Class : 12th Physics
Chapter- 11 : Dual nature of radiation and matter

Dual nature of radiation and matter

Dual Nature of Radia

- Light has both wave character as well as particle
- Interference explained by wave nature
- When light of sufficiently low wavelength, it behaves as a particle
- Light particle having definite energy and definite linear momentum called "photon" or Energy packets.

Energy of each photon = $h\nu = hc/\lambda$

Momentum of each photon = $h/\lambda = E/c$

Contribution

Einstein, after an average academic career put forward quantum theory of light in 1905 while working as a grade III technical officer in a patent office

Matter Waves

All matter can exhibit wave–like behaviour e.g. beam of electrons can be diffracted like water wave

De - Broglie relation

$\lambda = h/p$

λ = wavelength associated with particle or de-Broglie wavelength

p = momentum

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2\,m\,K_{max}}}$$

Davisson-Germer Experiment

A beam of electrons emitted by electron gun is made to fall on nickel crystal cut along cubical axis at a particular angle .Scattered beam of electrons is received by detector.

Results : λ = de Broglie's wavelength

$= h/p$

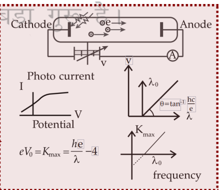
$= 1227/\sqrt{V}$ nm

$= 1227/\sqrt{54}$ nm

$= 0.167$ nm $= 1.67$ A°

This experiment verifies the wave nature of electrons & relation with de-Broglie wavelength.

Hertz and Lenard's Observation



Photoelectric effects

- When light of sufficiently small wavelength is incident on metal surface, electrons are ejected from the metal, the phenomenon is called photoelectric effect.
- Ejected electrons are called photoelectrons
- Minimum energy equal to work function (ϕ) must be given to an electron so as to bring it out of the metal

Einstein 's photoelectric equation

- If $\lambda = \lambda_0 = hc/\phi$

  $K_{max} = 0$, *i.e.*

  Electron may just come out.
- If $\lambda > \lambda_0$

  i.e. $E < \phi$

  no electron will come out
- If $\lambda \le \lambda_0$.

  Photoelectric effect takes place this λ_0
- λ_0 = depends on metal used

- $K_{max} = E - \phi = eV_0$

  $= \frac{hc}{\lambda} - \phi$, V_0 = stopping potential

  K_{max} = maximum kinetic energy of elected electrons

Hore, $\lambda_0 = hc/\phi$

λ_0 = Threshold Wavelength

$\lambda_0 = c/\lambda_0 = \phi/h$

λ_0 = Threshold frequency

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