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Einstein's photoelectric equation-particle nature of light.

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 11
CHAPTER NAME : Dual Nature of Radiation and Matter

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LEARNING OUTCOME

- Understand the concept of Einstein's photoelectric equation.
- To understand Laws of photoelectric emission.
- To determine Planck's constant and work function from stopping vs frequency graph.

Laws of Photoelectric emission:-

(i) For a given photosensitive material and frequency (above).

Photocurrent $\propto$ Intensity

(ii) For a given photosensitive material and a given frequency

Intensity $\propto$ Saturation current

But independent of stopping potential

(iii) For a given photosensitive material, there exists a certain minimum frequency (called threshold frequency) below which no emission of the photoelectron is possible.

(iv) The photoelectric emission is an instantaneous process (i.e it takes 10-9sec or less)

Einstein's Photoelectric effect

The energy of incident photon = maximum K.E of photoelectron + Work function

$$E = W + KE$$
$$hv = W + KE$$
$$KE = hv - w$$
$$KE = 1/2mv^2max = hv - hv_0$$
$$1/2mv^2max = h(v - v_0)$$

Where v_0 is the threshold frequency

Einstein’s Photoelectric effect

Einstein's photoelectric equations and can be used to explain the laws of photoelectric effect as follows :

1. Explanation of effect of intensity.
2. Explanation of threshold frequency..
3. Explanation of kinetic energy.
4. Explanation of time lag.

Determination of Planck's constant and work function

$K_{max} = hv - W_0$

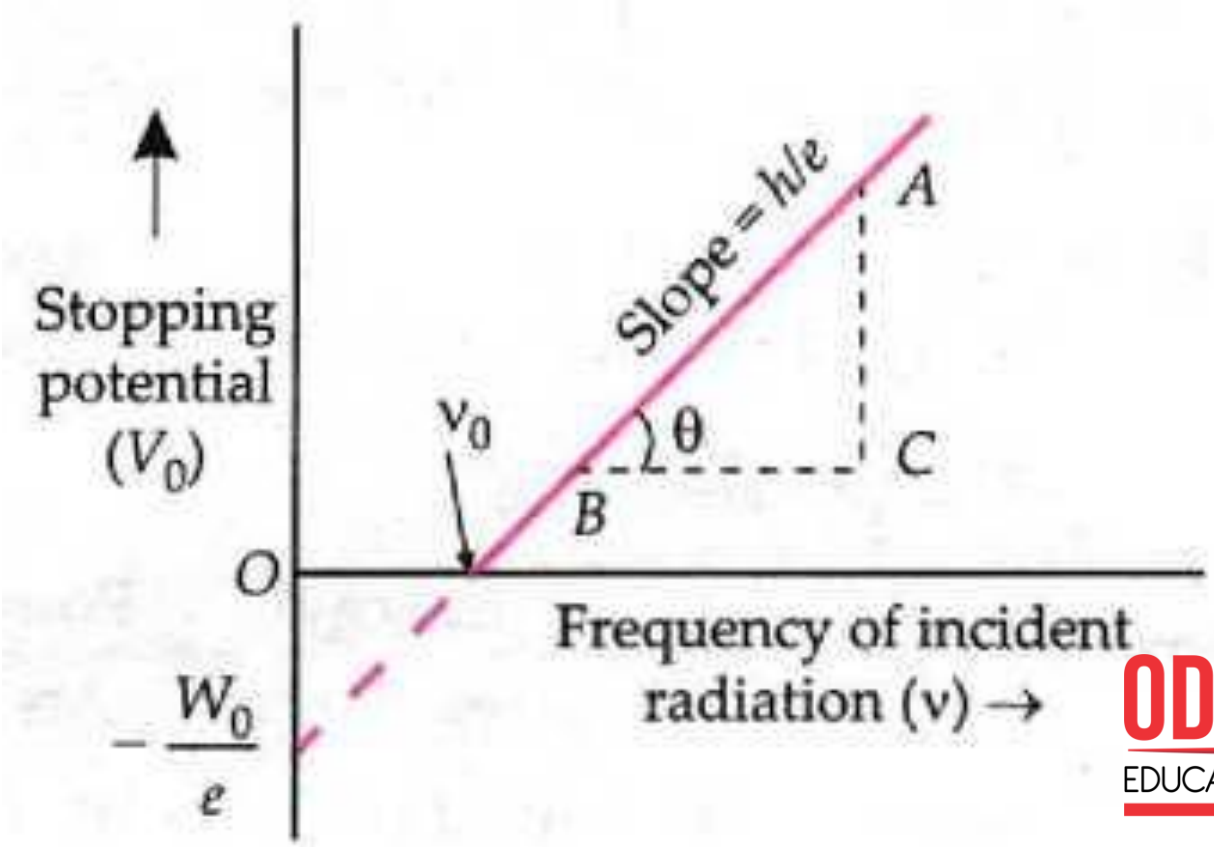
$K_{max} = eV_0$

$\therefore eV_0 = hv - W_0$

or $V_0 = \left(\frac{h}{e}\right) v - \frac{W_0}{e}$

$\therefore h = e \times \frac{AC}{BC} = e \times$ slope of V_0 - v graph

$\therefore W_0 = e \times$ Magnitude of the intercept on vertical axis.



Particle nature of light:-

1st suggested by Einstein. According to him when radiation interacts with matter, radiation behaves as if it is made of a packet of energy or quanta. It is later named as Photon.

Characteristics of Photons:-

- Energy of Photon ($E = hv = hc/\lambda$)
- Its rest mass is zero
- momentum $p(=hv/c = h/\lambda)$
- Photons are electrically neutral

Numerical

1.Light of wavelength 5000 A falls on a metal surface of work function 1.9 eV. Find (i) the energy of photons in eV (ii) the K.E. of photoelectrons and (iii) the stopping potential

2. A sheet of silver is illuminated by monochromatic ultraviolet light of wavelength = 1810 A What is the maximum energy of the emitted electron ? Threshold wavelength of silver is 2640 Å.

3. The maximum kinetic energy of the photoelectrons gets doubled when the wavelength of light incident on the surface changes from λ_1 to λ_2. Derive the expressions for the threshold wavelength λ_0 and work function for the metal surface.

4. When light of frequency 2.4×10^{15} Hz, falls on a photosensitive surface, the retarding potential needed to completely stop the emitted photoelectrons, is found to be 6.8 V. What is the work function (in eV) of the given photosensitive surface ?

5.A monochromatic source, emitting light of wavelength, 600 nm, has a power output of 66 W. Calculate the number of photons emitted by this source in 2 minutes.

THANKING YOU

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