11. Dual Nature of Radiation and Matter

Photoelectric effect: Phenomenon of emission of electrons from the surface of metals when radiations of suitable frequency fall on them.

Work function of a metal: It is the minimum energy required to liberate an electron from the surface of a metal without imparting any kinetic energy.

Factors affecting photoelectric effect:

- The number of photoelectrons ejected per second is directly proportional to the intensity of the incident light.
- For an incident radiation of frequency less than the threshold frequency, no emission of photoelectron is possible, even if the intensity is high.
- The maximum kinetic energy of the emitted photoelectron depends only upon the frequency (or wavelength) of the incident light, and is independent of the intensity of the incident light.

Einstein's photoelectric equation:

$$K_{max} = \frac{1}{2} m v_{max}^2 = h\nu - \phi_0$$

Where,

K_{max} = Maximum kinetic energy of the emitted electrons

V_{max} = Maximum velocity of the electrons

ϕ_0 = Work function of the metal

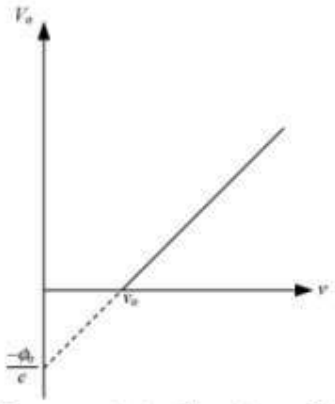
Stopping potential:

The stopping potential (V_0) depends on (*i*) the frequency of the incident light and (*ii*) the nature of the emitter material. For a given frequency of incident light, it is independent of its intensity. The stopping potential is directly related to the maximum kinetic energy of electrons emitted:

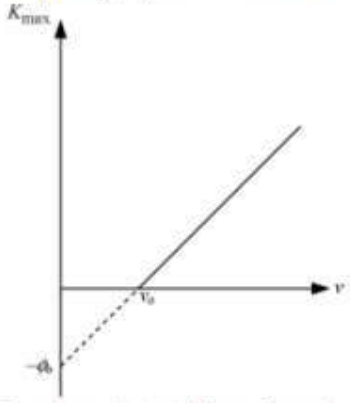
$$eV_0 = \left(\frac{1}{2}\right) m v_{max}^2 = K_{max}$$

Important graphs related to photoelectric effect:

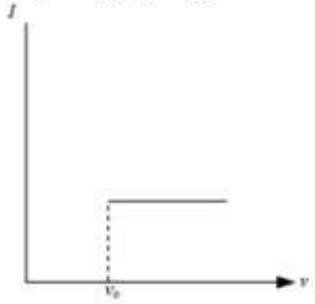
- Frequency (ν) and stopping potential (V_0) graph



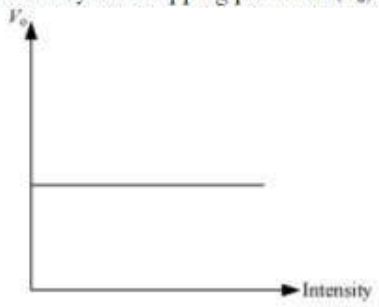
- Frequency (ν) and maximum kinetic energy (K_{max}) graph



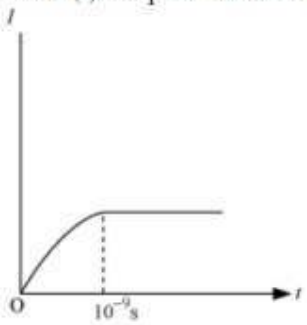
- Frequency (ν) and photoelectric current (I) graph



- Intensity and stopping potential (V_o) graph



- Time (t) and photoelectric current (I) graph



Radiation has dual nature: Sometimes it behaves as a wave and sometime as a particle

- **De-Broglie hypothesis:** A moving particle sometimes acts as a wave and sometimes as a particle, or a wave is associated with a moving material particle which controls the particle in every respect. The wave associated with the moving particle is a called matter wave. De-Broglie wavelength, is given by

$$\boxed{\lambda = \frac{h}{mv}}$$