PHOTOELECTRIC EFFECT

It was observed by Hertz in 1887, quite by accident, that a spark would jump easily between two charged spheres when their surfaces are illuminated by light from another spark. The photoelectric effect, which is the emission of electons from metals due to incident electromagnetic radiation, was first investigated in detail by Hallwachs & Lenard during 1886-1900. The explanation of these experimental results came only after Max Planck proposed the quantum theory of radiation.

It was Sir Isaac Newton who had initially proposed the corpuscular theory of light. His theory was abandoned in favour of the wave theory, proposed by Huygens, as the latter was in agreement with experiments like interference and diffraction. More than a century later, Planck's quantum theory (somewhat similar to Newton's corpuscular theory), got support from Einstein in the explanation of the photoelectric effect

According to Planck's quantum theory, light consists of packets of energy, referred to as photons hereafter, which have the following properties:

(i) A photon of light of frequency ν contains energy E which is directly proportional to the frequency : $E = h\nu$, where h is Planck's constant

(ii) Photons also carry momentum p:

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

where E is the energy of the photon, and c is the velocity of light in vacuum.

(iii) A photon is massless (zero rest mass) and moves with the velocity of light in vacuum ($c = 3 \times 10^8$ m/s). It can never be brought to rest.

Einstein explained the photoelectric effect by applying Max Planck's quantum theory:

(i) Metals contain "free electrons" which are free to move anywhere within the body of the metal. These "free electrons" however, cannot escape from the body of the metal and are, therefore, bound in that sense. The binding energy of these electons with the metal varies from one electron to another - the minimum binding energy of a free electron is known as the work function of the metal (W). It is the minimum amount of energy that is required to extract an electron from a metal.

(ii) A single photon of light can cause the emission of a single electron, and no more. Not all photons, however, end up causing the emission of photoelectrons. The photoelectric effect is not 100% efficient in ejecting photons into electrons.