Photo electric effect:

Free electron theory of metal: We have seen that certain elements are good conductor of electricity where as other elements are insulators. This can be explained by free electron theory. It has been found that there are some atoms in which coulomb force between the nucleolus and the outermost electrons is very very weak. When these atoms with loosely bound outermost electrons combined to form an element the loosely bound outermost electrons of the atoms do not remain confined to those particular atoms and move about freely inside the element as if they are free. These outer most electrons from all the atoms form an electron gas.

If we consider an electron inside the element the resultant force on it is zero but if we consider the electron near the surface the resultant force is directed inward perpendicular to the surface. Thus the electrons although move about freely inside the element cannot leave the surface of the element. The elements in which there are free electrons are good conductors. There are atoms in which the outermost electron is very tightly bound with the nucleus, elements formed by these atoms do not have any free electron and are insulators. Metals generally have free electrons and are good conductors. In order to just free electron from the surface i.e. To bring a free electron from just inside the surface to just outside the surface work is to be done against the attractive force. This work done is known as Work function (ϕ).

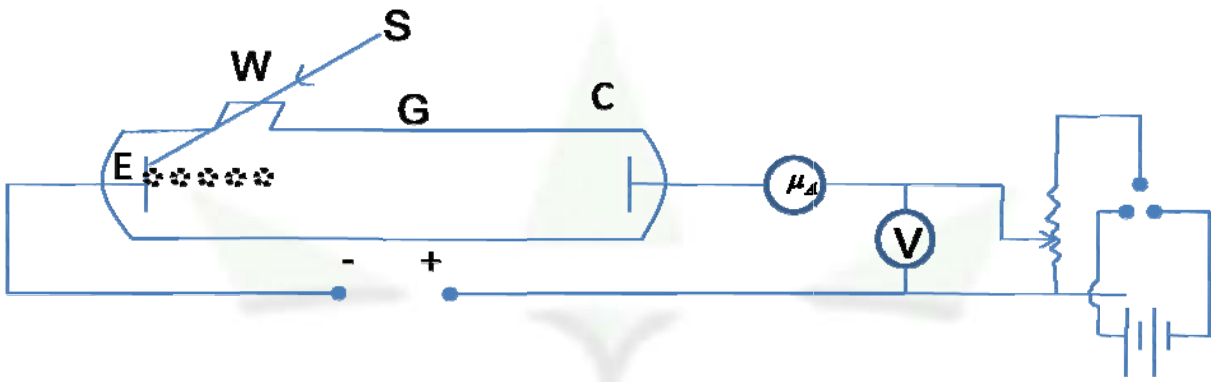
Work function of an element is defined as the minimum amount of energy required to make an electron just free from the surface is known as work function. The energy required to make an electron free from the surface can be supplied in three different ways:

1. **In the form of heat energy:** The corresponding emission of electrons is known as thermionic emission.
2. **In the form of light energy:** The corresponding emission is known as Photo electric emission.
3. **In the form of electrical energy**: By applying very high potential difference across the electrode and the corresponding emission is known as field emission or cold emission.

Photoelectric effect:

The knocking of electrons from solids and liquids by incident light energy is known as photo electric effect.

Experimental demonstration:



G is a glass discharge tube having a window W of quartz which allow the ultraviolet light to pass through. E is the emitting surface and C is the collecting electrode. A potential difference known as accelerating potential difference is applied between the two electrodes by using a potential divider arrangement and commutator and he applied potential difference is measured by a voltmeter. The photo electric current flowing in the circuit is measured by micro ammeter.

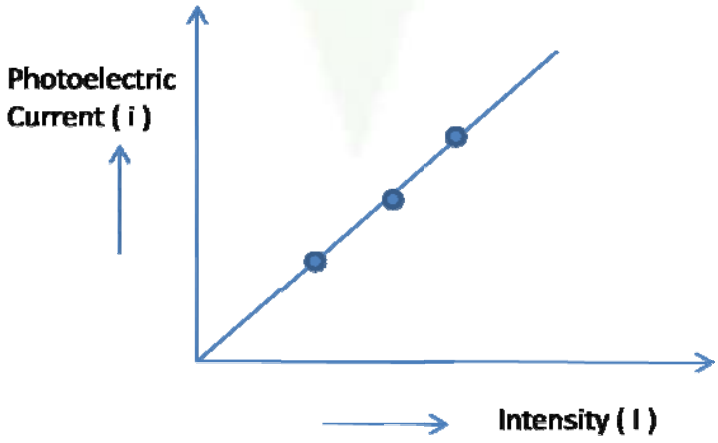
The experiment is performed by changing

1. The intensity of incident light I

2. The frequency of the incident light

3. The accelerating Potential difference V and for each of them photo electric current is measured.

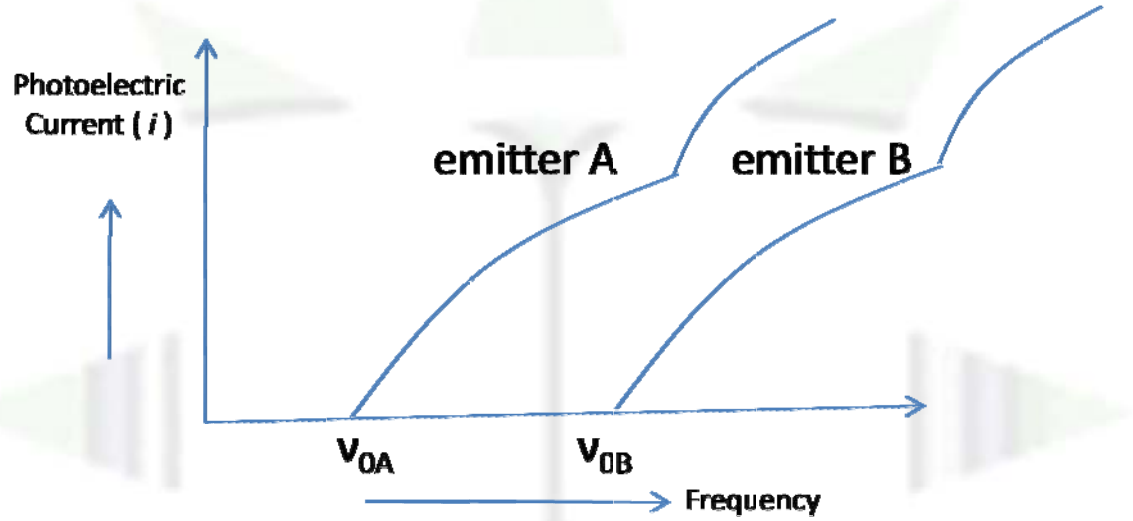
Experiment I: Keeping ν constant and V constant, I is changed and for each intensity the corresponding photoelectric current is measured.



The values obtained from the experiment plotted in graph which gives a straight line hence

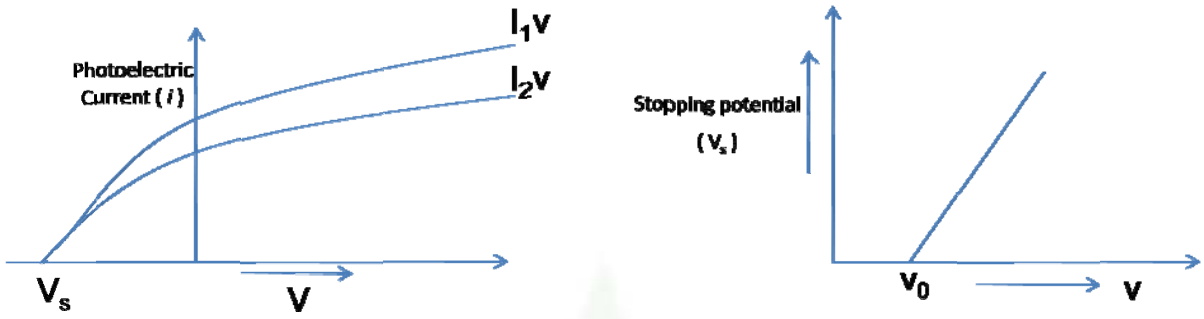
$$i \propto I$$

Experiment II: Keeping I and V constant the frequency of the incident light is varied and corresponding photo electric current is measured and graph is plotted. It is found that for a given emitter there is a minimum value of frequency of light below which no photo electron is emitted exceeding that frequency the photo electric current increases with the increases in the frequency of the light. This minimum value of frequency of the incident light below which no photo electric current is obtained is known as Threshold frequency (v_0). The threshold frequency is different for different emitting surface.



Experiment III: Keeping I and v constant the accelerating potential difference V is changed andthe corresponding photo electric current is measured. It is found that as long as V is (+) Ve i.e. The collector is at (+) ve potential with respect to the emitter i practically remains constant. When V is changed. But when V is (-) Ve i.e. The collector is kept at (-) ve potential with respect to the emitter i decreases rapidly as V become more and more negative and i becomes zero at a particular value of negative potential. This negative potential at which photo electric current becomes zero is known as stopping potential V_s , from the graph we find that the stopping potential V_s does not depend on the intensity of the incident light but depends on the frequency of the incident light and increases linearly with the increase in the frequency.

The above experimental observations are known as laws of photo electric emission.



Laws of photo electric emission:

First law: The photo electric current is linearly proportional to the intensity of incident light.

Second law: For every emitting electrode there is a minimum value of frequency of the incident light below which no photoelectric current is emitted and that frequency is known as threshold frequency.

Third law: The maximum K.E of the emitted photo electro i.e. The stopping potential V_s depends on frequency of the incident light and increases with the increase in frequency.

Fourth law: There is absolutely no time lag between the incidence of the light and the emission of photo electron.