

Unit VII

Dual Nature of Matter And Radiation

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DUAL NATURE OF MATTER AND RADIATION

KEY POINTS

- Light consists of individual photons whose energies are proportional to their frequencies.
- A photon is a quantum of electromagnetic energy :
Energy of photon

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

Momentum of a photon

$$= \frac{h\nu}{c} = \frac{h}{\lambda}$$

Dynamic mass of photon

$$= \frac{h\nu}{c^2} = \frac{h}{c\lambda}$$

Rest mass of a photon is zero.

- **Photoelectric effect** : Photon of incident light energy interacts with a single electron and if energy of photon is equal to or greater than work function, the electron is emitted.
- Max. kinetic energy of emitted electron = $h(\nu - \nu_0)$ Here ν_0 is the frequency below which no photoelectron is emitted and is called threshold frequency.
- If 'V' is the stopping potential of photoelectron emission, then max. kinetic energy of photo electron $E_K = qV$

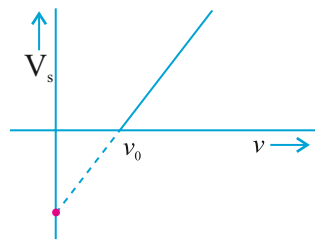
- Wavelength associated with the charge particle accelerated through a potential of V. volt.

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

- Wavelength associated with electron accelerated through a potential difference

$$\lambda_e = \frac{12.27}{\sqrt{V}} \text{ \AA}$$

- Stopping potential versus frequency graph



$v_0 \rightarrow$ threshold frequency

slope of the curve gives $\frac{h}{e}$

The intercept on V axis gives $\frac{\phi}{e}$ i.e. $\frac{\text{Work function}}{e}$

- A moving body behaves in a certain way as though it has a wave nature having wavelength,

$$\lambda = \frac{h}{mv} = \frac{h}{p} = \frac{h}{\sqrt{2m E_k}}$$

where E_k is kinetic energy of moving particle

- Einstein's Photoelectric equation

$$\frac{1}{2}mv_{\max}^2 = hv - hv_0$$

or

$$eV_0 = hv - hv_0$$