

QUANTUM THEORY OF LIGHT

**BRAIN
MAP**
CLASS XII

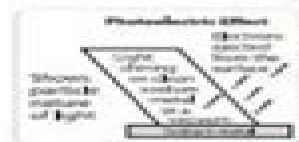
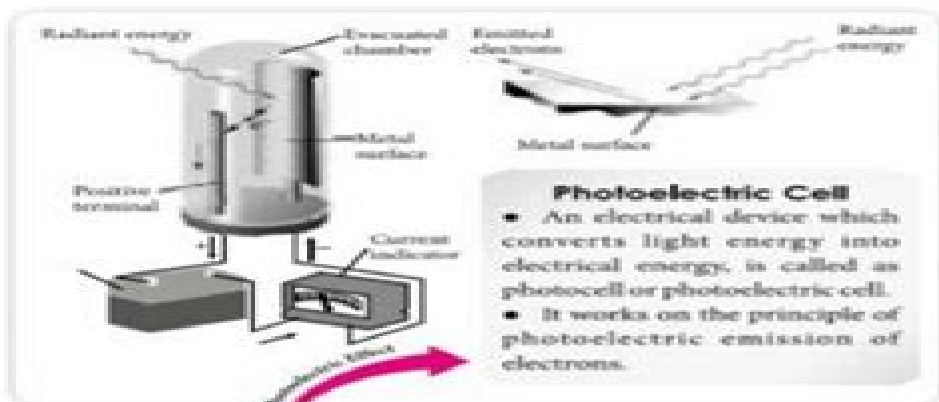
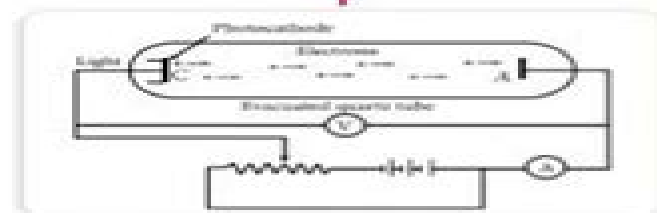


Photo-electric Effect

- The phenomenon of emission of electrons from a metal surface when an electromagnetic wave of suitable frequency is incident on it is called photoelectric effect.

Photoelectric Equation

- $E = K_{\max} + \phi_0$
where ϕ_0 = work function of metal,
 E = energy of incident light,
 K_{\max} = maximum kinetic energy of electrons
- $\frac{1}{2}mv_{\max}^2 = h\nu - \phi_0 = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$
where, $\lambda_0 = \frac{hc}{\phi_0}$ = threshold wavelength



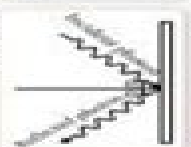
Basic Quantum Theory of Light

- According to Planck, the energy of a photon, $E = h\nu$;
 $E = h\nu = \frac{hc}{\lambda} = \frac{1240}{\lambda(\text{in nm})} \text{ eV}$
- Momentum of photon, $p = \frac{E}{c} = \frac{h\nu}{c} = \frac{h}{\lambda}$
- If source is 100% efficient, then the number of photons emitted per second by the source can be given by
 $n = \frac{\text{Power of source}}{\text{Energy of photon}} = \frac{P}{E} = \frac{P}{h\nu} = \frac{PA}{hc}$
- The energy crossing per unit area per unit time perpendicular to the direction of propagation is called the intensity of a wave.
 $I = E/At = P/A$
- Force exerted on perfectly reflecting surface
 $F = \frac{\Delta p}{t} = \frac{2Nh}{t\lambda} = n\left(\frac{2h}{\lambda}\right) = \frac{2P}{c}$
Pressure = $\frac{F}{A} = \frac{2P}{cA} = \frac{2I}{c}$
- Force exerted on perfectly absorbing surface
 $F = \frac{\Delta p}{t} = \frac{Nh}{t\lambda} = n\left(\frac{h}{\lambda}\right) = \frac{P}{c}$
Pressure = $\frac{F}{A} = \frac{P}{cA} = \frac{I}{c}$



PARTICLE NATURE OF RADIATION

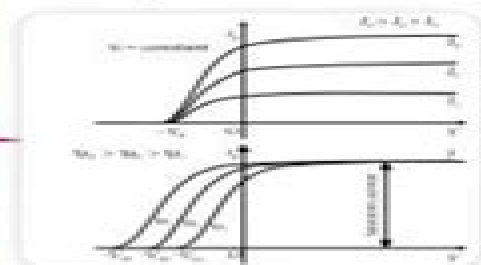
- When a beam of light is incident at an angle θ on perfectly reflector surface then force exerted on the surface,
 $F = \frac{2P}{c} \cos \theta = \frac{2IA \cos \theta}{c}$
Pressure = $\frac{2I \cos \theta}{c}$



Conclusions of Experimental Study of Photoelectric Effect

- Photo-current is directly proportional to the intensity of incident light, i.e., $i_p \propto I$.
(At constant frequency ν and potential V)
- At constant frequency and intensity, the minimum negative potential at which the photocurrent becomes zero is called stopping potential (V_0).
- At stopping potential V_0 , $K_{\max} = eV_0$
- For a given frequency of the incident radiation, the stopping potential is independent of its intensity.
- The stopping potential varies linearly with the frequency of incident radiation but saturation current value remains constant for a fixed intensity of incident radiation.

- Quantum efficiency = $\frac{n_e}{n_{ph}}$
 n_e = number of electron emitted per second
 n_{ph} = total number of photon incident per second



Study Guide Quantum Theory

**Massachusetts Institute of
Technology. Department of Chemistry**



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