ARJUNA NEET BATCH

Structure of Atom

LECTURE - 5

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Quick Recap

Light

Particle — (Discontinous)

Wave — (Continous)

Cosmic < γ < X < UV < Visible < IR < Micro < Radio λ ↑

⇒ Planck's

⇒ $E \propto \nu$

$\because \nu = \frac{c}{\lambda}$

⇒ $E = h\nu$

$c \rightarrow$ speed of light

⇒ $E = \frac{hc}{\lambda}$

$\rightarrow 3 \times 10^8\, m/s$

$$\boxed{E = n h\nu}$$

$\Rightarrow E = nh\nu$

$\Rightarrow \text{Power} = \dfrac{\text{Energy}}{\text{Time}}$

$\Rightarrow \dfrac{nh\nu}{T}$

$\Rightarrow \dfrac{n}{T}\left(h\nu\right)$

$h :\rightarrow$ Planck's constant

$\Rightarrow 6.626 \times 10^{-34}$ Js

$c :\rightarrow 3 \times 10^{8}$ m/s

$\Rightarrow E = \text{Joule}$ $\quad \lambda \Rightarrow m$

$$\underline{\underline{hc \Rightarrow 2 \times 10^{-25}}}$$

$\Rightarrow E \Rightarrow eV \Rightarrow ?$ $\quad hc = 12400$

$\lambda = A^{\circ}$

Objective of today's class

PHOTOELECTRIC EFFECT

⇒ Black-Body Radiation

$E \propto \nu$

Heat is form of Energy.

$E \propto \nu$

□ → Red, orange, yellow, Blue, violet

$\lambda \uparrow \quad \nu \downarrow$

Cosmic γ X UV Visible IR Micro Radio

V I B G Y O R

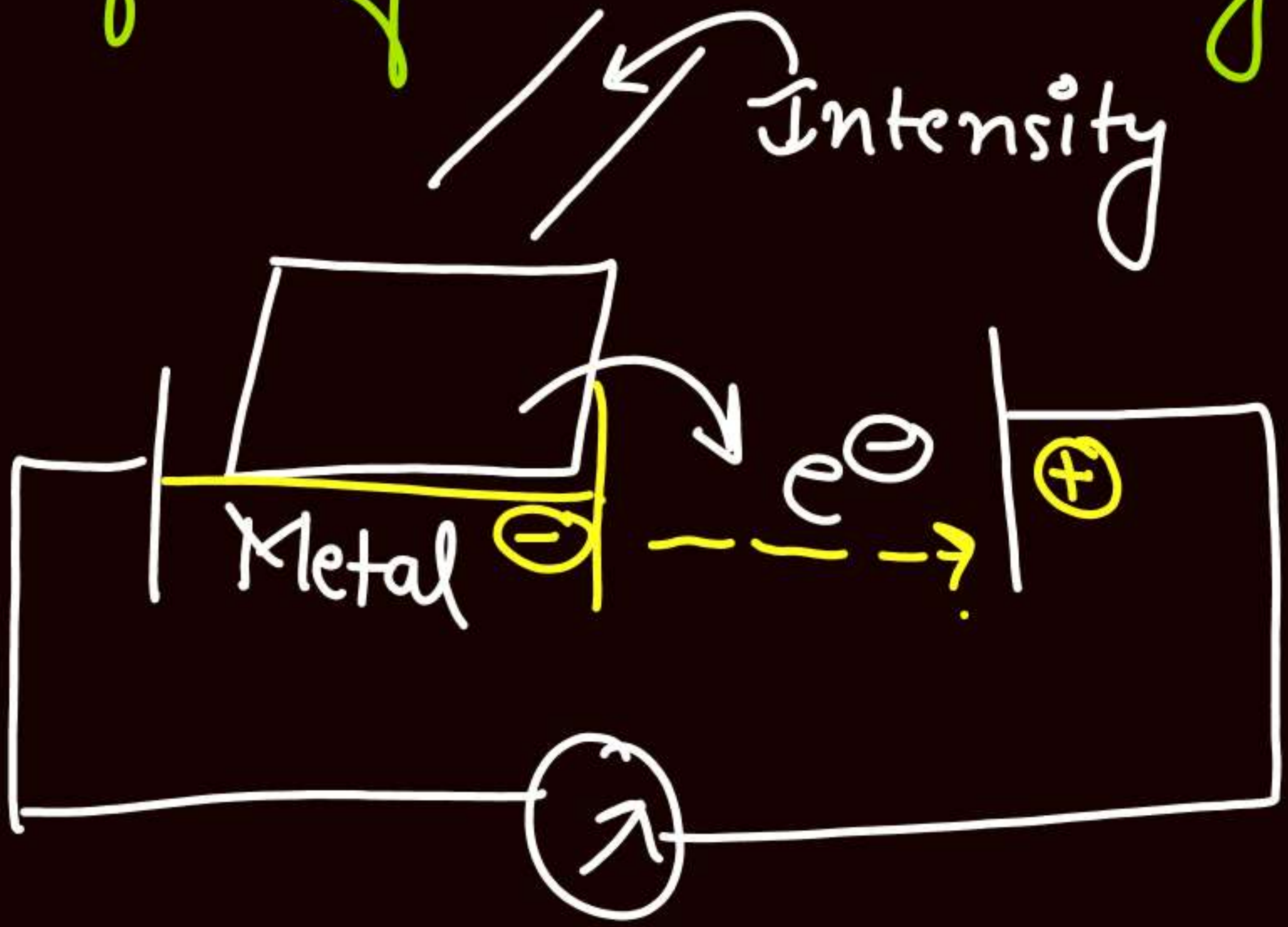
$\nu \uparrow$

PHOTOELECTRIC EFFECT

light

current

flow of current due to light



Photoelectric Equation

$$E_i = E_0 + K.E.$$

or

ω

or

ϕ

$\because E = h\nu$

$$K.E. = E_i - E_0$$

$$\boxed{K.E. = h\nu_i - h\nu_0}$$

$$K.E. = \frac{hc}{\lambda_i} - \frac{hc}{\lambda_0}$$

$$K.E. = hc\left[\frac{1}{\lambda_i} - \frac{}{\lambda_0}\right]$$

$$K.E. = \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2 = hc\left[\frac{\lambda_0 - \lambda_i}{\lambda_i \lambda_0}\right]$$

$$V^2 = \frac{2hc}{m}\left[\frac{\lambda_0 - \lambda_i}{\lambda_i \lambda_0}\right]$$

$$\boxed{V = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda_i}{\lambda_i \lambda_0}\right)}}$$

$V \rightarrow$ Velocity

$h \rightarrow$ planck's constant

$c \rightarrow$ velocity of light

$\lambda_0 \rightarrow$ threshold wavelength

$\lambda_i \rightarrow$ Incident wavelength

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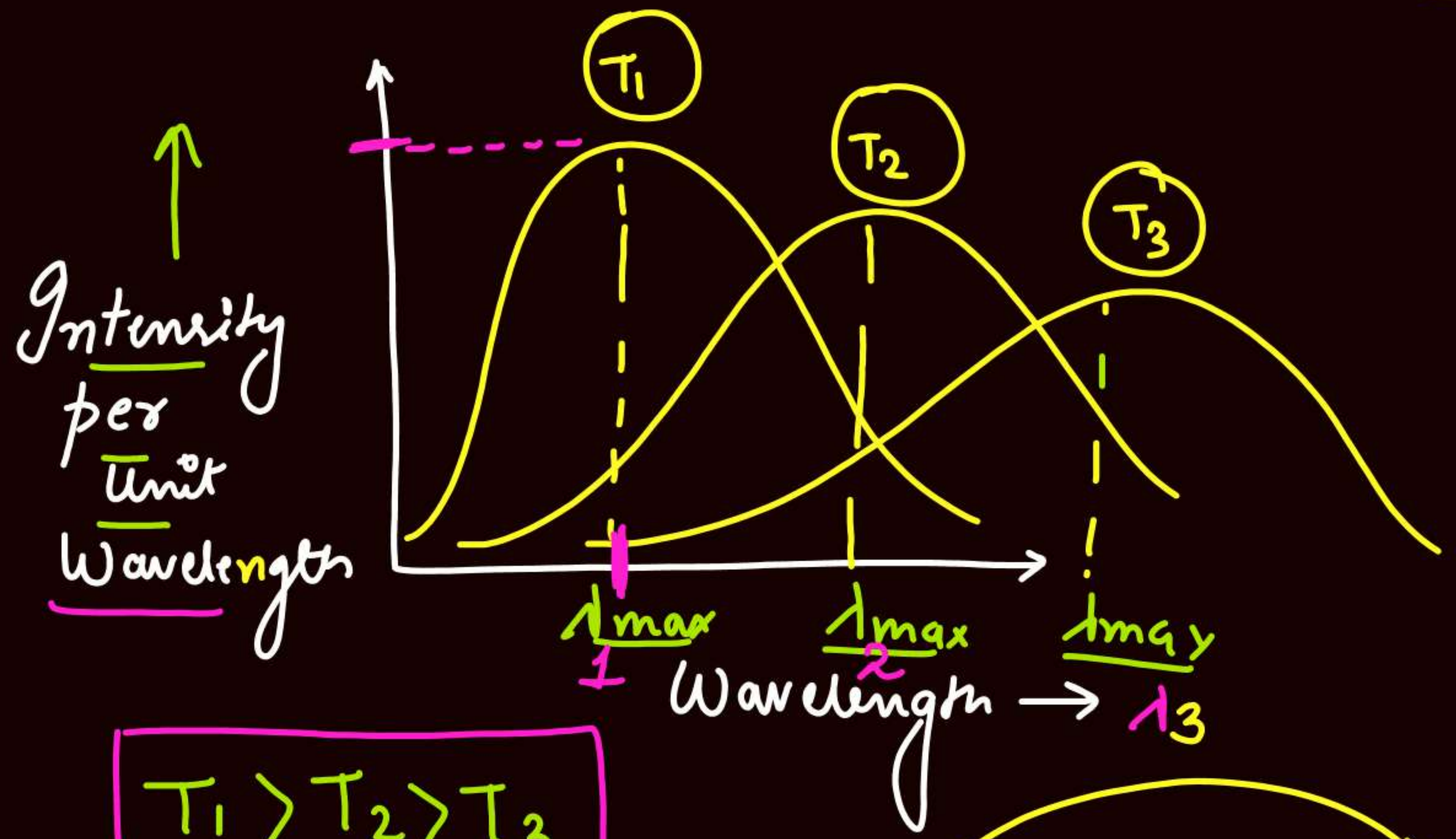
EVIDENCE IN SUPPORT OF PLANK'S QUANTAM THEORY (Particle NATURE)

BLACK BODY RADIATION :-

- The body which absorb & emits all types of radiation is caused BLACK BODY and radiations emitted by that body is known as BLACK BODY RADIATION.
- There is no ideal black body for $\boxed{\text{Eg:- Iron (Fe)}}$
- At a given temperature which ↓ in wavelength, intensity of emitted radiation first ↑ to max. and then start decreasing with ↓ in wavelength.
- At a given high temperature with further ↑ in temperature its colour almost remains same but its glow increases.



$\Rightarrow \boxed{E \propto \nu \propto \frac{1}{\lambda}}$

$E \propto \nu$

$\Rightarrow \lambda_{max} \uparrow \; E \downarrow$

$\boxed{T_1 > T_2 > T_3}$

$\boxed{E_{high} \rightarrow \lambda_{Low}}$

$\lambda_3 > \lambda_2 > \lambda_1$

~~$E \propto \nu$~~

Fe body

$T \uparrow$

Red, orange, yellow ---- Blue --- Violet

Heat is a form of energy

$T \uparrow$

$\lambda \uparrow, \nu \downarrow$

Cosmic γ X UV Visible IR Micro Radio

VIBGYOR

$\nu \uparrow$

PHOTOELECTRIC EFFECT

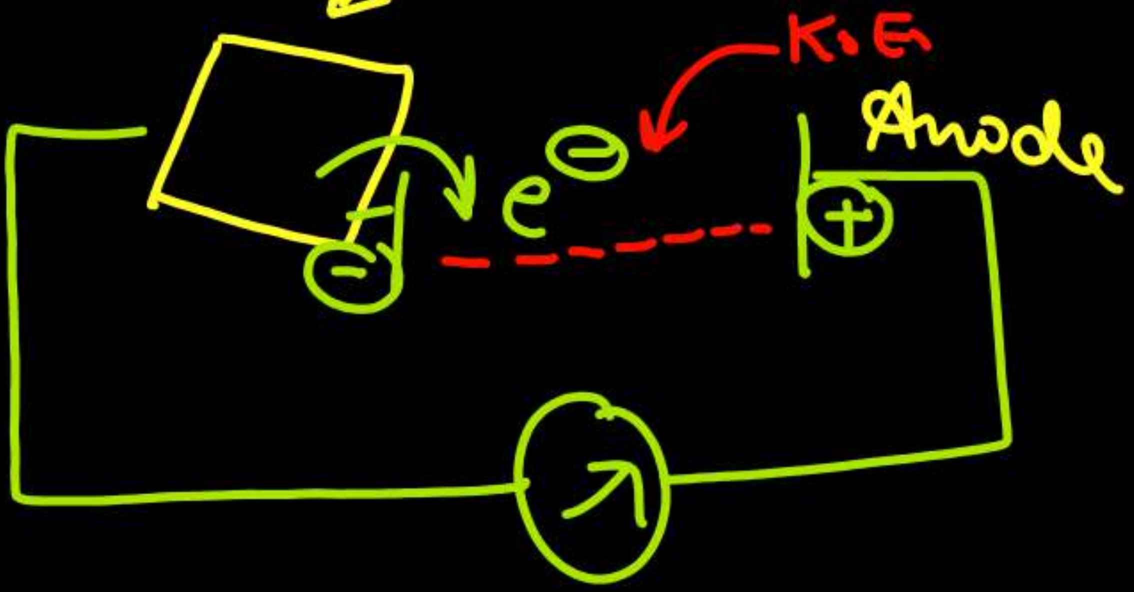
Photo – Light

Electric – Current

⇒ **Flow of current due to light** → Photoelectric Effect

$$\boxed{E_i = E_0 + K.E.}$$

Incident Energy (E_i)



electron

When the light is incident on metal surface then $e^{\ominus}$ is ejected out from metal surface and from metal surface and $e^{\ominus}$ move between cathode and anode and current produces known as PHOTOCURRENT and effect is termed as PHOTOELECTRIC EFFECT.

THRESHOLD ENERGY/ WORK FUNCTION:- (E_0, ϕ, ω)

Minimum amount of energy required to eject $e^{\ominus}$ out of metal surfaces.

E_0 or ϕ or ω

$\boxed{E = h\nu_0}$

$E = \frac{hc}{\lambda}$

THRESHOLD FREQUENCY :- (v_0)

(ν_0)

Minimum amount of frequency required to remove $e^{\ominus}$ from metal surface.

THRESHOLD WAVELENGTH:-(λ_0)

Maximum amount of wavelength required to remove $e^{\ominus}$ from metal surface.

$E \propto \frac{1}{\lambda}$ $\quad E = \frac{hc}{\lambda}$

or

$E \propto \nu$ $\quad E = h\nu$

CONDITION TO EJECT $e^{\ominus}$ OUT :-

(i) $\boxed{E_i, \geq E_o / \phi / \omega}$

E_i = Incident Energy

$E_o / \phi / \omega$ = Threshold Energy

$E_i \geq E_0$

(ii) $\boxed{V_i \geq V_o}$

(iii) $\boxed{\lambda_I \leq \lambda_o}$

$\nu_i \rightarrow$ Incident frequency

$\nu_0 \rightarrow$ Threshold frequency

$\lambda_i \rightarrow$

Conditions for PhotoElectric Effect

① $\Rightarrow E_i > E_0$

② $\Rightarrow \nu_i > \nu_0$

③ $\Rightarrow \lambda_i < \lambda_0$

$E_i = E_0 + K.E_0$

PHOTOELECTRIC EQUATION

$\Rightarrow E_i = E_0 + K.E.$

$\Rightarrow \boxed{K.E. = E_i - E_0}$

$\Rightarrow \boxed{K.E. = h\nu_i - h\nu_0}$

$E_i = \dfrac{hc}{\lambda_i} \leftarrow E_i = h\nu_i$

$E_0 = h\nu_0$

$E_0 = \dfrac{hc}{\lambda_0}$

$$\Rightarrow K.E. = h\nu_i - h\nu_0$$

$$\Rightarrow K.E. = \frac{hc}{\lambda_i} - \frac{hc}{\lambda_0}$$

$$\because K.E. = \frac{1}{2}mv^2$$

$$\Rightarrow \frac{1}{2}mv^2 = hc\left[\frac{1}{\lambda_i} - \frac{1}{\lambda_0}\right]$$

$$\Rightarrow v^2 = \frac{2hc}{m}\left[\frac{\lambda_0 - \lambda_i}{\lambda_i \lambda_0}\right]$$

$$\boxed{\Rightarrow v = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda_i}{\lambda_i \lambda_0}\right)}}$$

NOTE:- Photon can cause ejection of only 1 $e^{\ominus}$.

Therefore no. of $e^{\ominus}$ depends on no. of photons per Unit area (INTENSITY)

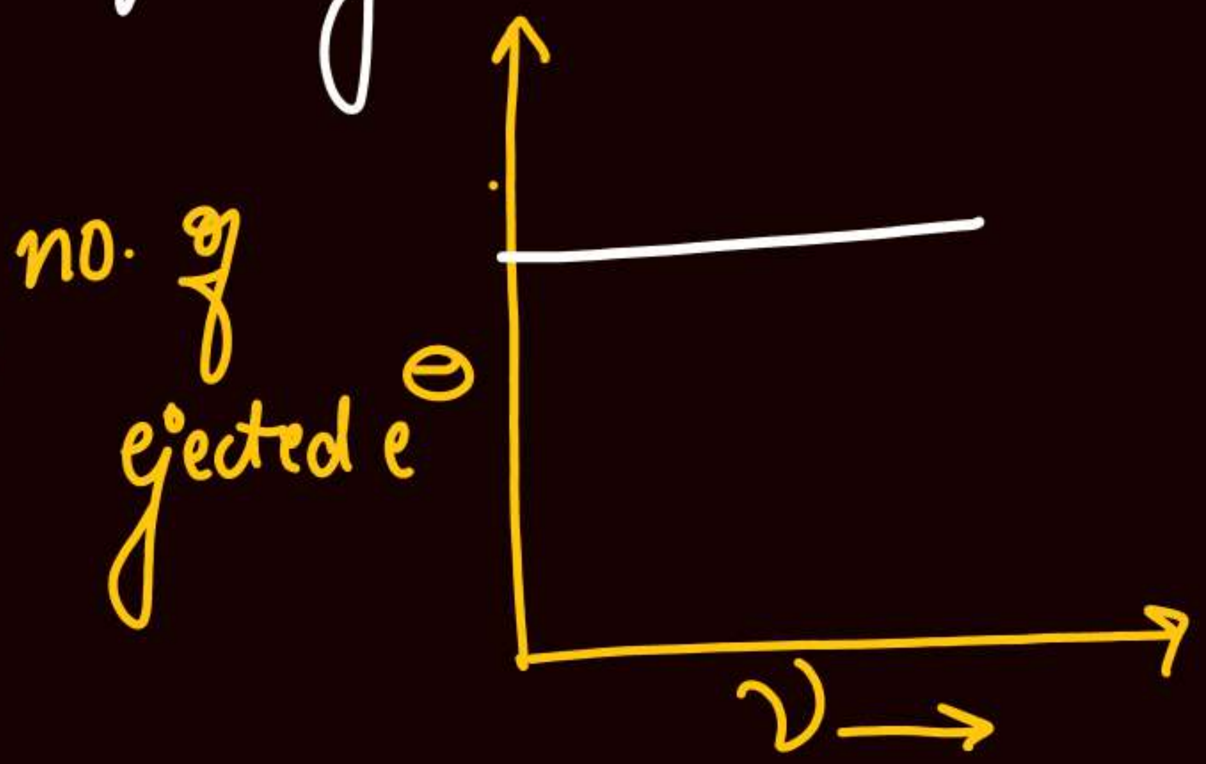
$\Rightarrow$ K.E. of $e^{\ominus}$ depends on energy of Photon & is independent on Intensity of light.

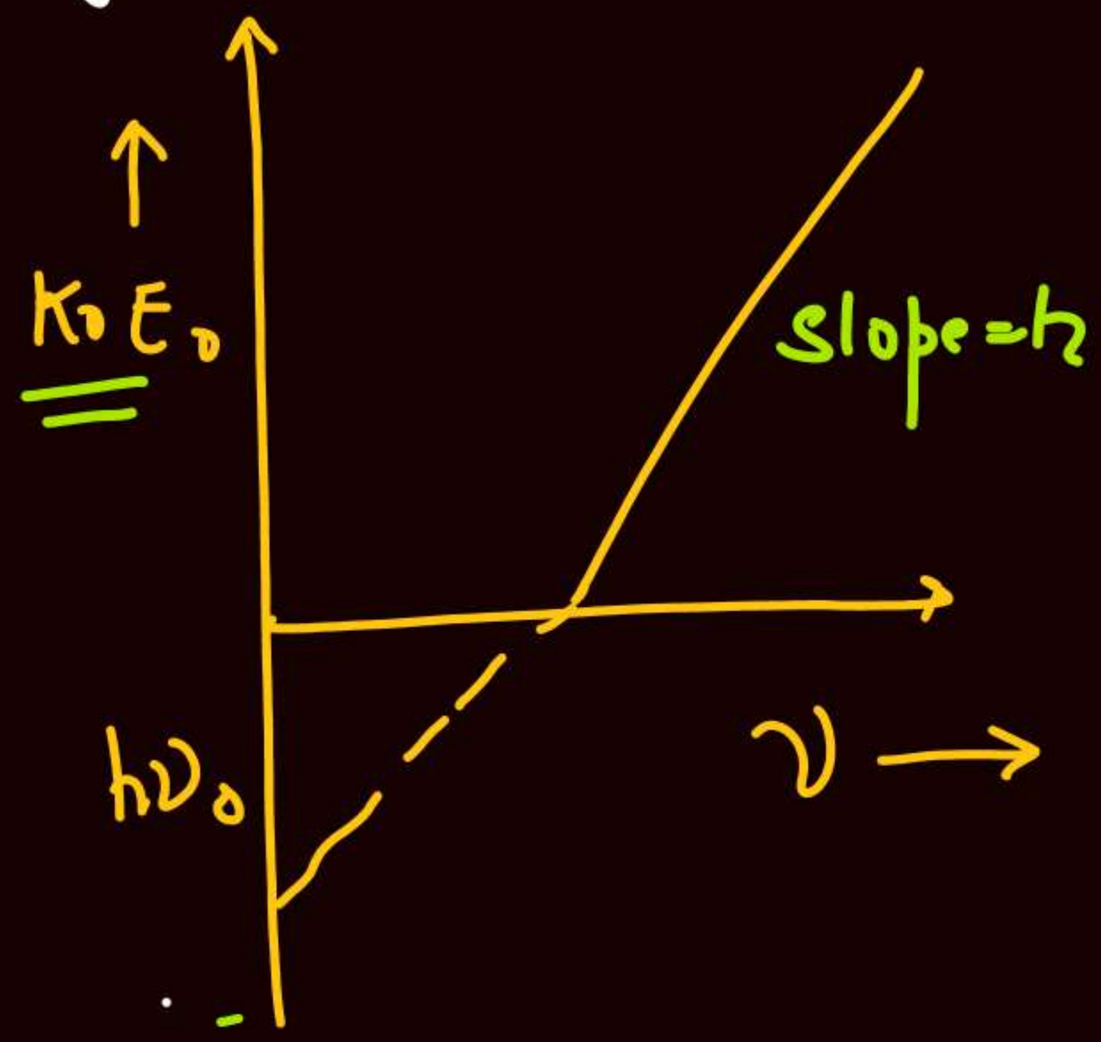
$$K.E. = h\nu_i - h\nu_0$$

$$y = mx - c$$

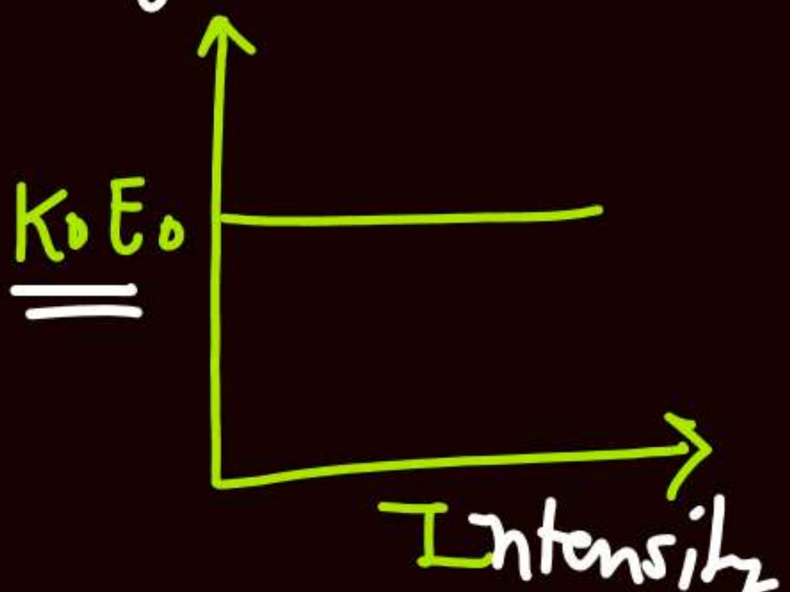
Effect of Frequency (ν) :- On increasing the frequency of incident light, there will be no change in the no. of Photo $e^{\ominus}$ ejecting but the K.E. of ejected $e^{\ominus}$(s) will be $\uparrow$ in frequency.

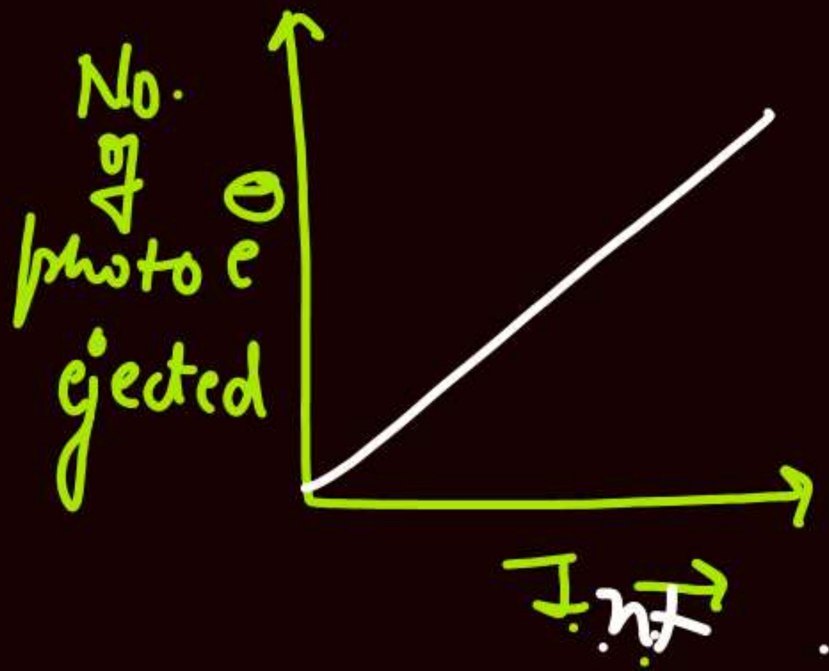
$\Rightarrow$





Effect of Intensity :- On changing the intensity of incident ray, the no. of photons falling per unit area changes. Hence on ↑ing intensity the no. of ejected photo $e^{\ominus}$s will increase but there will be no change in the K.E. of photo $e^{\ominus}$.





NOTE :→ K, Rb, Cs show Photoelectric effect in presence of visible light therefore these are used in Photovoltaic cell / Photoelectric cell.

STOPPING POTENTIAL

$E_i = E_o + K.E._{max}$

$\boxed{K.E. = q \times V_o}$

q = Charge of $e^{\ominus}$

⇒ V_o = Stopping potential (Voltage)

$K.E. = eV_o$ (Stopping potential)

⇒ The Enternal potential in presence of which the K.E. of ejected photo $e^{\ominus}$s becomes Zero is called Stopping Potential.

ARJUN

V_0 & v (frequency):-

$ev_0 = hv - hv_0$

$$V_0 = \frac{h}{e}v - \frac{h}{e}v_0$$

$Y = mn - c$

When slope → $m = h/e$

$V_0 \Rightarrow$ Stopping potential

$K.E. = h\nu_i - h\nu_0$

$e \times V_0 = h\nu_i - h\nu_0$

$$\boxed{V_0 = \frac{h}{e}\nu_i - \frac{h}{e}\nu_0}$$

$Y = mn - c$

$$\text{Slope} = m = \frac{h}{e}$$

The external potential applied to circuit by which K.E. becomes zero known as **STOPPING POTENTIAL.**

Note:-

Potassium , Rubidium, ceasium shows PHOTOELECTRIC EFFECT in visible light.

Q. Find the ratio of slop of plot K.E. v/s V and v_0 v/s v

HoW→

Q. Light of frequencies v_1 & v_2 incident on metal surface so that K.E. of $e^{\ominus}$ in first case is double of K.E. in second case. Determined the relation between wavelength.

H.W.

Q. The energy difference between ground state and encited state of an atom is 4.4×10^{-19} J. Find the wavelength in nm correspond to the transition.

H.W.

Q. The amount of energy of energy required to ionize a Na atom is equal to the energy associated with wavelength of 250 nm. Calculate the I.E. of Na in KJ /mol.

Q. A photon of wavelength 300 nm is absorbed at high energy level from ground state. It emits two photon. Wavelength of one of the photon is 400 nm. Then find the wavelength of other.

Q. A certain metal when irradiated with light ($\nu = 3.2 \times 10^{16}$ Hz) emits photo $e^{\ominus}$ with twice K.E. as did photo $e^{\ominus}$ when the same metal is irradiated by light ($\nu = 2.0 \times 10^{16}$ Hz). Calculate threshold frequency of $e^{\ominus}$.

Q. Photo electrons are removed with K.E. 1.864×10^{-21} Joule. When photons of light with energy 4.23×10^{-19} J fall on the metal. What is the minimum energy in KJ required per mole to remove an $e^{\ominus}$ from potassium metal.

Q. The energy absorbed by each molecule (A_2) of a substance is 4.4×10^{-19} J and bond energy per molecule is 4.4×10^{-19} J. The kinetic energy of the molecule per atom will be?

Q. **Light of wavelength 400 nm stickes a metal surface with threshold energy 2.13 eV. Calculate the K.E. of most energetic $e^{\ominus}$.**

Q. **The wavelength of incident light is 400 nm. Calculate the no. of metals which can show photoelectric effect from the following:-**

Metal	Li	Na	K	Cs	Mg	Ca
ϕ (ev)	3.7	4.2	1.8	0.9	5.2	3.13

thanks
for watching

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