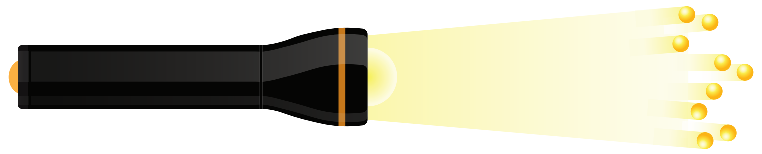
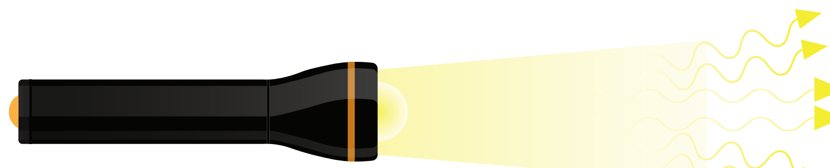
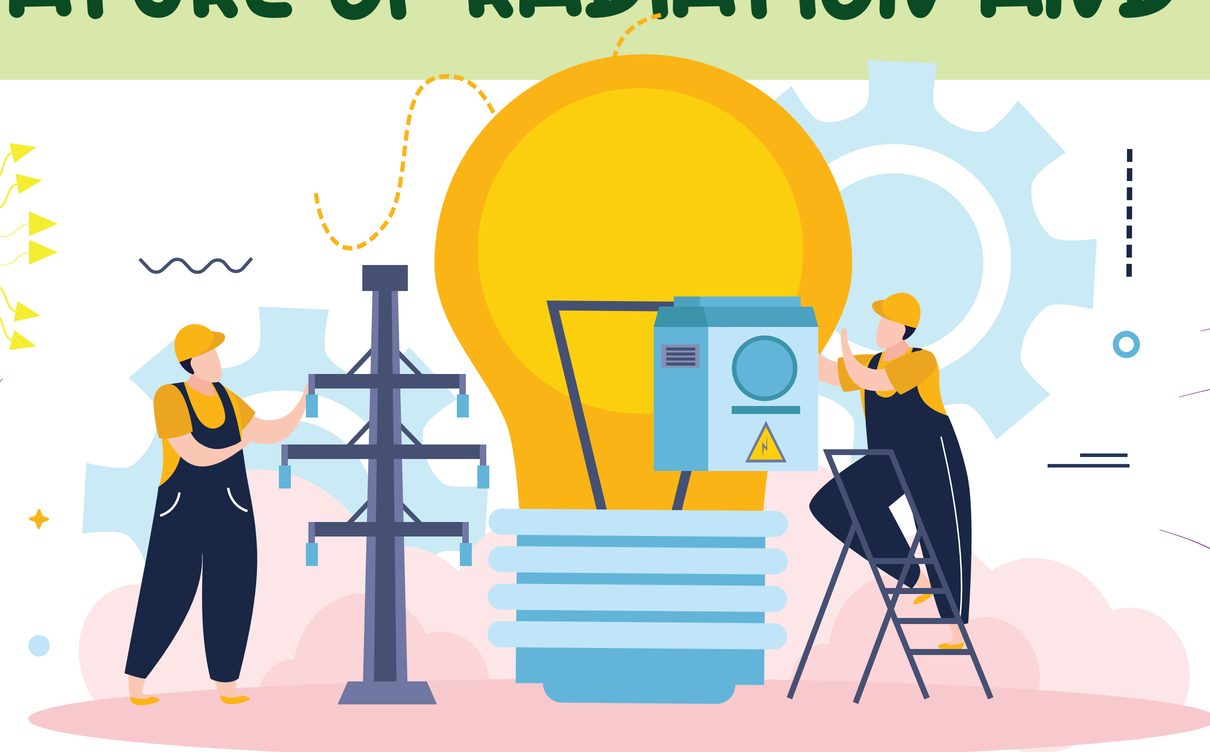
DUAL NATURE OF RADIATION AND MATTER



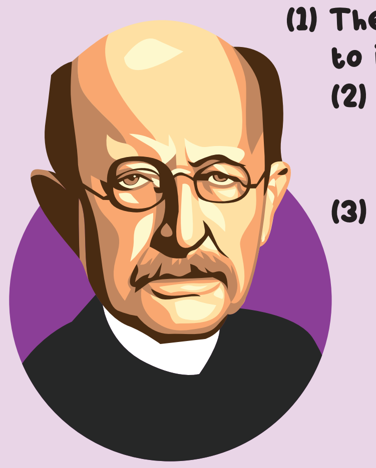
Particles



Waves



PLANCK'S QUANTUM THEORY OF LIGHT



(1) The energy of one photon is proportional to its frequency
(2) $E \propto \nu$, $E = h\nu$
h = Planck's constant
$= 6.62 \times 10^{-34}$ JS
(3) Energy of any light or radiation is one integral multiple of $h\nu$.
$E = nh\nu$
(4) Energy of one photon.
$E = h\nu = \frac{1240}{\pi(\text{nm})}$ eV

PHOTOELECTRIC EFFECT

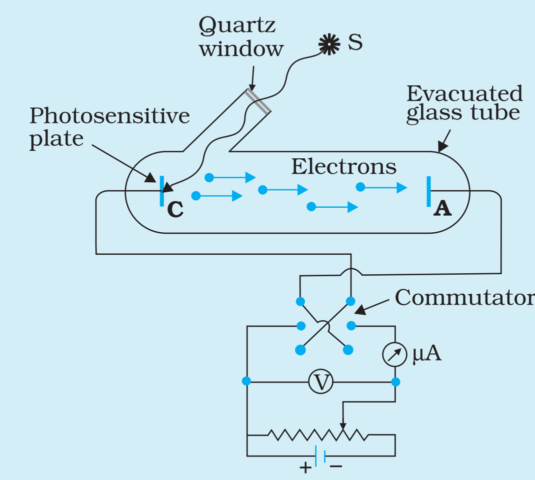
(1) It is a phenomenon of ejecting electrons by falling light of suitable frequency on a metal
(2) Ejected electrons are called photoelectrons.
(3) Current flowing due to the photoelectrons is called photocentric current

LAWS

(1) No emission takes place below the threshold frequency.
(2) Above threshold frequency, no. of photoelectrons emitted per seconds is directly proportional to intensity of radiation
(3) The emission of photoelectrons is an instantaneous process.
(4) Above threshold frequency, K.E (max) depends on frequency

EXPERIMENTAL STUDY

- The emission of electrons causes flow of electric current in the circuit.



PARTICLE NATURE OF LIGHT

(1) In interaction of radiation with matter, radiation behaves as if is mode of particles called photons
(2) $E = h\nu$ and $p = \frac{h\nu}{c}$
(3) In a photon – particle collision, total energy and total momentum are conserved.

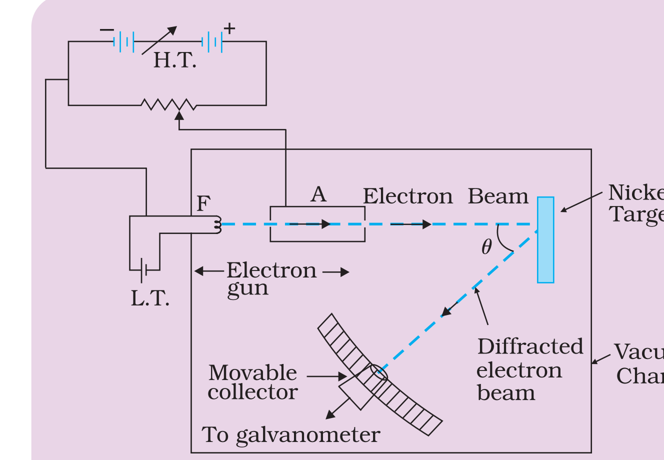
DUAL NATURE OF LIGHT

de – Broglie wavelength, $\lambda = \frac{h}{mv}$ & $2\pi r = n\lambda$

- $Mvr = \frac{nh}{2\pi}$

This is Bohr quantisation condition

DAVISSON-GERMER EXPERIMENT



- at $\phi = 50$ and accelerating potential = 54 V, maxima is obtained
- This experiment confirmed the wave nature of electron.

PROPERTIES OF PHOTONS

(1) Photon is just a packet of energy.
(2) Energy of photon does not change with medium.
(3) Photon can not be deflected by electric field and magnetic field.
(4) Momentum of photon $|\vec{P}| = m \times c = \frac{h}{\lambda} = \frac{E}{C}$
(5) Intensity of light beam = $\frac{\text{Energy}}{\text{area} \times \text{time}}$

PHOTON EMITTED PER SECOND

(1) $E = Nh\nu$
(2) Power, $P = Nh\nu$
$\Rightarrow N = \frac{p}{h\nu} = \frac{p\lambda}{hc}$
Number of photon per second = $\frac{\text{Power}}{\text{energy of one Photon}}$

PHOTON FLUX

- Photon flux is no. of photon incident normally to a surface per seconds
- $\phi = \frac{n}{A} = \frac{P}{h\nu}$

FORCE AND RADIATION PRESSURE EXERTAD BY A LIGHT BEAM

(1) $n = \frac{p\lambda}{hc}$
(2) momentum of one photon = $\frac{h}{\lambda}$ momentum imparted per second = $n \times \frac{h}{\lambda} = \frac{P}{C}$
$\Rightarrow$ Force exerted = $\frac{P}{C}$
(3) Radiation pressure = $\frac{F}{A} = \frac{P}{CA} = \frac{I}{C}$

WORK FUNCTION

- Minimum energy required for getting a free electron away from the metal surface.
- work function $(\phi_o) = h\nu_o$

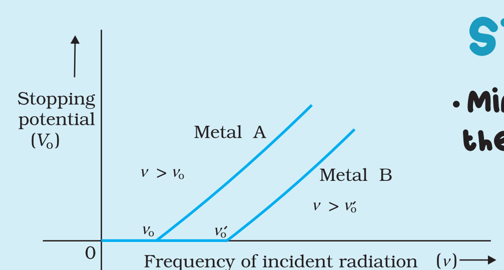
$\nu_o = \frac{\phi}{h}$ = threshold frequency

EINSTEIN'S PHOTOELECTRIC EQUATION

- The electron is emitted with maximum K.E
$K.E_{max} = h\nu - \phi_o$
$h\nu = K.E_{max} + \phi_o$
- Range of K.E.

$0 \le K.E._{\text{Photoelectrons}} \le h\nu - \phi_o$

STOPPING POTENTIAL

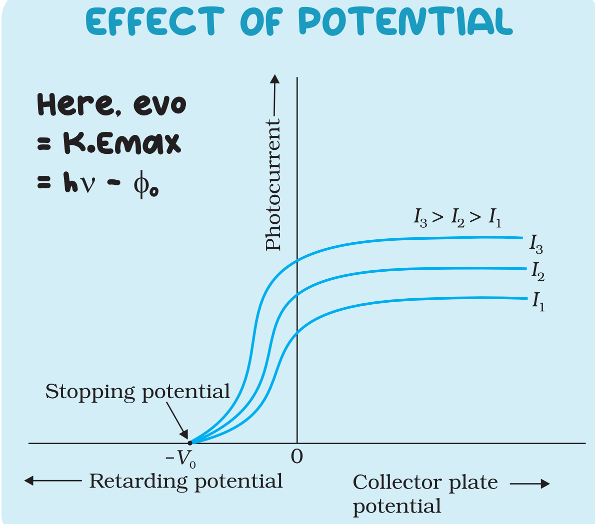


- Minimum negative potential required to stop the electron of maximum K.E.

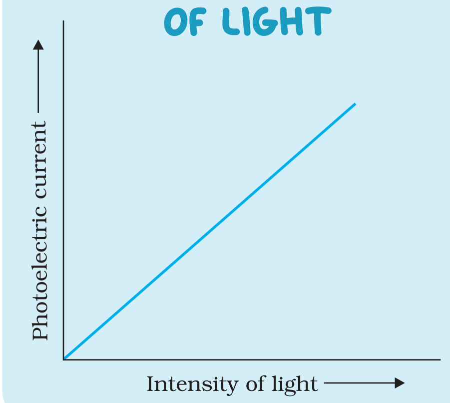
$V_o = \frac{K.E_{max}}{e} = \frac{h}{e}(\nu - \nu_o)$ Volts

EFFECT OF POTENTIAL

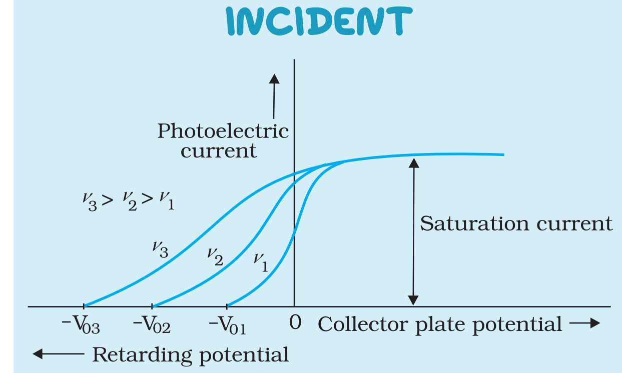
Here, $e\nu_o$
$= K.E_{max}$
$= h\nu - \phi_o$



EFFECT OF INTENSITY OF LIGHT



EFFECT OF FREQUENCY OF INCIDENT



MATTER WAVE THEORY

- de – Broglie wavelength associated with moving particles, $\lambda = \frac{h}{p}$
- K.E of particle = $\frac{1}{2}mv^2 = \frac{p^2}{2m}$
- momentum, $P = mv$

$\sqrt{2m \times K.E}$

FOR UNCHARGED PARTICLES

$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2m \times K.E}}$

SPECIAL CASE FOR ELECTRON

$\lambda = \frac{1.227}{\sqrt{V}}$ nm

And

$V = \frac{150.1}{[\lambda(\mathring{A})]^2}$ Volt

FOR ACCELERATED CHARGED PARTICLES

$\lambda = \frac{h}{\sqrt{2m \times K.E}}$

V = potential difference

FOR GASEOUS MOLECULES

$K.E = \frac{3}{2}KT$

$\Rightarrow \lambda = \frac{h}{\sqrt{2m \times \frac{3}{2}KT}}$

$\Rightarrow \lambda = \frac{h}{\sqrt{3mKT}}$