PHYSICS

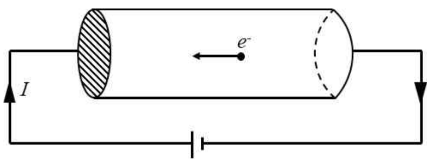
CLASS NOTES FOR CBSE

Chapter 19. Current Electricity

01. Electric Current

The motion of charges (positive and negative) constitute electric current. The electric current is defined as rate of flow of charge I=q/t. Current is a scalar quantity. Its S.I unit is Ampere. We define current in two ways

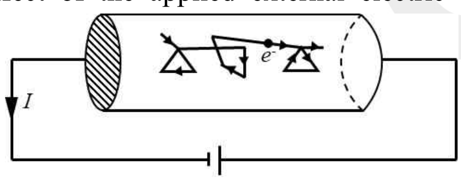
(i) Average current
(ii) Instantaneous current



Directions of current
Direction of current is taken as direction of motion of positivity charged particles and opposite to the direction of negativity charged particles. This is called *conventional current*.
Directions of electric current
The direction of flow of electrons gives the direction of *electric current*. The direction of electric current is opposite to that of conventional current.

02. Drift velocity

Drift velocity is defined as the velocity with which the free electrons get drifted towards the positive terminal under the effect of the applied external electric field.



At any given time, an electron has a velocity $\vec{v_1} = \vec{u_1} + \vec{a\tau_1}$, where $\vec{u_1}$ = the thermal velocity and $\vec{a\tau_1}$ = the velocity acquired by the electron under the influence of the applied electric field. τ_1 = the time that has elapsed since the last collision. Similarly, the velocities of the other electrons are

$$\overline{v_2} = \overline{v_2} + \vec{a\tau_2}, \overline{v_3} = \overline{u_3} + \vec{a\tau_3} ..... \overline{v_N} + \vec{a\tau_{N.}}$$

The average velocity of all the free electrons is equal to the drift velocity of the free electrons

Relation between Drift Velocity and Electric Current

$$I = nAv_d e$$

03. Mobility (μ)

It is defined as the magnitude of the drift velocity per unit electric field.

$$\mu = \left| \frac{\overrightarrow{v_d}}{\overrightarrow{E}} \right|$$

Its SI unit is $m^2 V^{-1} s^{-1}$

Its practical unit is $cm^2 V^{-1} s^{-1}$

We have $\quad v_d = \dfrac{e\tau E}{m}$

$\Rightarrow \quad \mu = \dfrac{V_d}{E} = \dfrac{e\tau}{m}$

Mobility of free electrons is independent of electric field and dimension of conductor.

04. Ohm's Law

If V be the potential between the ends of the conductor through which a current I is flowing, then Ohm's states that

$V \propto I$ or $V = RI$

where R is the proportionality constant known as Resistance of the conductor, SI unit of resistance are VA^{-1} or ohm (Ω).

Resistance of the conductor depends on

(i) Dimensions of conductor and

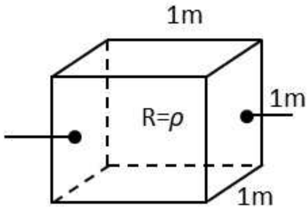
(ii) Material of conductor

(i) Resistivity and Conductivity

For a given conductor of uniform cross-section A and length l, the electrical resistance R is directly proportional of length l and inversely proportional to cross sectional A.

$R \propto \dfrac{l}{A}$ or $R = \rho \dfrac{l}{A}$

If $\quad l = 1m, A = 1m^2 \ then \ \rho = R$



ρ is known as resistivity or specific resistance. Resistivity depends on

(i) Nature of material

(ii) Temperature of material

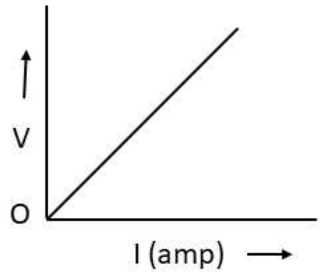
The reciprocal of resistivity is called the conductivity $\boxed{\sigma = \dfrac{1}{\rho}}$

Its unit is mho/m.

(i) V-I Characteristics or Limitations of Ohm's Law

Linear V-I characteristics

At constant temperature, if current is directly proportional to the applied potential difference. This law is called ohm's law and substance which obey it are called ohmic or linear conductors.



Non-Linear V-I characteristics

- The relation between V and I depends on the sign of V. In other words, if I is the current for a certain V, then reversing the direction of V keeping its magnitude fixed, does not produce a current of the same magnitude as I in the opposite direction Fig. (i)

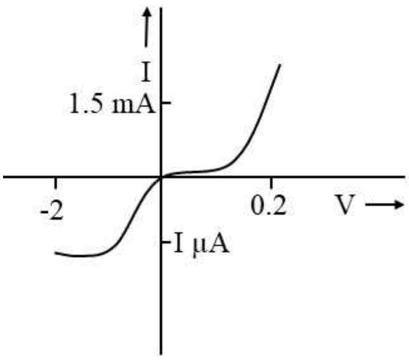


Fig. (i)
Characteristic curve of diode, Note the different scales for negative and positive Values of the voltage and current

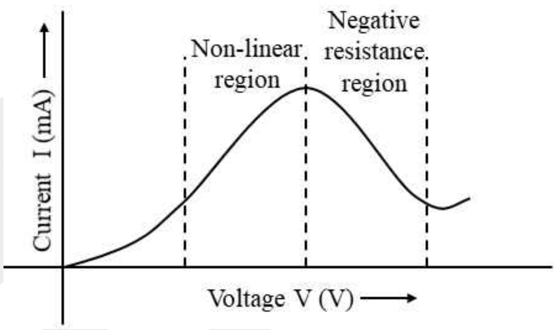


Fig. (ii)
Variation of current versus voltage for GaAs.

- The relation between V and I is not unique, i.e., there is more that one value of V for the same current I fig.(ii). A material exhibiting such behaviour is GaAs.

05. Temperature dependance of resistivity and resistance

The resistivity of a material is found to be dependent on the temperature over a limited range of temperatures (not too large). The resistivity of a metallic conductor is approximately given by

$$\rho_T = \rho_0[1 + \alpha(T - T_0)]$$