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Carriers of current: The charged particles which by flowing in a definite direction set up an electric current are called current carriers. The different types of current carriers are as follows.

(1) In solids: In metallic conductors, electrons are the charge carriers. The electric current is due to the drift of electrons from low to high potential regions. In n-type semi-conductors, electrons are the majority charge carriers while in p-type semiconductors, holes are the majority charge carriers. A hole is a vacant stat from which an electron has been removed and it acts as a positive charge carriers. A hole is a vacant stat from which an electron has been removed and it acts as a positive charge carrier.

(2) In liquids: In electrolytic liquids, the charge carriers are positively and negativily charged ions. e.g. $CuSO_4$ solution has Cu^{+2} and SO_4^{-2} ions, which act as the charge carriers.

(3) In gases: In ionised gases, positive and negative ions and electrons are the charge carriers.

(4) In Vacuum tubes: In vacuum tubes like radio valves cathode ray oscilloscope (CRO), picture tube etc. free electrons emitted by the heated cathode act as charge carriers.

Mechanism of current flow in a conductor:

Concept of drift velocity and relaxation time:

Metals have a large number of free electrons, nearly 10^{28} per cubic meter. In the absence of any electric field, these electrons are in a state of continuous random motion due to thermal energy. At room temperature, they move with velocities of the order of $10^5\ ms^{-1}$. However, these velocities are distributed randomly in all directions. There is no preffered direction of motion. On the average, the number of electrons travelling in any direction will be equal to number of electrons travelling in any direction will be equal to number of electrons travelling in the opposite direction. If $\vec{u}_1, \vec{u}_2, \ldots \vec{u}_N$ are the random velocities of N free electrons, then average velocity of electrons will be –

$$\vec{u} = \frac{\vec{u}_1 + \vec{u}_2 + \vec{u}_3 + \cdots + \vec{u}_N}{N} = 0$$

Thus, there is no net flow of charge in any direction.

In the presence of an external field $\vec{E}$, each electron experiences a force $-e\vec{E}$ in the opposite direction of $\vec{E}$ (since an electron has negative charge) and undergoes an acceleration $\vec{a}$ given by –

$$\vec{a} = \frac{\text{Force}}{\text{Mass}} = -\frac{e\vec{E}}{m}$$

where, m is the mass of an electron.

As the electrons accelerate, they frequently collide with the positive metal ions or other electrons of the metal. Between two successive collisions, an electron gains a velocity component (in addition to its random velocity) in a direction opposite to $\vec{E}$. However, the gain in velocity lasts for a short time and is lost in the next collision. At each collision, the electron starts afresh with a random thermal velocity.

If an electron having random thermal velocity $\vec{u_1}$ accelerates for time τ_1 (before it suffers next collision), then it will attain a velocity,

$$\vec{v_1} = \vec{u_1} + \vec{a}\tau_1$$

Similarly, the velocities of the other electrons will be-

$$\vec{v_2} = \vec{u_2} + \vec{a}\,\tau_2$$

$$\vec{v_3} = \vec{u_3} + \vec{a}\,\tau_3$$

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$$\vec{v_N} = \vec{u_N} + \vec{a}\,\tau_N$$

The average velocity $\vec{v_d}$ of all the N electrons will be-

$$\vec{v_d} = \frac{\vec{v_1} + \vec{v_2} + \vec{v_3} + \dots + \vec{v_N}}{N}$$

$$= \frac{(\vec{u_1} + \vec{a}\tau_1) + (\vec{u_2} + \vec{a}\tau_2) + \dots + (\vec{u_N} + \vec{a}\tau_N)}{N}$$

$$= \frac{\vec{u_1} + \vec{u_2} + \vec{u_3} + \dots + \vec{u_N}}{N} + \vec{a}\,\frac{\tau_1 + \tau_2 + \dots + \tau_N}{N}$$

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$$\vec{v}_d = 0 + \vec{a}\cdot\tau$$

Where $\tau = (\tau_1 + \tau_2 + \ldots \tau_N)/N$ is the average time b/w two successive collisions. The average time that elapses b/w two successive collisions of an electron is called relaxation time. For most conductors, it is of the order of 10^{-14} s. The velocity gained by an electron during this time is –

$$\boxed{\vec{v}_d = \vec{a}\tau = -\frac{e\vec{E}\tau}{m}}$$

The parameter $\vec{v}_d$ is called drift velocity of electrons. It may be defined as the average velocity gained by the free electrons of a conductor in the opposite direction of the externally applied electric field.