R \propto \frac{1}{A}$$

$$\Rightarrow R \propto \frac{L}{A} \longrightarrow \boxed{R = \rho \frac{L}{A}}$$

(T is constant) temp

$$\Rightarrow L = 1m \qquad \Rightarrow \boxed{R = \rho}$$

$$A = 1m^2$$

Resistance of one cube of material is called Resistivity.