MODERN PHYSICS - I

1. Planck's Quantum theory - $Q = NE$

$\begin{cases} Q = \text{total energy} \\ E = \text{energy of each photon} \\ N = \text{no. of photons} \end{cases}$

$$\boxed{E = h\nu = \frac{hc}{\lambda} = \frac{12400}{\lambda(A^\circ)} \text{ e-V.}}$$

$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J.}$

2. $E = h\nu = \frac{hc}{\lambda} = mc^2.$

$$\boxed{p = mc = \frac{E}{c} = \frac{h\nu}{c} = \frac{h}{\lambda}.}$$

for photons - rest mass = 0
- chargless, electrically neutral.

3. I = intensity of light.

$$\boxed{I = \frac{E}{At} = \frac{P}{A} = \frac{N(h\nu)}{At} = \frac{nh\nu}{A}}$$

$\left(n = \frac{N}{t} = \text{no. of photons incident per s}\right)$

$\therefore \boxed{P = nh\nu}$

$$\boxed{n = \frac{P}{h\nu} = \frac{P\lambda}{hc} = (5 \times 10^{24} \text{ J}^{-1}\text{m}^{-1}) P \times \lambda.}$$

4. If a = absorptive power = $\frac{\text{absorbed energy}}{\text{total incident energy}}$,

r = reflective power = $\frac{\text{reflected energy}}{\text{total incident energy}}$,

$\boxed{a + r = 1.}$

Case I	Case II	Case III
$a = 1,\ r = 0$	$a = 0,\ r = 1$	$0 < a < 1.$
$F = \frac{IA}{c}$	$F = \frac{2IA}{c}$	$F = \frac{IA}{c}(1+r)$
$P = \frac{I}{c}$. (P = pressure)	$P = \frac{2I}{c}.$	$P = \frac{I}{c}(1+r).$

→ If light beam is incident at angle θ with the vertical.

Case I	Case II	Case III
$a = 1,\ r = 0$	$a = 0,\ r = 1$	$0 < a < 1.$
$F = \frac{IA\cos\theta}{c}$	$F = \frac{2IA\cos^2\theta}{c}$	$\vec{F}_{net} = \vec{F}_a + \vec{F}_r$
$P = \frac{I}{c}\cos^2\theta.$	$P = \frac{2I}{c}\cos^2\theta$	$P = \frac{I}{c}\cos^2\theta\,(1+r).$

supports particle nature
does not support wave nature (time lag, accumulation, no existence of threshold energy)

Quantum

5. Photo Electric Effect (PEE) -

(i) Work function (ϕ or W) - minimum energy required for emission of
- constant for a metal - minimum for Cs.

(ii) ~~Saturation~~ Stopping Potential - minimum magnitude of -ve potential of an wrt. to cathode for which current is zero. It does not depend on Intensity

(iii) Saturation current = maximum current.

→ ejection of e^- does not depend on intensity or total energy. It depends on λ or ν as it depends on E $(E = h\nu = hc/\lambda)$.

→ on increasing I, n increases ∴ Q increases. $(Q = NE)$
(E does not change) If n increases ⇒ no. of e^-s emitted increases.
⇒ current increases.

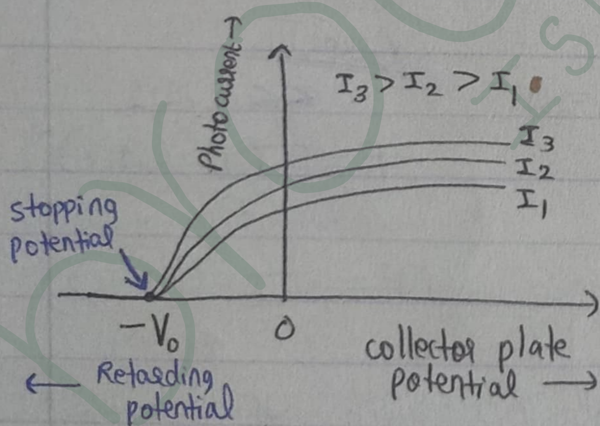
→ One photon can give energy to only one photon.
No. of ejected e^-s << No. of incident photons
(∵ energy of e^-s will be lost in internal collision).

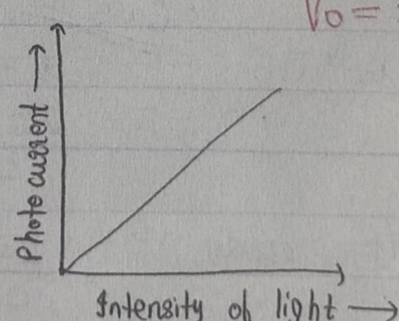
(iii) Ignoring energy loss due to collision,

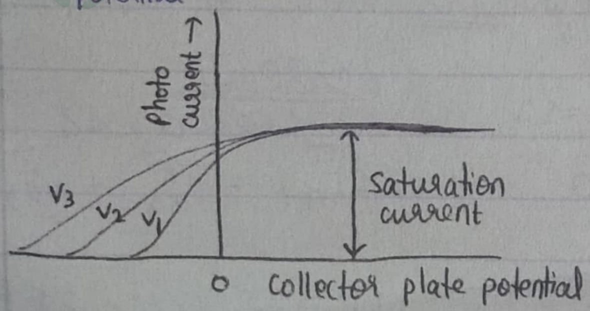
$$\boxed{E = h\nu = (KE)_{max} + \phi_0}$$

$$\Rightarrow h\nu - h\nu_0 = KE_{max} = eV_0 \qquad \Rightarrow \boxed{eV_0 = h\nu - h\nu_0}$$

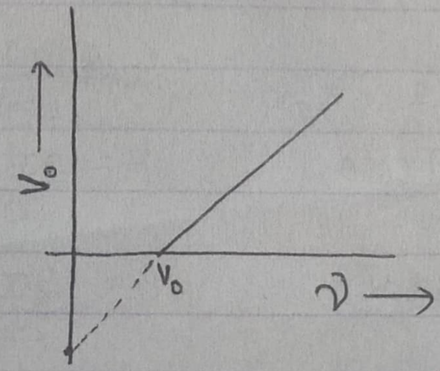
V_0 = stopping potential.







$V_3 > V_2 > V_1$



Quantum efficiency $= \dfrac{\text{number of } e^- \text{ emitted per s}}{\text{no. of photons incident per s}} = \dfrac{n_e}{n_p}$.

6. De broglie imagined that despite particle nature of matter, waves must also be associated with material particles.
Wave associated with material particles are defined as matter waves.

$$\boxed{\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mK}}}$$

$$\boxed{K = qV}$$ V = potential, q = charge

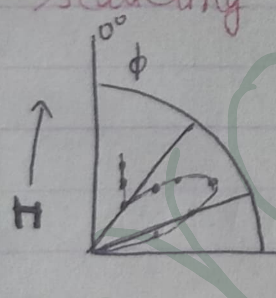
$$\boxed{\lambda\,(\text{in } A^\circ) = \frac{12 \cdot 27}{\sqrt{V}} = \sqrt{\frac{150}{V\,(\text{volts})}}} \Rightarrow \text{for electron.}$$

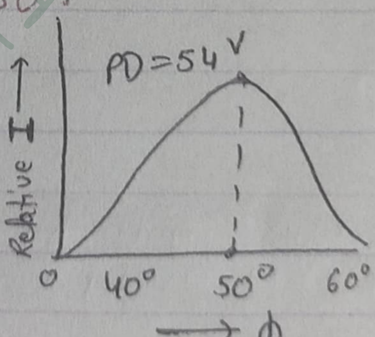
→ For uncharged particles/ gas molecules -
Thermal kinetic energy, $KE = \frac{3}{2} KT$.

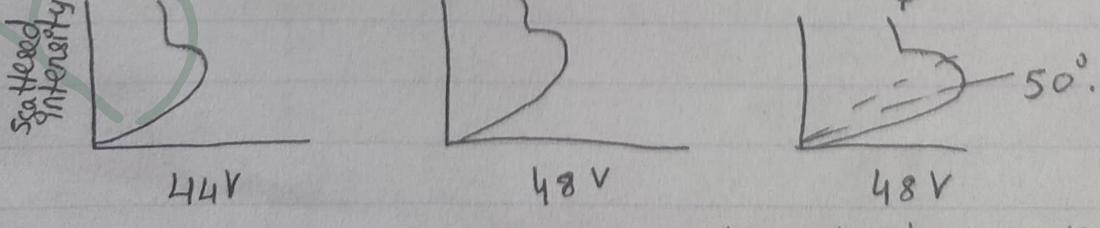
$$\therefore \boxed{\lambda = \frac{h}{\sqrt{3mKT}}}$$

where K = Boltzmann's constant
T = temperature (K).

7. Davisson And Germer Experiment — experimental evidence for wave nature of material particles.
→ accelerating voltage varies from 44V to 68V.
→ Intensity of scattered e⁻s is maximum at 54V at a scattering angle of 50°.



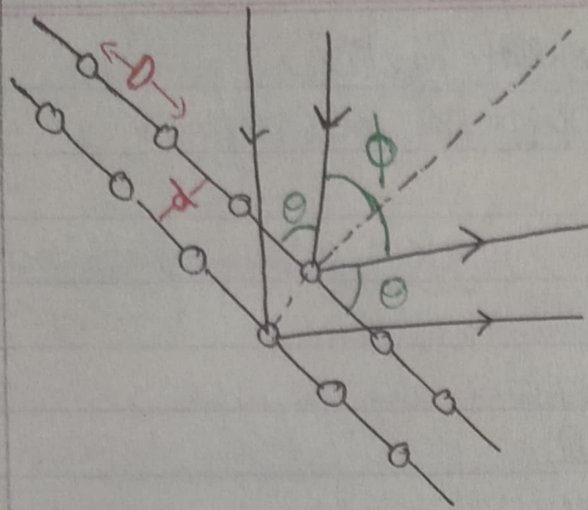




→ $\boxed{2d \sin\theta = D \sin\phi = n\lambda}$

d = Interplanar distance.
D = distance between two atoms in same Lattice plane.

θ = glancing angle (angle with horizontal)
ϕ = angle of diffraction.



Nickel crystal = 3-D diffraction grafting.

$$\boxed{\theta = 90^\circ - \frac{\phi}{2}}$$

8. **Bohr Quantisation**

→ Acc. to De-Broglie, e^- revolves round the nucleus in the form of stationary waves in the similar fashion as stationary wave in vibrating string.

→ e^- revolves in those circular orbits whose circumference is integral multiple of λ of e^-.

$$\boxed{2\pi r = n\lambda}$$

$$\boxed{mvr = \frac{nh}{2\pi}}$$ ⇒ angular momentum should be integral multiple of $\frac{h}{2\pi}$.

Particle nature of light is also supported by compton effect and Raman effect