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Q-2 (Sub)

CLASSMATE

Einstein's photoelectric equation

Q. What is Photoelectric effect and give the laws of photoelectric emission? Derive Einstein's photoelectric equation.

Ans. → The photoelectric effect is the phenomenon of the emission of electrons by certain substances, chiefly metals, when they are illuminated by radiations like x-rays, ultraviolet light and even visible light. The electrons ejected from a substance in this manner are called photoelectrons, though they are in no way different from other electrons.

Laws of Photoelectric emission:-

(1.) For light of any given frequency, the photoelectric current is directly proportional to the intensity of light, provided the frequency is above the threshold frequency.

(2.) For a given photosensitive material, there is a certain minimum frequency, called the threshold frequency, below which the emission of photoelectrons stops completely, no matter how great is the intensity of light.

(3.) The photoelectric emission is an instantaneous process. As soon as the frequency of light exceeds the threshold frequency, the emission of electrons starts immediately without any apparent time lag.

(4.) The max^m Kinetic energy of the photoelectrons is

found to increase with the increase in frequency of the incident light provided the frequency exceeds the threshold limit. The max^{m} kinetic energy is, however, found to be independent of the intensity of light.

Theory of Photoelectric effect: Einstein's photoelectric eq^{n}.

The above laws of photoelectric emission could not be accounted for classical wave theory of light. The theoretical explanation of the laws of photoelectric emission was given by Einstein in 1905 based on the quantum theory. According to this theory, light consists of particles of a definite amount of energy $h\nu$, called a quantum, where h is Planck's constant and ν the frequency of light wave. Such a packet is called a photon. Now, when a photon of energy $h\nu$ is incident on a metal plate, part of its energy ϕ_0 is used up in liberating the electron from the surface of the plate and the other part ($\frac{1}{2}mv^2$) is used in imparting a velocity v to the ejected electron. The energy used up in extricating electrons depends upon the nature of the metal and is called the work function. When the electrons leave the surface of the plate, the metal plate becomes positive to an equal extent and there will be attraction between the positive surface and the negative

electrons, tending to pull back the electrons into the surface of the metal. Work will be done to overcome this pull, in order to enable the electrons to leave the surface. This work will depend upon the nature of the element and accounts for the work function.

Equating the energy,

$$h\nu = \frac{1}{2}mv^2 + \phi_0$$

$$\text{or, } \frac{1}{2}mv^2 = h\nu - \phi_0$$

$$= h\nu - h\nu_0 = h(\nu - \nu_0) \quad \text{— (1.)}$$

The equation is called Einstein's photoelectric eqn. Here, ν_0 is called the threshold frequency.