Photoelectric Effect

Aim:-

To determine

i. The threshold frequency for photoelectric emission
ii. Work function of photoemission matter
iii. To calculate the plank’s constant.

Apparatus:-

- Planck’s constant consisting of a photocell
- Mercury vapor lamp
- DC voltage source
- Digital voltmeter
- A set of filters

Introduction

- Photoelectric effect and its experimental verification by Albert Einstein was a major milestone in the history of physics which changed its course- from the classical physics to the quantum mechanics.
- Max Plank's quantum theory helped the development of modern physics.
- Plank's constant "h" and the electronic charge "e" are generally associated together as ratio "h/e".
- There were many attempts even before Einstein to determine this ratio.

Introduction.........

•In 1901 Max plank proved that the energy contained in the photons emitted by a moving electron is directly proportional to its frequency.

•The proportionality constant, called by him as "Quantum of action", is now known as Plank's constant(h). h= 6.26x10-27 ergs/sec.

•Plank received the Nobel Prize in physics in 1918 for this fundamental discovery and it eventually led to many more fundamental discoveries in the field of quantum mechanics.

•The photoelectric effect involves emission of electrons(photoelectrons) from the surface of a material when light impinges on it. It was first observed by Alexander Edmond Becquerel in 1839.

Introduction.........

•Later (1887) Heinrich Hertz and Philipp Lenard (1902) published the first through investigation of photoelectric effect.

•But it was Albert Einstein (1905) who applied quantum mechanics and obtained an expression for the photo electric effect.

•He showed how the photon energy is used to overcome the potential barrier and release electrons from outer orbit of an atom and provide them necessary kinetic energy to move out of the surface of the material and reach a collector where they can be counted in terms of electric current.

•For this invention, he was awarded the 1921 Nobel prize in physics.

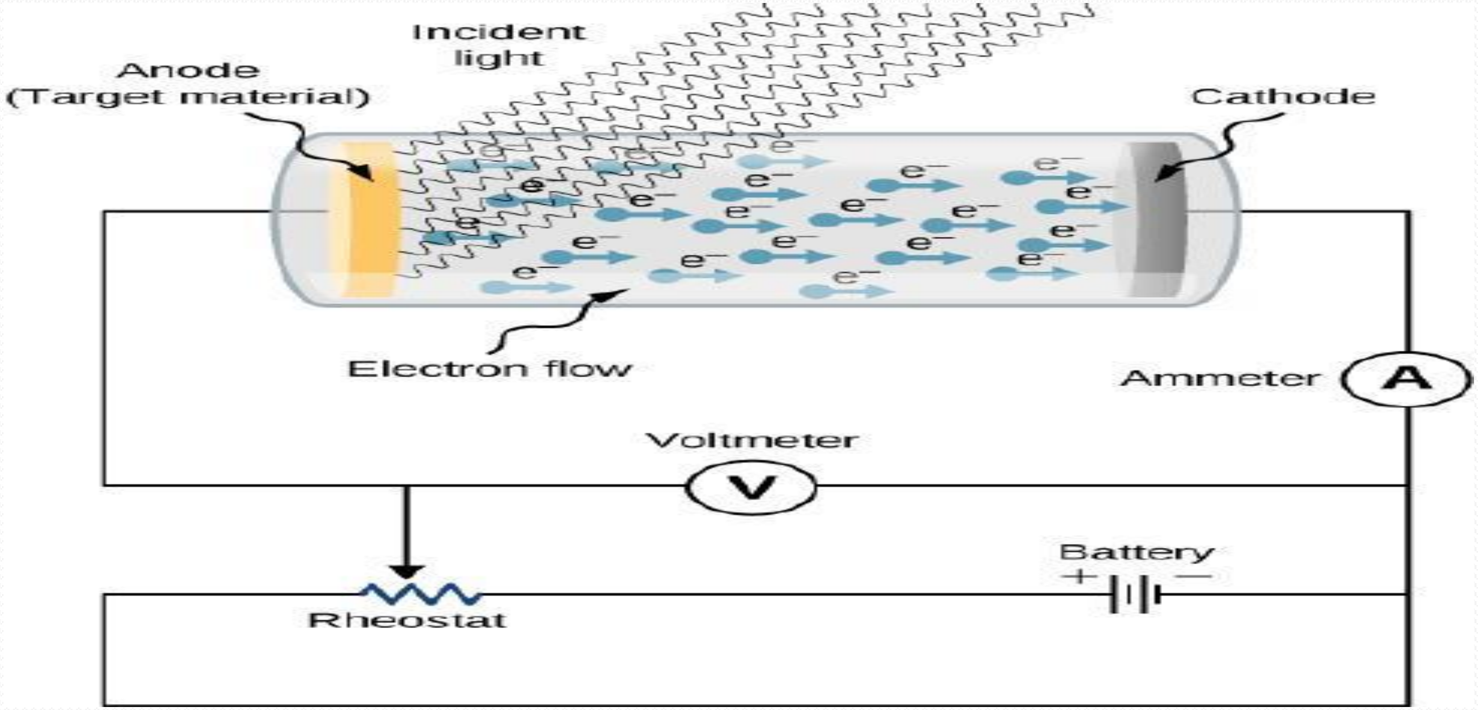

Fig.1 Experimental setup for Photoelectric effect.

Theory:

- Emission of electrons from a metal piece when illuminated by light or any other radiation of suitable frequency(or wavelength) is called photoelectric effect.

- The ejected electrons are called photoelectrons and the directed motions of photoelectrons constitute photoelectric current.

- The magnitude of photoelectric current is directly proportional to the intensity of the incident light.

- The photocell shown in Fig.1 consists of a photosensitive surface called emitter , a collector in an evacuated quartz bulb.

- According to Einstein, when a single photon is an incident on the metal surface, it is completely observed and import its energy is a single electron during collision. The photon energy is utilized for the two purposes.

Theory..........

1. Partly for getting the electron free from the atom and away from the metal surface. This energy is known as photoelectric work function(Φ) of the metal.

2. The balance of the photon energy is used up in giving the electron a kinetic energy There fore einstein photoelectric equation can be written as

$$h\nu = \Phi + \tfrac{1}{2} m v^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots i$$

Note: In case the photon energy is just sufficient to liberate the electron on then

$$h\,\nu_o = \Phi_o \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots ii$$

From both *eq* $K.E = \tfrac{1}{2} m v^2{}_{max} = h(\nu - \nu_o) \ldots\ldots\ldots\ldots iii.$

Increase in frequency of incident light increase the velocity with which photoelectrons are ejected.

Now when the voltage is reverse i.e when the emitter is made positive with respect to collector photoelectric current doesnot immediately drop to zero provided that emitter.

Theory.........

•The retarding potential difference between the two electrods at which the photoelectric current reduced to zero is known as stopping potential.

•Now V_{max} is maximum velocity of emission of a photoelectron and V_o is stoping potential then $½ mv^2_{max} = eV_o$.

• Therefore, Einstein photoelectric equation may be expressed in terms of stopping potential as:

• $h\nu = \Phi + eV_o$ or $h\nu = h\nu_o + eV_o$

•$V_o = h/e (\nu - \nu_o)$

Theory.........

The graph of the equation (4) shown in Fig.2 is straight line with slope h/e when $V_o = 0$.

$h\nu /e = h\nu_o /e$

$\nu = \nu_o$

Therefore, Planks' constant h = e * slope

Work function $\Phi_o = h/e * \nu_o$ or $\Phi_o = slope * \nu_o$

Theory……….

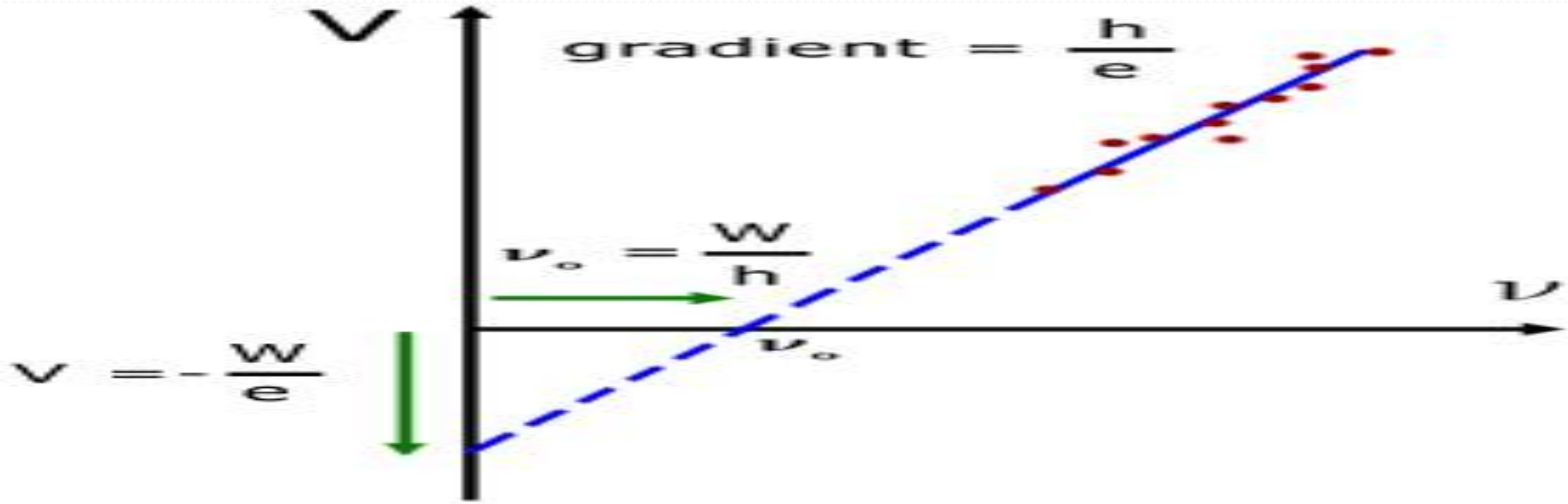

Fig.2 A plot of the photoelectric equation

- The **x-axis intercept** would represent the reciprocal of the threshold wavelength,
- The **slope** would equal the expression (hc/q), and
- The **y-axis intercept** would represent the work function divided by the fundamental charge of an electron.

Procedure:

1. The mode of the swith is kept in reverse position.
2. Filters are arranged in the order of decreasing wavelength.
3. Filter with maximum wavelength is inserted in the slot.
4. The lamp is situated on.
5. When slowly increase the negative voltage required to reduce the photocurrent to zero value and is known as stopping potential.
6. The experiment is repeated for other filter and values for corresponding stopping are required in tabular column.

Observation Table:

Sr.no	Wavelength	Frequency	T1	T2	AVG
1					
2					
3					
4					
5					

Calculation:

h= (slope of the graph) * e.

h=............................Js.

ν_o= ....Hz.

$\Phi_o = h\nu_o$= ....eV

Results:

1. The threshold frequency ν_o= ....Hz.

2. Work function $\Phi_o = h\nu_o$= ....eV

3. Plank's constant h=..........................Js.

Thank you