BRAIN MAP

CLASS XII

DUAL NATURE OF RADIATION AND MATTER

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Nature's Love with symmetry arises the matter-wave duality

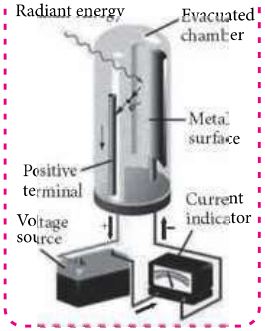
Particle Nature of Radiation

Application of Photoelectric Effect

Wave Nature of Matter

Application of de Broglie Waves

Photocell



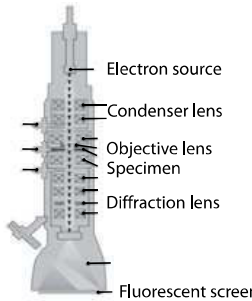
Photoelectric Cell

- An electrical device which converts light energy into electrical energy, is called as photocell or photoelectric cell.
- It works on the principle of photoelectric emission of electrons.

Electron Microscope

- Electron microscope is a device designed to study very minute objects.
- Based on principle of de Broglie wave and the fast moving electrons can be focussed by E or B field in a same way as beam of light is focussed by glass lenses.

Transmission electron microscope



de Broglie Wavelength

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

- For electron having K.E. (K) is
$$\lambda = \frac{h}{\sqrt{2mK}}, \text{ here } p = \sqrt{2mK}$$
- For a charged particle accelerated by potential V is
$$\lambda = \frac{h}{\sqrt{2qmV}}, \text{ here } p = \sqrt{2qmV}$$

Photoelectric 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.

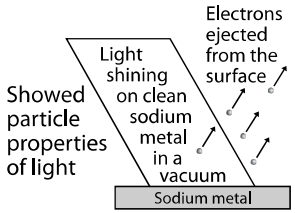
Photoelectric Equation

- $E = K_{max} + \phi_0$, where ϕ_0 = work function,
E = energy of incident light, K_{max} = maximum K.E. of e^-
$$\Rightarrow \quad h\upsilon = \frac{1}{2}mv_{max}^2 + h\upsilon_0 \quad \Rightarrow \quad \frac{1}{2}mv_{max}^2 = h(\upsilon - \upsilon_0)$$

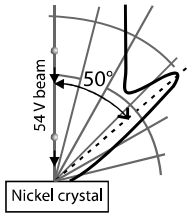
Experimental Study and Conclusion of Photoelectric Effect

- At constant frequency υ and potential V
(Photo-current) $i_p \propto I$ (intensity)
- 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} of $e^- = eV_0$
- For a given frequency of the incident radiation, the V_0 is independent of I.
- The V_0 varies linearly with υ.

Photoelectric Effect

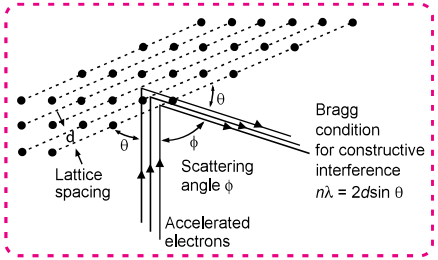


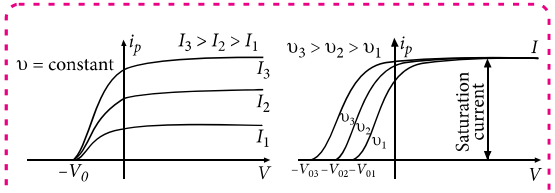
Davisson-Germer Experiment



de Broglie Hypothesis

- Due to symmetry in nature, the particle in motion also possesess wave-like properties. And these waves are called matter waves.





Davisson and Germer Experiment

- Study of wave nature of electron.
- At a suitable potential V, the fine beam of electrons from electron gun is allowed to strike on the nickel crystal. The electrons are scattered in all directions and following assumptions were made :
  - Intensity of scattered electrons depends over scattering angle ϕ.
  - A kink occurs in curve at $\phi = 50°$ for 54 eV beam.
  - The intensity is maximum at accelerating voltage 54 V. After this voltage, intensity starts decreasing.
  - Here, $\theta = \frac{1}{2}(180° - \phi) \Rightarrow \theta = 65°$ at $\phi = 50°$
  From Bragg's law (particle nature), $\lambda = 2d \sin\theta \Rightarrow \lambda = 1.65$ Å.
  Also, from wave nature at $V = 54$ volt, $\lambda = \frac{12.27}{\sqrt{54}} = 1.65$ Å

MASTERJEE CLASSES