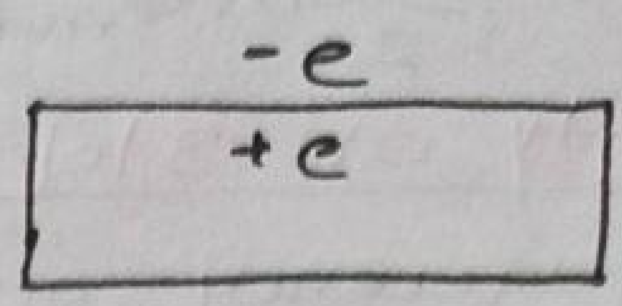
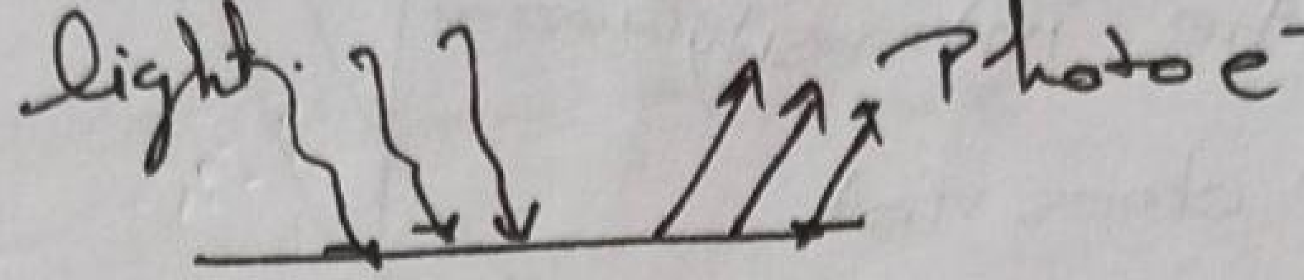
Photo Electric Effect

1) Electron Emission

↓

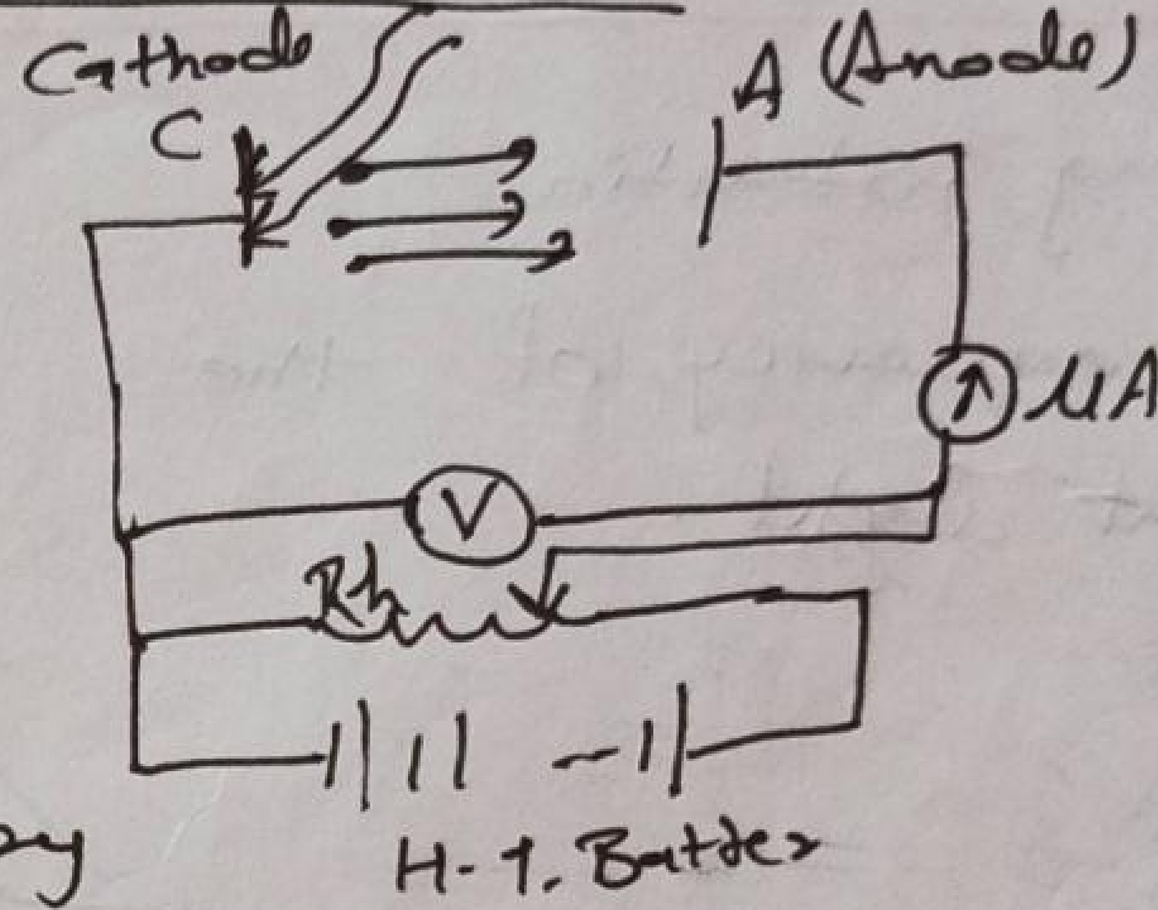
2) Photo electric Emission.



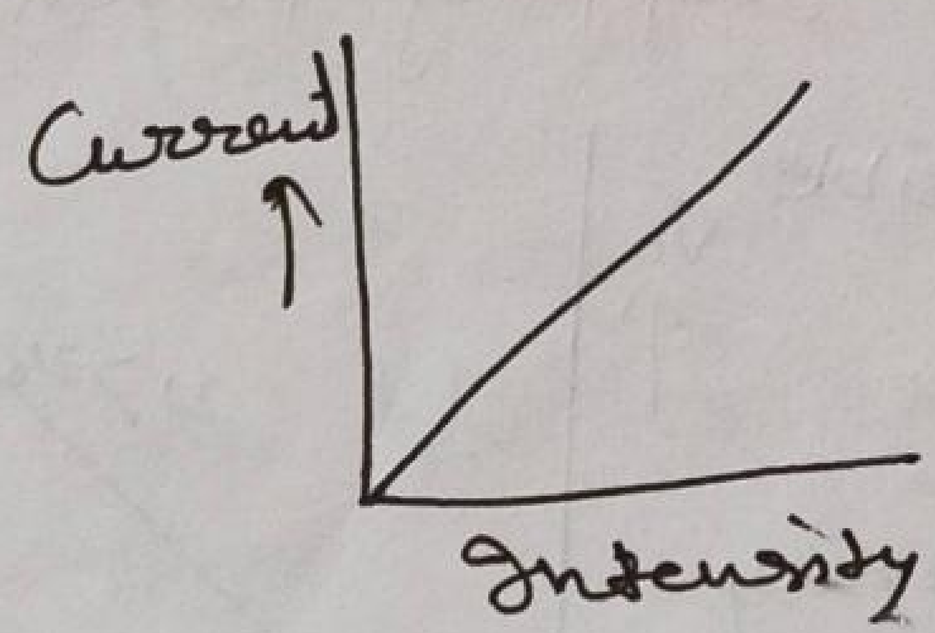


3) Experimental study of Photo electric effect

(i) Effect of Intensity light on Photo electric current



As the intensity of incident light increases, more & more Photo electrons are emitted by the cathode and Photo electric current increases linearly. [keeping the frequency

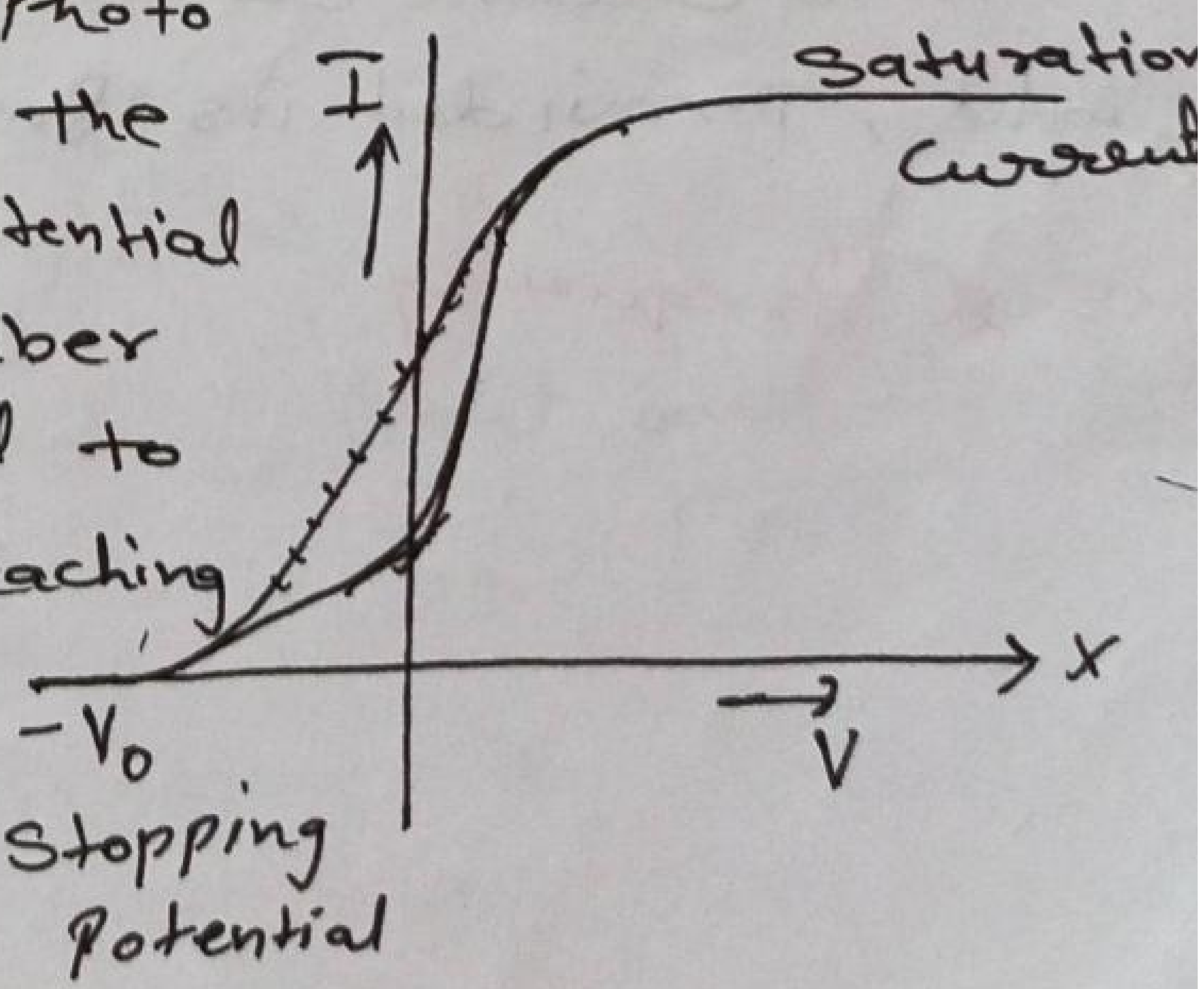


(ii) Effect of Potential on Photoelectric Current :-

For fix frequency & fix Intensity, Photo Electric current increases with the increase in applied +ve Plate Potential

Saturation current :- where number of Photo electron emitted is equal to the number of Photo electron reaching the Plate A.

· And Potential of A Plate decreases.

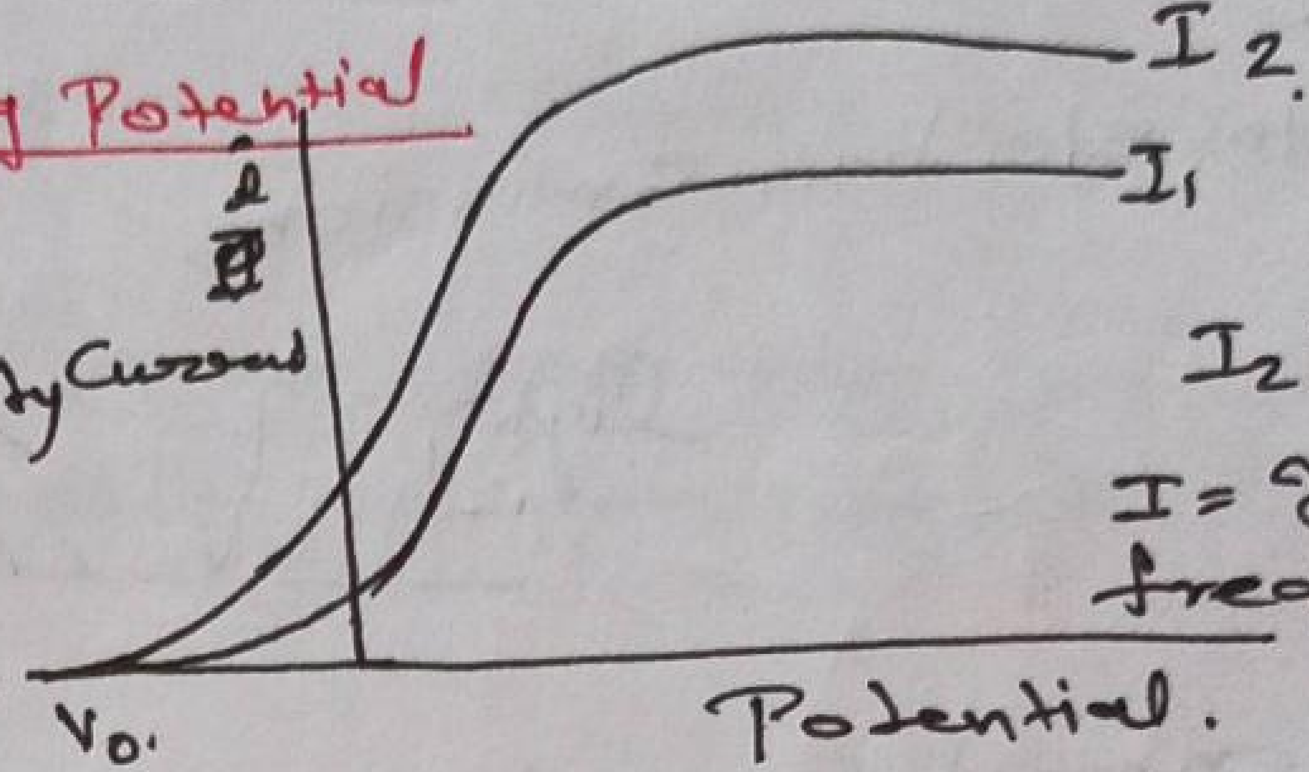


Stopping Potential :- The minimum -ve Potential applied to plate A for which Photo electric current becomes zero OR No Photo electros reach the plate A

In this case $\frac{1}{2}m v_{max}^2 = eV_0$

Effect of Intensity on stopping Potential

* For a given frequency of incident radiation, the intensity of incident radiation does not effect the stopping Potential.

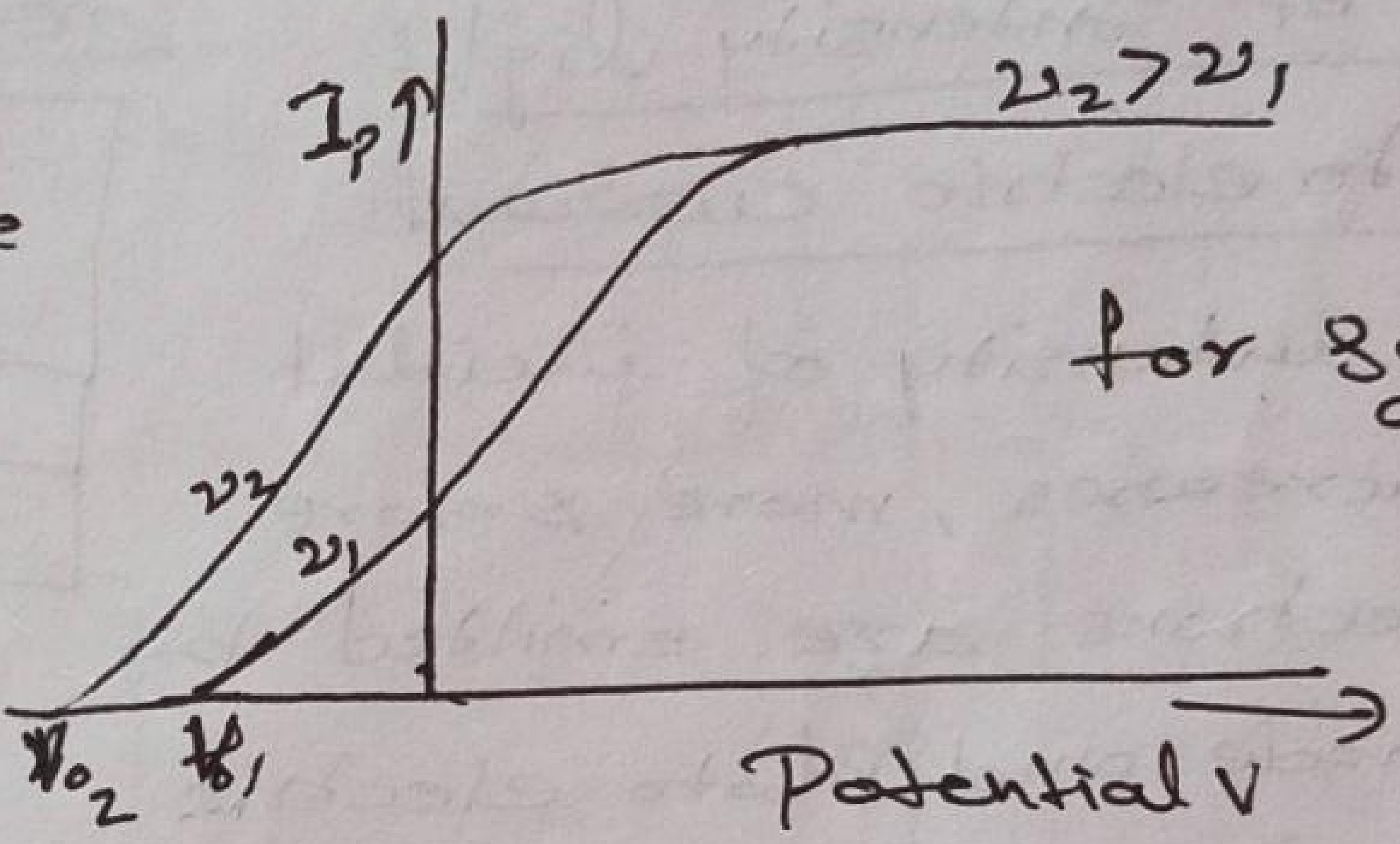


$I_2 > I_1$

I = Intensity frequency fix.

Effect of frequency of Incident light on stopping potential

Stopping Potential $\propto$ frequency of the incident light.

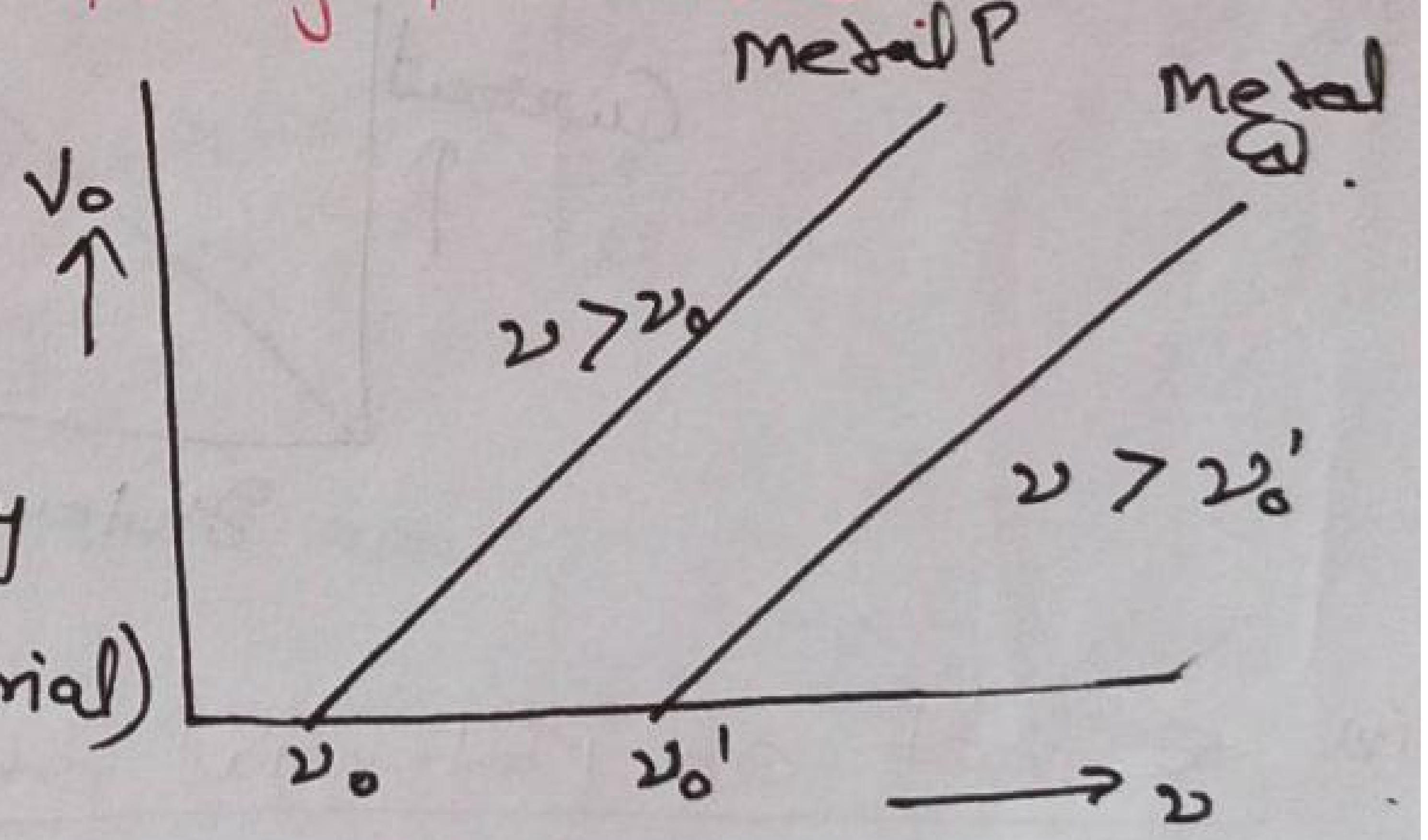


for same Intensity

Graph for frequency and stopping Potential

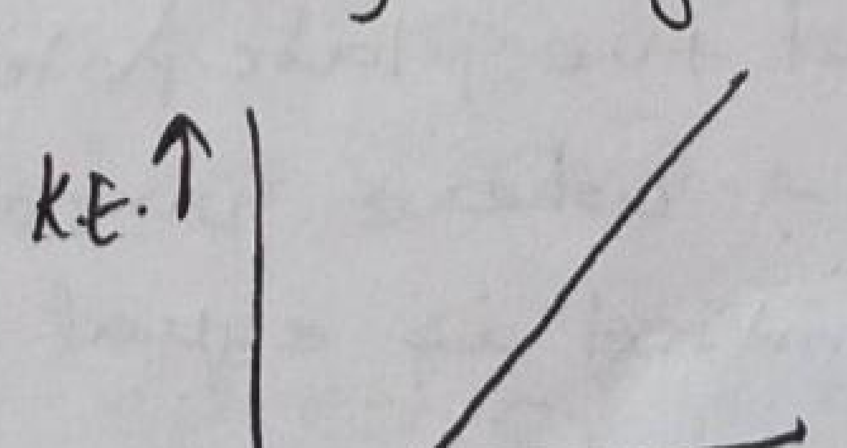
*· No photoemission is Possible below cut off frequency

* Stopping Potential $\propto$ frequency (differently for different material)



* Photo electric current depend upon the intensity of light, Provided its frequency is greater than threshold freq

K.E & frequency.



Plank's Hypothesis :- Planck Postulated that light consis of tiny bundles of energy called quanta. and each energy of quanta or photon is $E = h\nu$.

Einstein's theory :- The energy of Photon is used in tw ways.

(i) It is used by the electron to cross the surface barrie to come out the metal surface. known work function

(ii) K.E. of emitted photon.

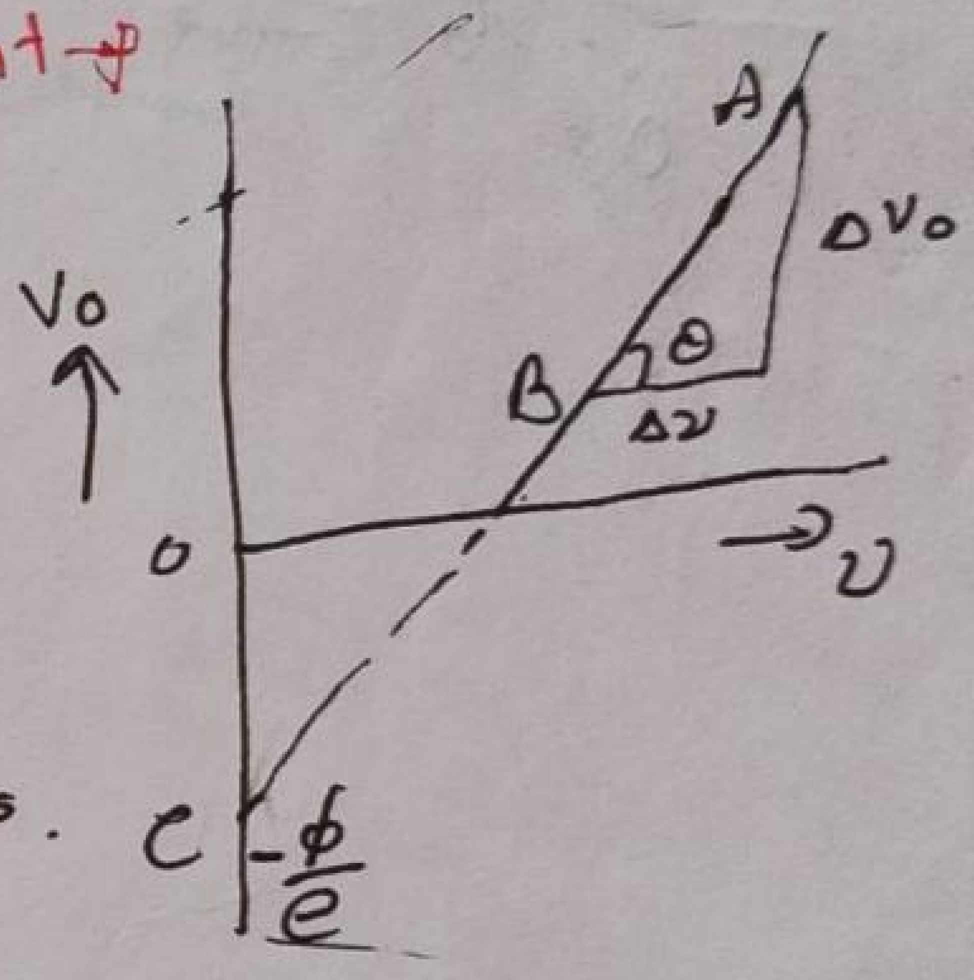
$$h\nu = W + \frac{1}{2}mv^2$$

If $\nu = \nu_0$ $\quad \frac{1}{2}mv^2 = 0$

$$W = h\nu_0.$$

$$\boxed{\frac{1}{2}mv^2 = h\nu - h\nu_0}$$

Determination of Planck's constant :-



$$\frac{1}{2}mv_{max}^2 = h(\nu - \nu_0) = eV_0.$$

$$eV_0 = h(\nu - \nu_0)$$

$$V_0 = \left(\frac{h}{e}\right)\nu - \left(\frac{h}{e}\right)\nu_0 = \frac{h}{e}\nu - \frac{\phi_0}{e}$$

$\phi_0 = h\nu_0$.

Compare with $y = mx + C$.

$m = h/e$ & $OC = -(\phi/e)$

slope $\qquad$ Intercept on Y axis

$$\frac{h}{e} = \tan\theta = \frac{\Delta V_0}{\Delta\nu}, \quad h = e\tan\theta$$

$\boxed{h = e\tan\theta}$ = $e \times$ slope of V_0 versus ν graph

for work function $OC = -\frac{\phi}{e}$

OC = Intercept on y axis

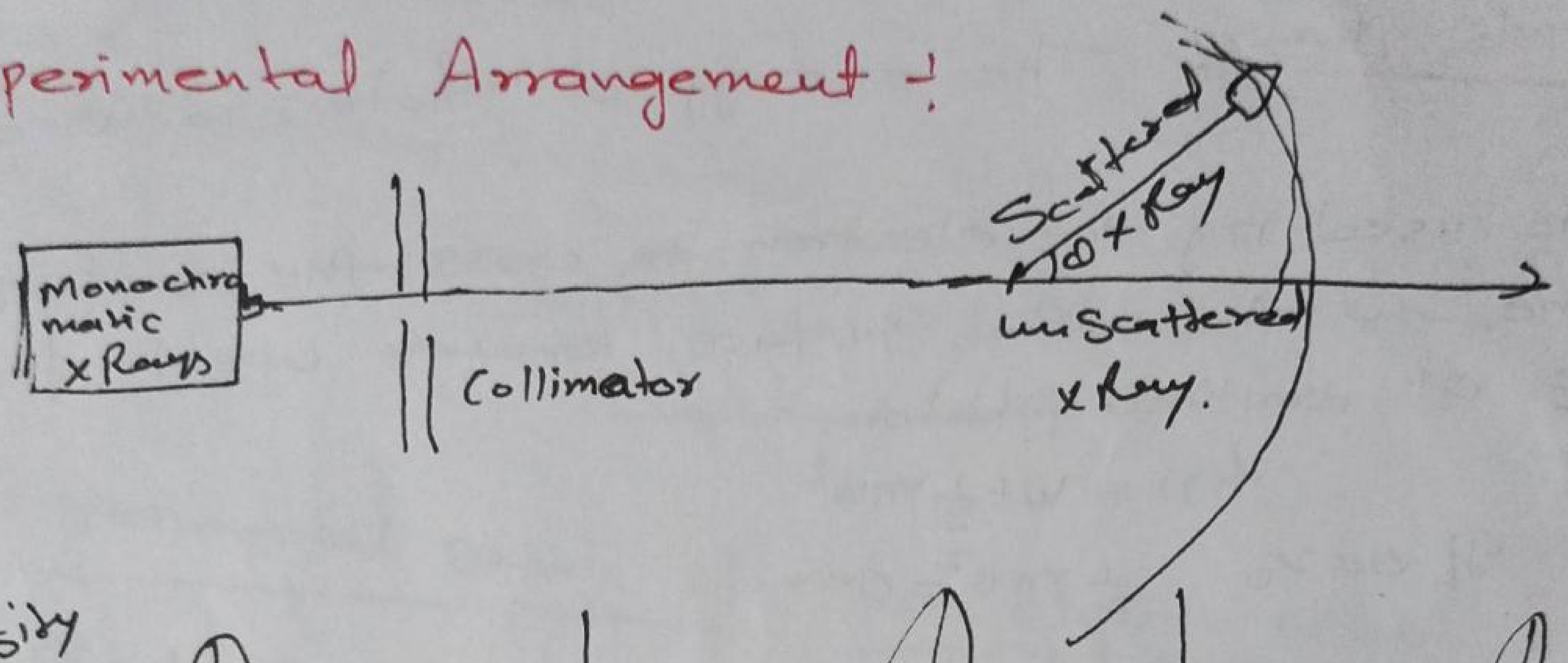
* Photon travels with speed of light and its has zero rest mass

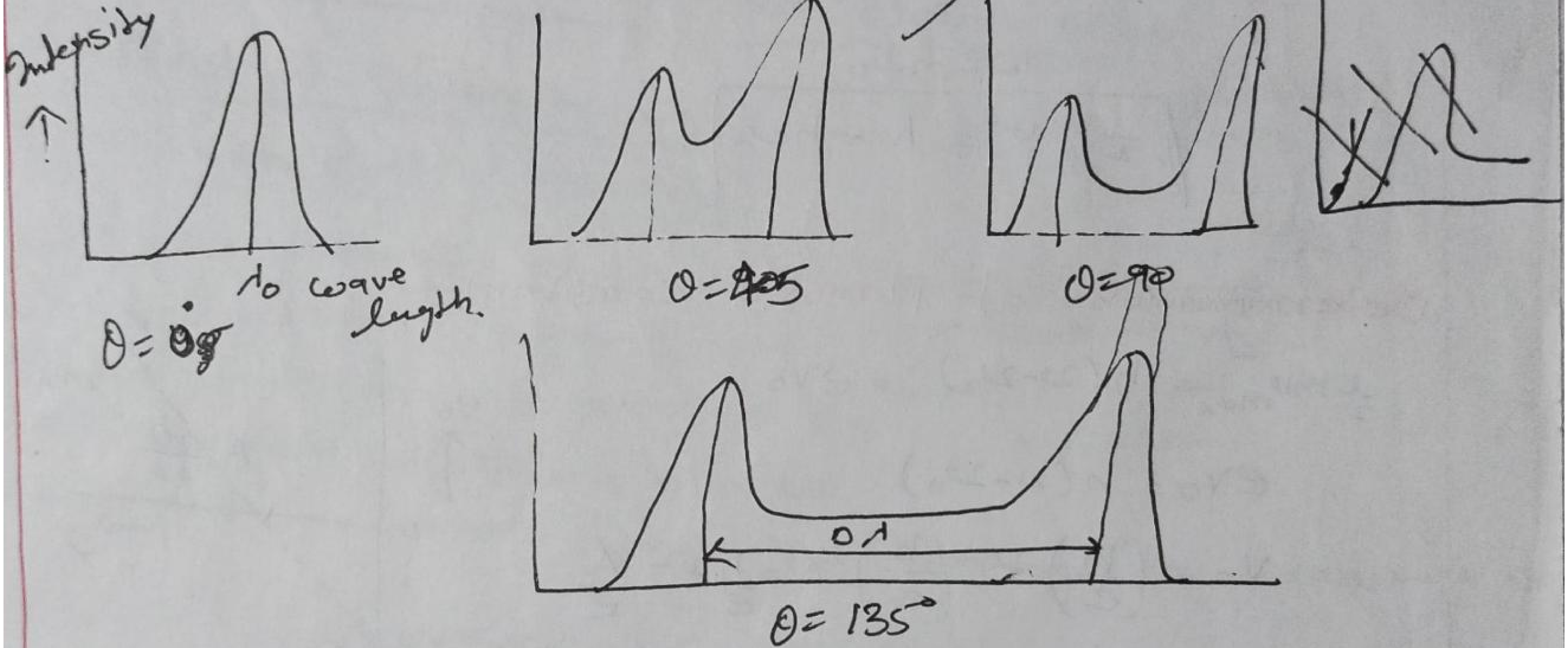
$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}, \quad m_0 = 0 \quad \boxed{v = c}$$

Energy of a photon depends upon the frequency of th radiation so energy of the photon does not change fro one medium to another

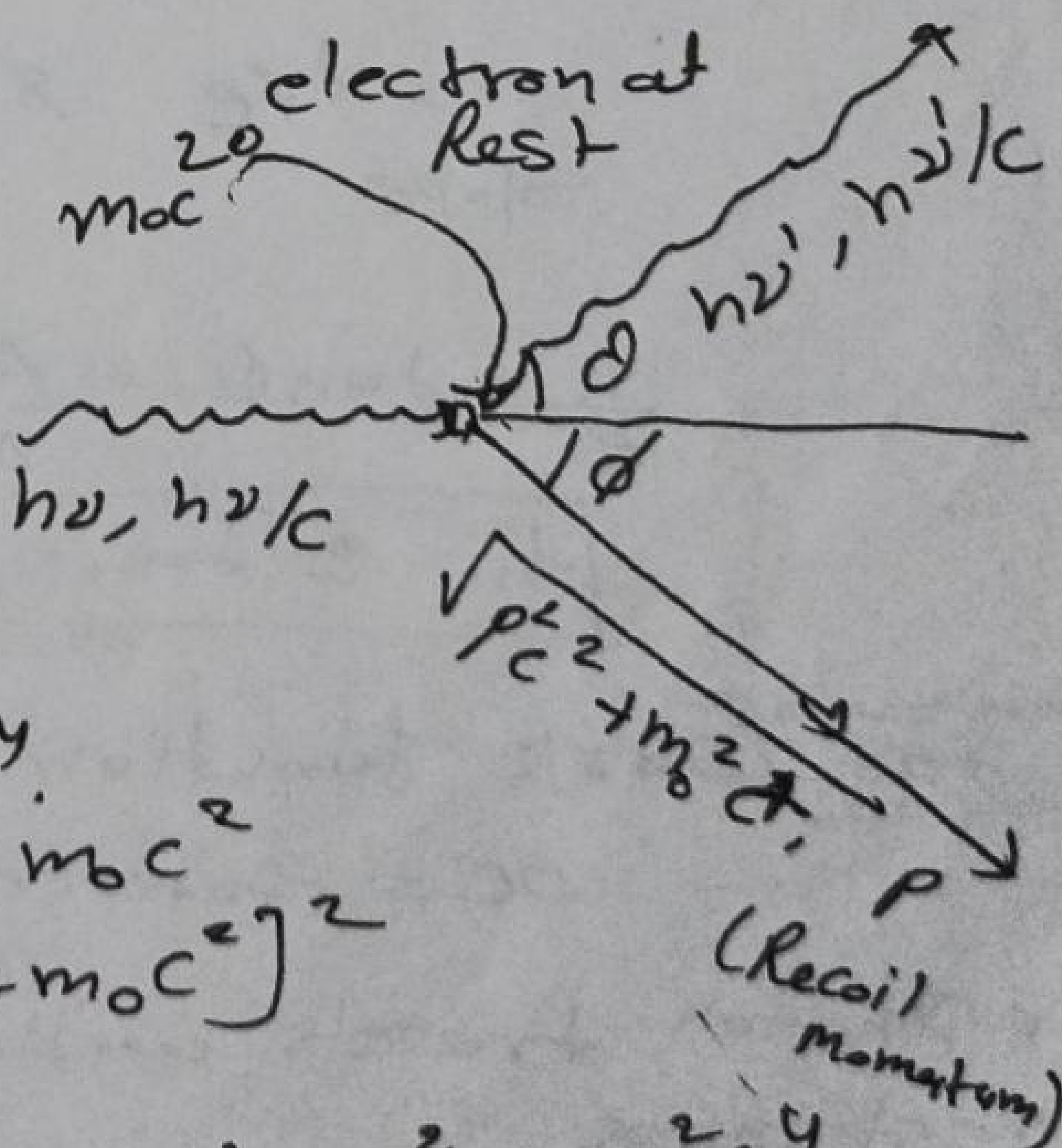
Compton Effect : Compton provided most conclusive confirmation of the particle aspect of radiation. By scattering x ray off free electron, the wave length of scattered radiation > wave length of Incident Radiation

Experimental Arrangement :





Explanations :



Scattering Process treated as elastic Collision.

energy of e^- at rest $E_1 = m_0c^2$

After Recoil $E_2 = (p^2c^2 + m_0^2c^4)^{1/2}$

law of conservation of energy

$$h\nu' + (p^2c^2 + m_0^2c^4)^{1/2} = h\nu + m_0c^2$$

$$p^2c^2 + m_0^2c^4 = [h(\nu - \nu') + m_0c^2]^2$$

$$p^2c^2 + m_0^2c^4 = h^2(\nu - \nu')^3 + 2h(\nu - \nu')m_0c^2 + m_0^2c^4$$

$$\frac{p^2c^2}{h^2} = (\nu - \nu')^2 + \frac{2m_0c^2}{h}(\nu - \nu')$$

Scanned by TapScanner

law of conservation of momentum.

$$p\cos\phi + \frac{h\nu'}{c}\cos\theta = \frac{h\nu}{c}$$

$$p\sin\phi = \frac{h\nu'}{c}\sin\theta$$

or $$\frac{pc}{h}\cos\phi = \nu - \nu'\cos\theta$$

$$\frac{pc\sin\phi}{h} = \nu'\sin\theta$$

$$\frac{p^2c^2}{h^2} = (\nu - \nu'\cos\theta)^2 + \nu'^2\sin^2\theta.$$

$$= \nu^2 - 2\nu\nu'\cos\theta + \nu'^2$$

$$= (\nu - \nu')^2 + 2\nu\nu'(1-\cos\theta) \quad \text{—— B}$$

$$\frac{2m_0c^2}{h}(\nu - \nu') = 2\nu\nu'(1-\cos\theta)$$

$$\frac{\nu - \nu'}{\nu\nu'} = \frac{h}{m_0c^2}(1-\cos\theta) \quad \text{or} \quad \frac{1}{\nu'} - \frac{1}{\nu} = \frac{h}{m_0c^2}(1-\cos\theta)$$

$$\nu' = \frac{c}{\lambda'}, \quad \nu = \frac{c}{\lambda} \quad \& \quad \nu' = \frac{c}{\lambda'} \quad \nu = \frac{c}{\lambda}$$

$$\boxed{\Delta\lambda = \lambda' - \lambda = \frac{h}{m_0c}(1-\cos\theta)}$$

Compton shift

or $$\Delta\lambda = \frac{2h}{m_0c}\sin^2\theta/2$$

The value of $\frac{h}{m_0c}$ is called Compton wave-length of the electron. $\frac{h}{m_0c} \simeq 0.0242\,Å$.