ATOMIC ENERGY CENTRAL SCHOOL-04, RAWATBHATA.

CLASS : XII **SUBJECT : PHYSICS**

CHAPTER : 11

"DUAL NATURE OF RADIATION AND MATTER".: MODULE-1

ELECTRON EMISSION

➢ The emission/ejection of electrons from the metal surface is known as **Electron Emission**.

Every metal has free electrons, these free electrons are free to the extent that they may transfer from one atom to another within the metal but they cannot leave the metal surface because of electrostatics attraction of positive nuclei inside the atom.

However, if sufficient energy is given to the free electrons, their kinetic energy increases and thus the electrons will cross over the surface barrier to leave the metal.

➢ **Work function** (ϕ_0): The minimum amount of energy required by an electron to just escape from metal's surface is called Work function (ϕ_0) of the metal.

The work function of pure metals varies roughly from 2eV to 6eV.

$$1eV = 1.602 \times 10^{-19}J$$

➢ **One Electron Volt (1eV):** It is the kinetic energy gained by an electron when it is accelerated through a potential difference of 1 volt.

METHODS OF ELECTRON EMISSION

➢ **Thermionic emission:** In this method, the metal is heated to a sufficient temperature (about 2500^0C) to enable the free electrons to leave the metal surface. The number of electrons emitted depends upon the temperature. The higher the temperature, the greater is the emission of electrons. The ejected electrons are called thermal electrons.

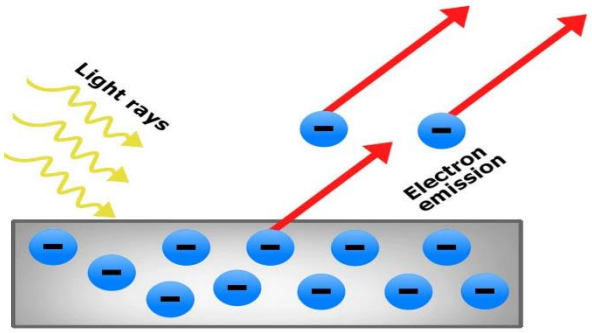
➢ **Field emission:** In this method, strong electric field (i.e. a high positive voltage) is applied at the metal surface which pulls the free electrons out of the metal because of the attraction of positive field. The ejected electrons are called field electrons.

➢ **Photoelectric emission:** In this method, the energy of light falling upon the metal surface is transferred to the free electrons within the metal to enable them to leave the surface. The greater the intensity of light beam falling on the metal surface, the greater is the photoelectric emission. The ejected electrons are called photoelectrons.

➢ **Secondary emission:** In this method, a high velocity beam of primary electrons strikes the metal surface. The intensity of secondary emission depends upon the emitter material, mass and energy of bombarding particles. The ejected electrons are called secondary electrons.

PHOTOELECTRIC EFFECT

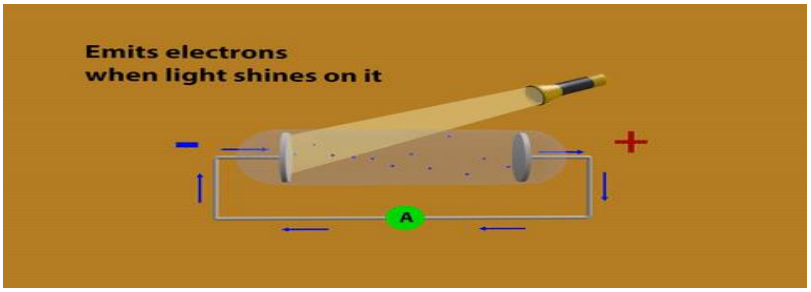
➢ The phenomena of emission of electrons from a metal surface, when radiations of suitable frequency is incident on it, is called **photoelectric effect**.



- *Alkali metals: Li, Na, K, Cs & Rb - Highly photosensitive - Emit electrons even with visible light.*
- *Metals: Zn, Cd, Mg, Al, etc - Ultraviolet light.*
- *Heavy Metals: X-rays.*

➢ The electrons emitted by this effect are called **photoelectrons** and the current constituted by photoelectrons is known as **photoelectric current** or **photocurrent.**

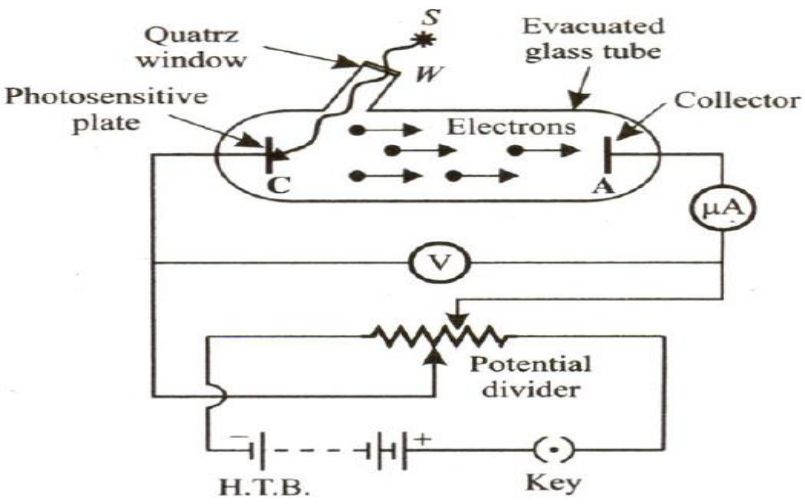
- *It was discovered by **Heinrich Hertz** in **1887** during his EM waves experiments.*



EXPERIMENTAL STUDY OF PHOTOELECTRIC EFFECT:

Philipp **Lenard** studied the photoelectric effect practically.

Fig. shows his experimental setup



C – Metallic cathode

A – Metallic Anode

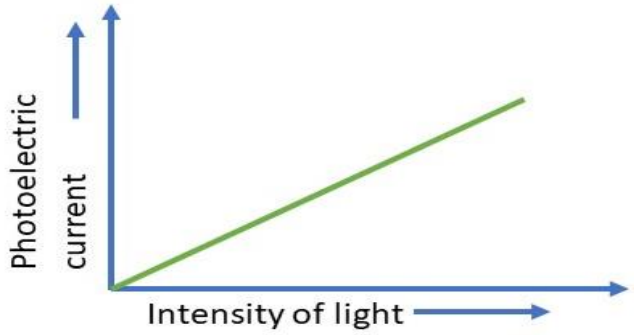
W – Quartz Window

When light of suitable frequency falls on the metallic cathode, photoelectrons are emitted. These photoelectrons are attracted towards the +ve anode and hence photoelectric current is constituted.

EFFECT OF INTENSITY OF LIGHT ON PHOTOELECTRIC CURRENT:

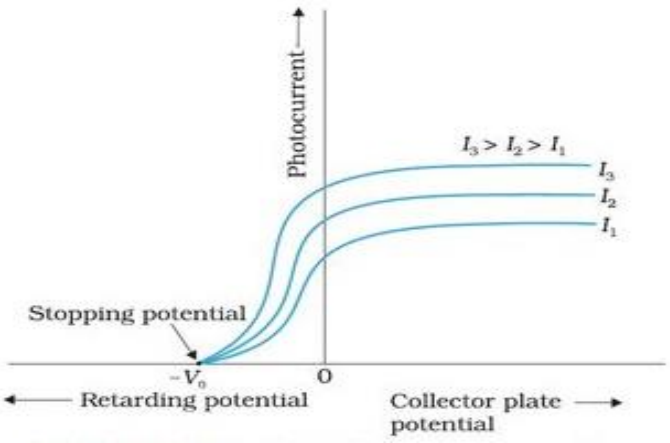
- Current is number of electrons passing through a cross section in unit time.

- As Intensity increase↑: No of electron emitted increase↑: Current ↑
- **Photocurrent ∝ Intensity** *as the frequency & accelerating potential is fixed.*



EFFECT OF COLLECTOR POTENTIAL:

- *Collector potential is meant for collecting emitted electrons.*
- *Current first increases with increase in collector potential after which it saturates. It saturates (become constant) when emitted electrons = collected electrons. This maximum current is called saturated current.*
- *Now If we keep voltage negative, it will repel electrons. At some potential, all electrons will get repelled. At this potential, Photocurrent will be zero. This is called stopping potential.*
- $\boldsymbol{eV_{stopping} = KE_{max}}$
- $\boldsymbol{KE_{max}} = h\nu - \boldsymbol{eV_{stopping}} = h\nu - \phi_0$
- $\boldsymbol{V_{stopping}} = \frac{(h\nu - \phi 0)}{e}$
- ***So, stopping potential depends on frequency and work function.***



As Frequency is same but I > I > I :

- *Saturation current increases in proportion to intensity.*
- *But Stopping potential is independent of intensity.*