Photon

-> As we know, to describe the phenomenon of black-body radiation, plank proposed that the emitted radiation from the body is in the form of discrete package which was named quantum. These quantum have definite value of energy also known as photon.

Photon: Discrete package of energy

Energy of photon $(E) = hf$ $(h\nu)$

Rest Mass of photon $(m) = 0$

kinetic mass $(m) = \frac{hf}{c^2} \Big| \frac{h}{\lambda c}$ $\quad [v = \lambda f]$

Momentum $= \frac{hf}{c^2} \times c$

$= \frac{hf}{c} \Big| \frac{h}{\lambda}$

Properties of Photon:

(i) It is the discrete packet of energy.
↳ It is the quanta of energy.

(ii) It is massless particle which means it travels in a straight line with speed 3×10^8 m/s.

(iii) It is chargeless which means it is not deflected by electric & magnetic field.

(iv) The velocity of photon change with change in medium where as the frequency always remains constant.

Frequency never changes. Depends upon source

Metal — Photosensitive EMW (RMIVUXγ)

alkali metals — Francy X - Radioactive hydrogent —

11:30 — 12:15 / 2081

Date ____ Page ____

Photoelectric Effect:- The phenomenon of emission of electron from metallic surface when the light of suitable frequency is incident upon it is called photoelectric effect. The emitted e^- is called photoelectron & the current so produced is called photo current.

. Cesium is most sensitive alkali metal
[Li, Na, K, Rubi, Cesi]

Work function (ϕ_0): It is defined as the minimum value of energy required to knockout the electron from metallic surface. of incident photon

$$\phi_0 = h f_0 \quad \left[\Rightarrow \phi = h\nu_0 \right]$$

where,

f_0 = Threshold frequency

Threshold frequency:- It is defined as the minimum frequency of the incident photon required to knockout electron from metallic surface.

Also, the corresponding energy is called threshold energy which is equivalent to work function.

Threshold wavelength (λ_0):- The maximum ~~frequency~~ wavelength of incident photon required to knockout electron from metallic surface.

Einstein's photoelectric Equation:

This equation is based on the principle of conservation of energy. Einstein used Planck's equation to determine the energy of photon which is

$$E = hf$$

where h = planck's constant
f = frequency

According to him, the energy of the photon is imparted into two part:

1) Some of the energy is used to knockout the electron from the atom.
i.e work function $(\phi_0) = hf_0$
where, f_0 = threshold frequency

2) Rest of the energy is used to increase the kinetic energy of the electron.
i.e $K.E = \frac{1}{2} m v_{max}^2$

Therefore,

$$E = \phi_0 + K.E$$

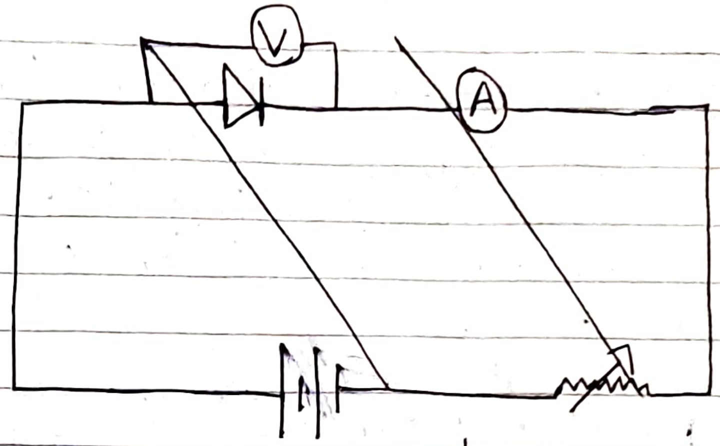
$$\left[hf = hf_0 + \frac{1}{2} m v_{max}^2 \right]$$

$$\frac{1}{2} m v_{max}^2 = hf - hf_0$$

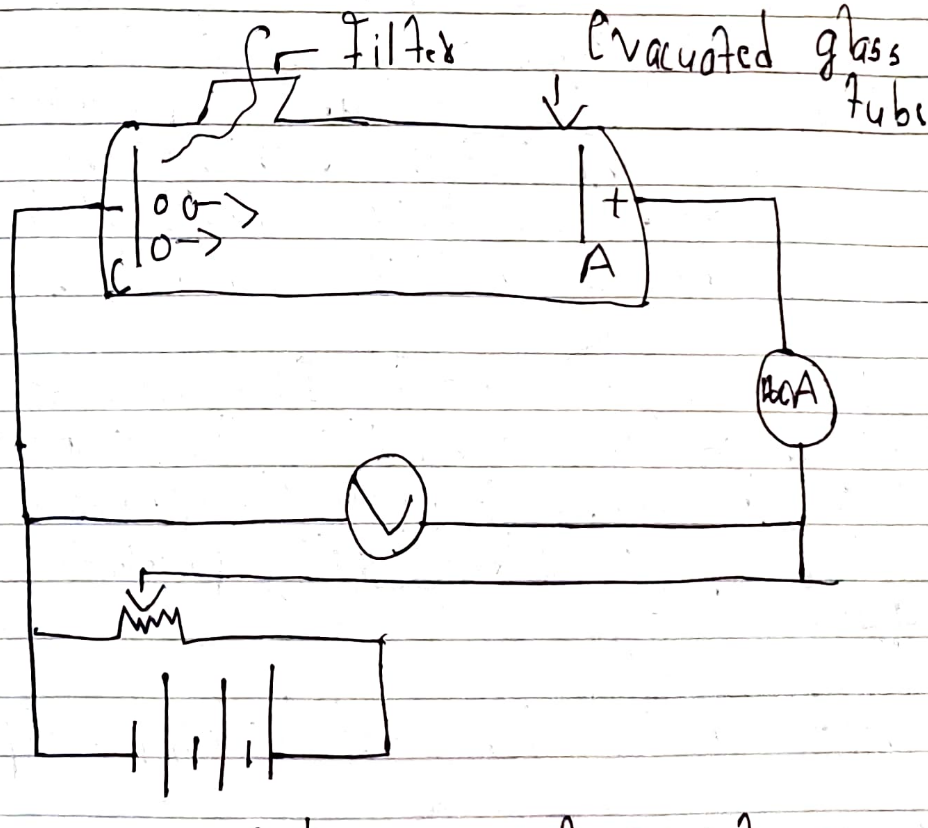
Now, If λ & λ_0 be the corresponding wavelength with f & f_0

$$\frac{1}{2} m v_{max}^2 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$$\frac{1}{2} m v_{max}^2 = hc\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$$



Experimental study of Photoelectric equation.



The experimentally arrangement consists an evacuated glass tube fitted with metal inside. One of the metal acts as cathode (emittor) & another acts as anode (collector).

Furthermore, the tube is equipped with voltmeter, micro ammeter, DC source & rheostat as shown in figure.

Note:- The ~~evacuated~~ evacuated glass tube is maintained at very low pressure & contammination of metal due to the oxide firm production. Here, this firm is produced due to the collison of electron with air molecule.

Accelerating Potential:- It refers to the +ve potential on anode. As the potential is ~~i~~ increased (voltage increase) the value of photoelectric current will also increase till the value of potential at which the photo electric current becomes constant. Here, this constant photoelectric current is called saturation current.

IP Retarding potential:- It refers to the -ve potential on anode. Also, the minimum potential on the anode at which the photoelectric current becomes 0 is called stopping potential / cut off potential (voltage).

At cut off Potential / stopping potential

i.e. $E_{max} = eV_0$

$\frac{1}{2}mv_{max}^2 = eV_0$

$[eV = 1.6\times10^{-19}]$

$E = \phi_0 + KE$

i.e. $E = \phi_0 - E$

$\Rightarrow h\nu_0 - h\nu$

Graphs

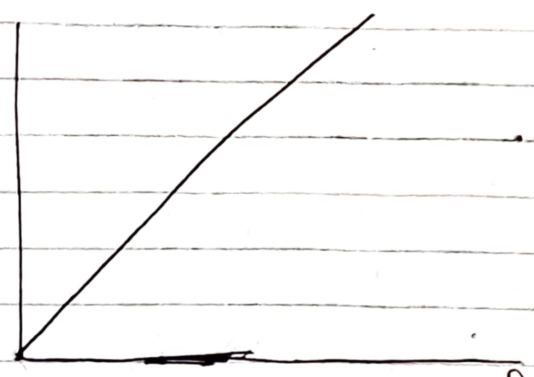
① Effect of intensity on photoelectric current.

Ip

I_p = photoelectric current

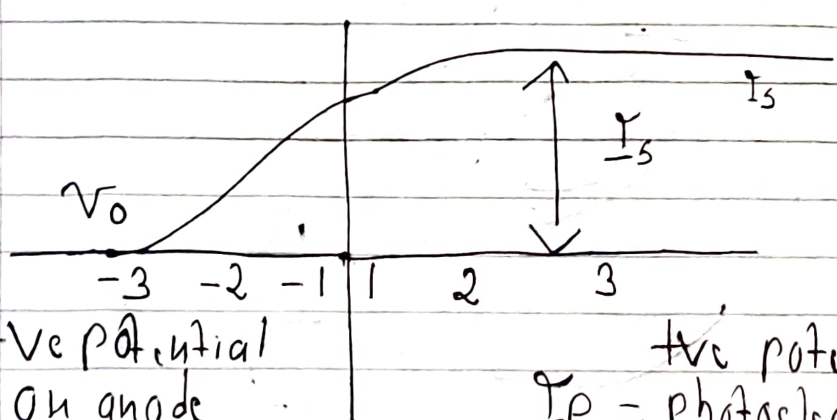
freq is constant

applied potential also constant



Intensity ∝ द (?) = photon ∝ द (?)

② Effect of potential on photoelectric current



-ve potential on anode

+ve potential anode

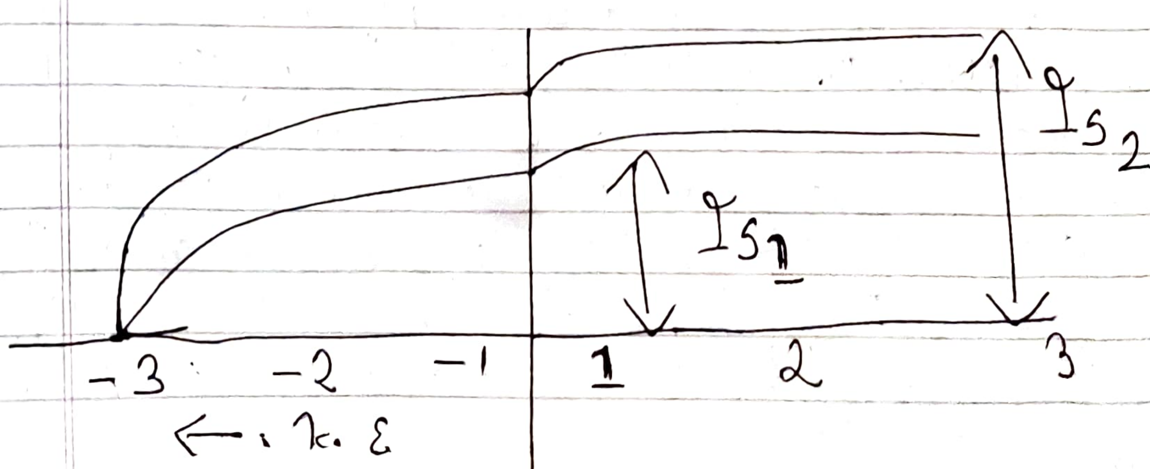
I_p = photoelectric current

V_0 = Stopping potential

I_s = Saturation current

Freq & Intensity constant

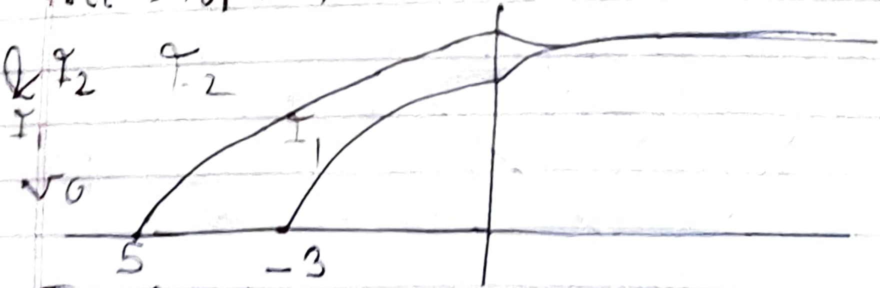
1# Plot the graph of effect of potential on photoelectric current when the light of intensities I_1 & I_2 is incident such that $I_2 > I_1$



Q, I_1 ... Graph of I_c, V ... stopping
(c) Graph of P_c, ϑ f → Saturation current same
f_1 f_2

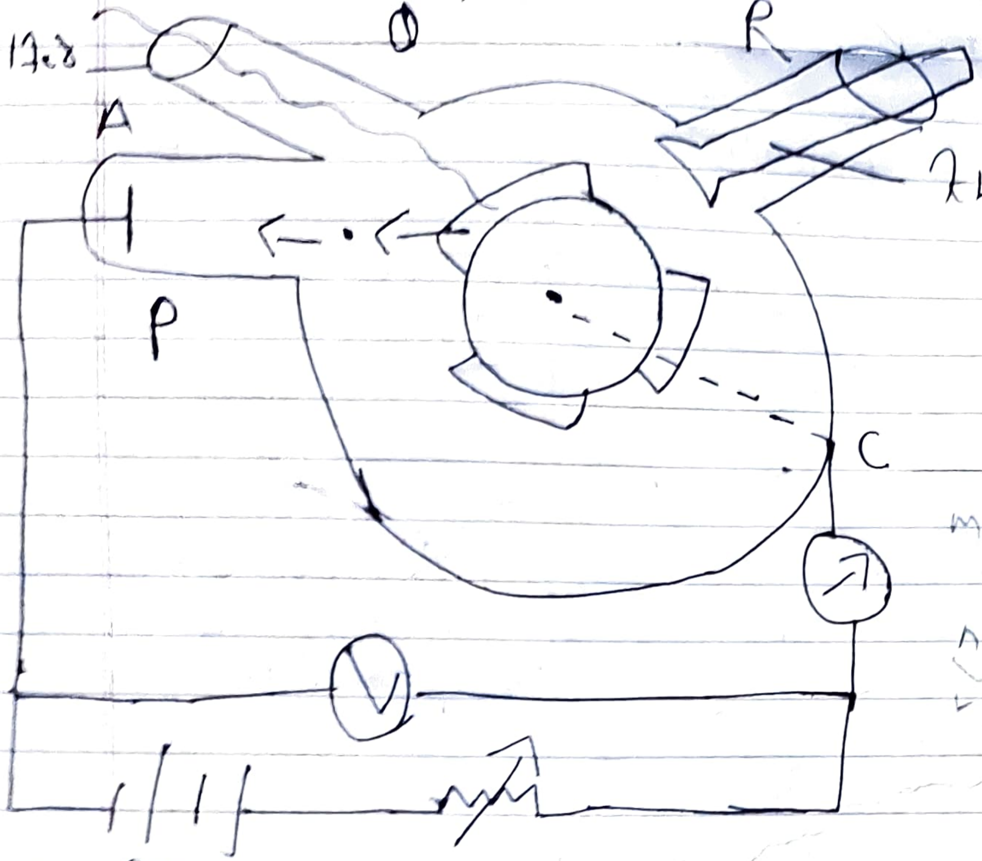
Free stop in PC

I_1 & I_2 I_2
$I_2 > I_1$



Millikan's Experiment:-

→ Determination of value of Plank's constant (h)



m = h/e
h = m e

The experimental setup consists an evacuated glass chamber fitted with Rotating wheel at its center. This wheel is coated with photosensitive metals (Li, Na, ...). It also consists 3 limbs where R consists knife for cleansing, Q consists filter which allow the light to incident on the metal. And limb P consists anode metal as collector. Furthermore, this chamber is also equipped with voltmeter, galvanometer, Rheostat & DC source.

Here, retarding potential is applied to study the variation of stopping potential with the frequency of light.

Now, from the einstein eqn of photoelectric effect,

$\frac{1}{2}mv_{max}^2 = hf - hf_0$ — (i)

Where;

f = freq of light
f_0 = threshold freq
v_{max} = maximum velocity

Again at stopping potential

$\frac{1}{2}mv_{max}^2 = eV_0$ — (ii)

Equating (i) & (ii)

$eV_0 = h(f - f_0)$

~~$h = \frac{eV_0}{f - f_0}$~~

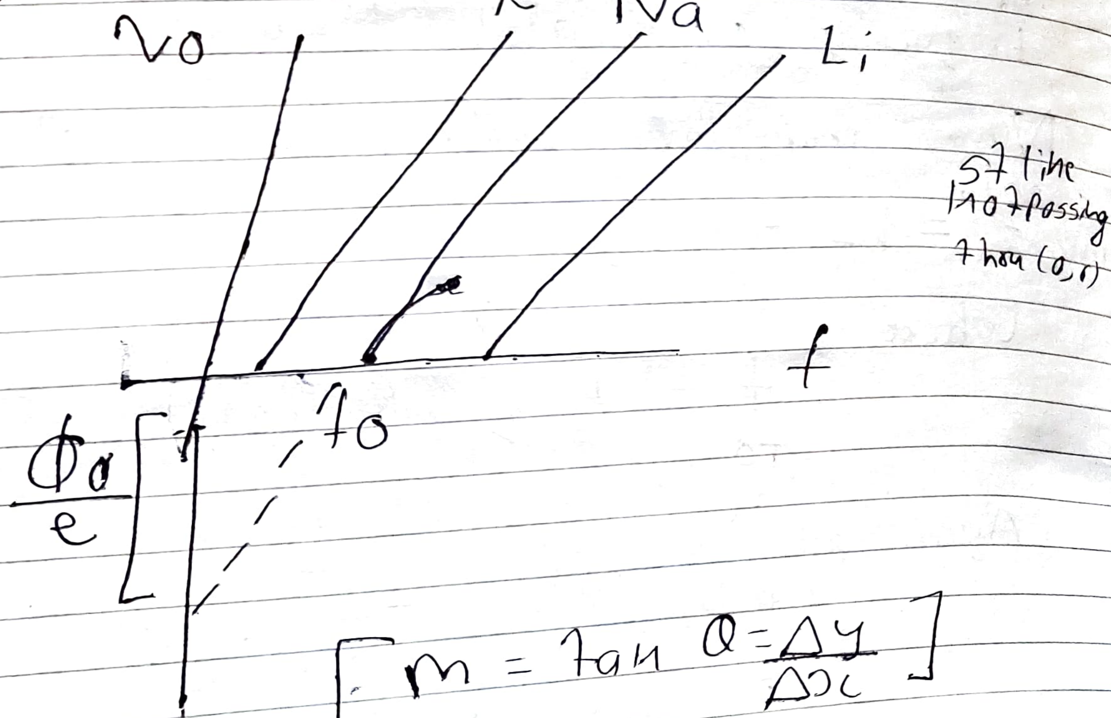
$V_0 = \frac{h}{e}f - \frac{h}{e}f_0$

$V_0 = \frac{hf}{e} - \frac{\phi_0}{e}$

This equation is similar to the equation $y = mx + c$. Where

$y = V_0$
$x = f$
$m = \frac{h}{e}$
$c = -\frac{\phi_0}{e}$

The nature of graph between f & Vo (stopping) is shown below:



VVI

$$\left[m = \tan \theta = \frac{\Delta y}{\Delta x} \right]$$