Dual Nature of Radiation & Matter

Energy of Photon

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

3×10^8 m/s

frequency

wavelength

h (Plank's Constant)

$= 6.63\times10^{-34}$ J.s

Kinetic mass & Momentum of Photon

$$m = \frac{E}{c^2} = \frac{h}{\lambda}$$

- Photon has zero rest mass

$$p = \frac{E}{c} = \frac{h}{\lambda}$$

3×10^8 m/s

Einstein's Photoelectric Equation

$$E = \phi_0 + K_{max}$$

Energy of incident Photon

Work function

$$h\nu = h\nu_0 + K_{max}$$

ν_0 Threshold frequency

or $\nu_0 = \frac{c}{\lambda_0}$

threshold wavelength

$$K_{max} = h(\nu - \nu_0)$$

maximum Kinetic energy $\left(K = \frac{1}{2}mv^2 = qV\right)$

Relation between $K.E_{max}$ & Stopping Potential (V_0)

$$K_{max} = \frac{1}{2}mv^2 = eV_0$$

∴ Einstein Eq. becomes

$$h\nu = \phi_0 + eV_0$$

or $V_0 = \underbrace{\frac{h}{e}}_{\text{Slope(m)}}\nu - \underbrace{\frac{\phi_0}{e}}_{\text{y-intercept(c)}}$

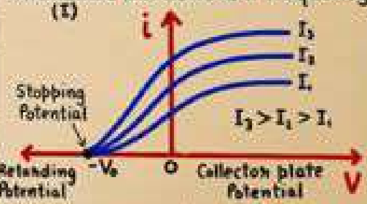
$y = mx + c$ Straight line eq.

Photoelectric current (i) versus intensity of photons (I):

$i \propto I$

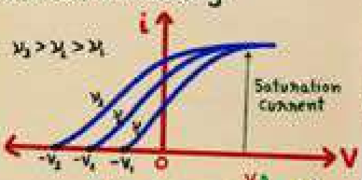
Photoelectric current (i) versus Frequency (ν):

Variation of photoelectric current (i) versus Potential (V) for different intensities (I) but constant frequency:



∴ V_0 is independent of Intensity of Photons

Variation of photoelectric current (i) versus Potential for different frequencies but constant intensity:



$$\boxed{V_0 \propto \nu}$$

de-Broglie Wavelength

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

or

$$\lambda = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mqV}}$$

For electron	For proton
$\lambda = \frac{12.27}{\sqrt{V}}$ Å	$\lambda = \frac{0.286}{\sqrt{V}}$ Å

Germer & Davisson Experiment:

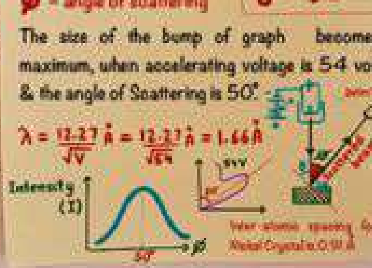
$\phi = 50°$

$\theta = 65°$

ϕ = angle of scattering

The size of the bump of graph becomes maximum, when accelerating voltage is 54 volt & the angle of Scattering is 50°.

$\lambda = \frac{12.27}{\sqrt{V}}$ Å $= \frac{12.27}{\sqrt{54}}$ Å $= 1.66$ Å



Inter atomic spacing for Nickel Crystal is 0.91 Å