PHOTOELECTRIC EFFECT
PART-II

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APPLIED PHYSICS

B.SC. (HOME SCIENCE) SEMESTER-IV

EINSTEIN's PHOTOELECTRIC EQUATION ; ENERGY QUANTUM OF RADIATION

Laws of Photoelectric Emission were explained by Einstein on the basis of **Planck's Quantum Theory**.

"Light radiations consist of tiny packets of energy called **quanta.** One quantum of light radiation is called a **photon**, which travels with the speed of light."

Energy of a photon, $E = h\upsilon$

h = Planck's constant

υ = Frequency of light radiations

ONE PHOTON OF SUITABLE LIGHT RADIATION → **METAL SURFACE** → **ONE PHOTOELECTRON**

ONE PHOTON OF LIGHT → PHOTOSENSITIVE METAL

OF FREQUENCY υ SURFACE

The energy of the photon($E = h\upsilon$) is spent in two ways –

- A part of the energy of the photon used in liberating the electron from the metal surface, equal to the work function, ω_0 , of the metal
- Rest of energy of photon used in imparting maximum kinetic energy K_{max} , to the emitted photoelectron

i.e. $E = \omega_0 + K_{max}$

If v_{max} = maximum velocity of the emitted photoelectron

m = mass of the photoelectron

Then $K_{max} = \frac{1}{2} m v_{max}^2$

Now $E = h\upsilon$ Also $E = \omega_0 + K_{max}$

Therefore $h\upsilon = \omega_0 + \frac{1}{2} m v_{max}^2$ 1

Work function, ω_0 , of the metal is a characteristic of the metal and does not depend upon the nature of incident radiation. Also called **Threshold Energy** of the metal

If υ_0 = Frequency corresponding to threshold energy of the metal(threshold frequency)

Then $\omega_0 = h\upsilon_0$

So, from equation 1 $h\upsilon = h\upsilon_0 + \frac{1}{2} m v_{max}^2$ 2

Einstein's Photoelectric Equation

Or $h\upsilon = h\upsilon_0 + K_{max}$

$K_{max} = h(\upsilon - \upsilon_0)$ 3

Explanation / Deduction of laws of Photoelectric Emission from Einstein's Photoelectric Equation

I

- One photon ejects one photoelectron from a metal surface
- Number of photoelectrons emitted per second depends upon the number of photons falling on the metal surface per second ,which in turn depends on the intensity of the incident light
- **If intensity of light is increased, the number of incident photons increases, resulting in increase in the number of photoelectrons ejected.**
  This is the **First law of photoelectric emission.**

II

- From equation 3, IF $\upsilon < \upsilon_0$, maximum kinetic energy is negative, which is impossible
- Photoelectric emission does not take place for the incident radiation below **threshold frequency.** This is **Second law of photoelectric emission.**

III

- From equation 3, IF $\upsilon > \upsilon_0$, maximum kinetic energy directly proportional to frequency
- Maximum kinetic energy of photoelectron depends only on the frequency or wavelength of incident light
- Increase in intensity of incident light radiation leads to increase in the number of incident photons falling per second on the metal surface. This is **Third law of photoelectric emission.**

IV

- Phenomenon of photoelectric emission has been conceived as an effect of an elastic collision between a photon and an electron inside the metal
- Absorption of energy by the electron of metal from the incident photon is a single event involving transfer of energy at once
- There is no time lag between the incidence of photon and the ejection of photoelectron. This is **Fourth law of photoelectric emission.**

Consequences of Photoelectric Emission

- Photoelectric emission is possible only if the incident light is in the form of packets of energy
- Each packet of energy having a definite value , more than the work function of the metal
- This implies that light is **not of wave nature** but of **particle nature**
- Due to this reason , photoelectric emission was accounted by the **Quantum Theory of Light i.e. Particle Nature of Light.**

END OF UNIT-I