-:(Physics):-

Semester 01:-

Chapter 06:-

Q.No1:-

What is electric current and current density and write its unit?

Answer:-

"The rate of flow of charges through a conductor is called electric current."

$$I = \frac{dq}{dt}$$

The SI unit of electric current is called Ampere.

"The current established in conductor is equal to one ampere when one coulomb charges flows through a conductor in one second.

Current Density:-

The current per unit cross sectional area of a conductor is called current density.

It is denoted by $\vec{J}$. It is a vector quantity. SI unit is Am^{-2}

$$J = \frac{dI}{da} \Rightarrow dI = \vec{J} \cdot \vec{da}$$

$$I = \int \vec{J} \cdot \vec{da}$$

$$I = JA$$

$$\boxed{J = \frac{I}{A}}$$

Q.No2:-

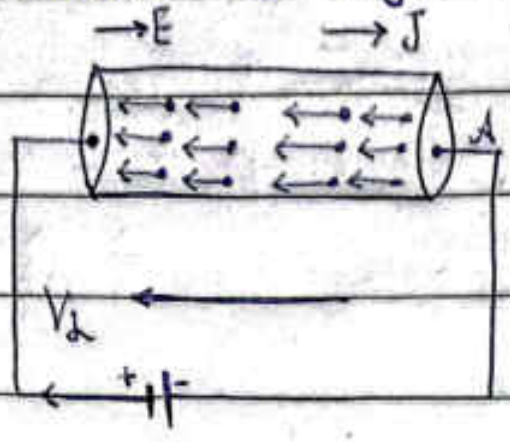
What is drift velocity? Establish a relation between drift velocity and current density?

Ans:-

"The constant average velocity acquired during this process by free electron against electric field is called Drift velocity." (V_d)

The drift velocity is of the order $10^{-3} ms^{-1}$.

Relational between drift velocity and current density:-



One carrier charge = e

nAL carrier charge = ALne

The total charge q on conductor is:

$$q = nALe \quad \text{(i)}$$

$$I = \frac{q}{t}$$

$$q = It \quad \text{(ii)}$$

$$I \times t = nALe$$

$$\{\because L = V_d t\}$$

$$I \cancel{t} = nAV_d \cancel{t} e$$

$$I = nAV_d e$$

$$\frac{I}{A} = nV_d e$$

$$J = neV_d$$

$$V_d = \frac{J}{ne}$$

Q No3:-

Define electrical resistance, conductance, resistivity, conductivity and write their units?

Answer:-

Electrical Resistance:-

"The measurement of opposition to flow of charges through a conductor due to collision with ionic cores of conductor is called Electrical resistance."

"The conductor used in a circuit to provide specified resistance is called Resistor."

$$R = \frac{V}{I}$$

Unit: ohm (Ω)

Conductance:-

The reciprocal of resistance is called conductance. It is denoted by G.

$$G = \frac{1}{R} = \frac{I}{V}$$

Unit: mho (Ω^{-1}) or siemen

Resistivity:-

"The ratio of electric field E applied to a conductor and current density J is called resistivity."

or "The resistance of one (meter)^3 of a material is called resistivity."

It is denoted by ρ.

$$\rho = \frac{E}{J}$$

Unit: Ohm-meter (Ω m)

Conductivity:-

The reciprocal of resistivity is called conductivity. It is denoted by σ.

$$\sigma = \frac{1}{\rho} = \frac{J}{E}$$

Unit: mho-meter $(\Omega m)^{-1}$

:(Applied Physics):-

Chapter 06:-

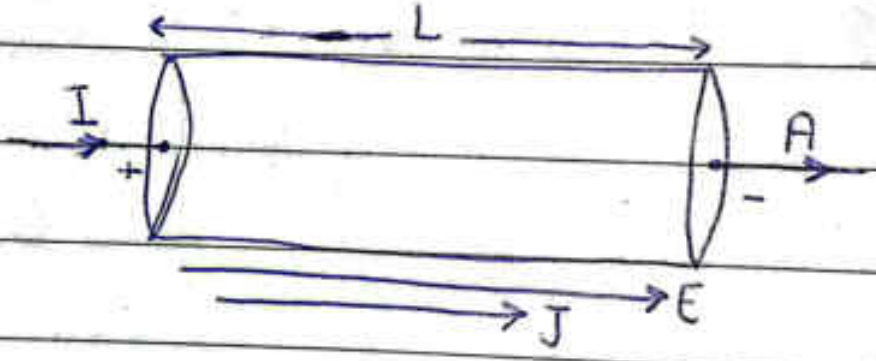
Q.No4:-

A potential V is applied across length L of a conductor. Relate:

(i) J with ρ and E with V and L.

(ii) Prove that $\rho = RA/L$?

Answer:-



Consider a cylinderical conductor having length L and cross sectional Area A. The current I flows through conductor when V is applied at the end of a conductor.

The electric field E and Pd V are related as:

$$E = \frac{V}{L}$$

$$E = \frac{IR}{L} \quad \text{(i)}$$

Resistivity is given as:

$$\rho = \frac{E}{J}$$

$$E = \rho J \quad \text{(ii)}$$

Compairing eq (i) and (ii)

$$\rho J = \frac{IR}{L}$$

$$J = \frac{IR}{\rho L} \quad \text{(iii)}$$

The current density is:

$$J = \frac{I}{A} \quad \text{(iv)}$$

Compairing eq (iii) and (iv)

$$\frac{I}{A} = \frac{IR}{\rho L} \Rightarrow A = \frac{\rho L}{R}$$

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

This is the relation between resistivity and resistance.

Q.NO5:-

What is temprature coefficient of resistivity. Derive its formula and explain effect of temprature variation on resistivity?

Answer:-

"The fractional change in resistivity per unit charge in tempreture is called temperature coefficient of resistivity."

It is denoted by α. Its SI unit is $(Kelvin)^{-1}$

Explanation:-

Consider a conductor having resistivity ρ_0 at temperature T_1. The resistivity of conductor increased by amount $d\rho = \rho_t - \rho_0$

It is experimently found that

increase in resistivity $d\rho$ is directly proportional to the changes in temperature dT and original resistivity ρ_0.

$$d\rho \propto \rho_0 dT$$

$$d\rho = \alpha \rho_0 dT$$

$$\alpha = \frac{d\rho}{\rho_0 dT}$$

The final resistivity of material is given by:

~~Final Resistance = Original~~

Final ρ = original ρ + Increase in ρ

$$\rho_t = \rho_0 + d\rho$$

$$\rho_t = \rho_0 \alpha \rho_0 dT$$

$$\rho_t = \rho_0 (1 + \alpha dT)$$

Using the relation of resistivity and resistance, we get

$$R_t = R_0 (1 + \alpha dT)$$

-:(Applied Physics):-

Chapter 06:-

Q.No6:-

Define current density. State and explain Ohm's law and write its macroscopic and microscopic form in terms of current density and electric field intensity?

Answer:-

"The current flowing through a conductor per unit area is called current density."

It is a vector quantity.

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

Am^{-2} = Unit

OHM's Law:-

The Ohm's law can be stated in two ways called macroscopic form and microscopic form.

(i) **Macroscopic Form:-**

The macroscopic form of ohm's law states that current flows through a conductor when Pd is applied at the ends of this conductor. The amount of this current is directly proportional to the applied Pd provided that physical state of conductor such as temperature remains constant.

$$V \propto I$$

$$V = IR$$

where R is proportionality constant called resistance of conductor.

Ohmic and Non-Ohmic Circuits:-

The material or circuit elements which obeys ohm's law is called ohmic. The graph b/w current and voltage is a straight line.

The material or circuits elements such as diode, bulb which does not obey ohm's law is called non-ohmic. The graph b/w current and voltage is non linear.

(ii) **Microscopic form:-**

The microscopic form of Ohm's law states that current density established in conductor is directly proportional to the electric field which is applied at the end of a conductor.

Explanation:-

Consider a conductor having length L and cylindrical cross sectional area A. The current I flows through conductor whe Pd 'V' is applied at its end.

$$V = IR$$

$$\text{As } R = \frac{\rho L}{A}$$

So,

$$V = I \frac{\rho L}{A}$$

$$\left\{ J = \frac{I}{A} \right\}$$

$$V = \rho J L$$

$$\frac{V}{L} = \rho J \quad \text{---- (i)}$$

Potential difference per unit length is equal to electric field.

$$\frac{V}{L} = E \quad \text{---- (ii)}$$

$$\boxed{E = \rho J}$$

This is called microscopic form of Ohm's law.

:(Applied Physics):-

Chapter 06:-

QNo7:-

Describe the relation b/w macroscopic and microscopic Parameter of Ohm's law?

Answer:-

(i) The macroscopic parameter current I and microscopic parameter current density of ohm's law are related as:

$$I = \int \vec{J} \cdot \vec{da}$$

(ii) The macroscopic parameter potential difference 'V' and microscopic parameter electric field E is related as:

$$V = \int \vec{E} \cdot \vec{dr}$$

(iii) The macroscopic parameter resistance R and microscopic parameter resistivity ρ of ohm's law is

related as:

$$R = \frac{\rho L}{A}$$

Q No 8:-

Show that metals obey Ohm's law taken into account microscopic form of Ohm's law. Prove $\rho = m/ne^2\tau$.-

Answer:-

Metals Obey Ohm's law:-

The ohm's law is not a fundamental law of electromagnetism. It depends upon the properties of conducting material Almost all the metals are conductors and having conduction electrons and ionic cores. The assembly of conduction electrons is called electron gas.

The electric force F_e experienced by electron having charge e due to applied electric field E is:

$$F_e = eE$$

This electric force F_e produces acceleration 'a' in electron having mass 'm'.

$$F_e = ma$$

Compairing both eqn.

$$ma = eE$$

$$a = \frac{eE}{m} \quad \text{---------- (i)}$$

The acceleration in term of drift velocity V_d and mean free time τ b/w collision is:

$$a = \frac{V_d}{\tau} \quad \text{(Put in (i))}$$

$$\frac{V_d}{\tau} = \frac{eE}{m}$$

$$V_d = \frac{eE\tau}{m} \quad \text{---------- (ii)}$$

The drift velocity in term of current density is:

$$V_d = \frac{J}{ne} \quad \text{(Put in eq (ii))}$$

$$\frac{J}{ne} = \frac{eE\tau}{m}$$

$$J = \frac{ne^2 E \tau}{m} \quad \text{---------- (iii)}$$

The microscopic form of ohm's law is:

$$E = \rho J$$

$$J = \frac{E}{\rho} \quad \text{(Put in (iii))}$$

$$\frac{E}{\rho} = \frac{ne^2 E \tau}{m}$$

$$\frac{1}{\rho} = \frac{ne^2 \tau}{m}$$

$$\boxed{\rho = \frac{m}{ne^2 \tau}}$$ Hence proved

where m, n, e^2 and τ is constant of proportionality. So,

ρ = constant

Therefore, It is concluded that parameter ρ is constant for metals. The microscopic form of Ohm's law is:

$$E = \rho J$$

$$\rho \longrightarrow \text{constant}$$

$$E \propto J$$

Hence, it is concluded that all metals obey ohm's law.