Modern Physics

(Lec-5)

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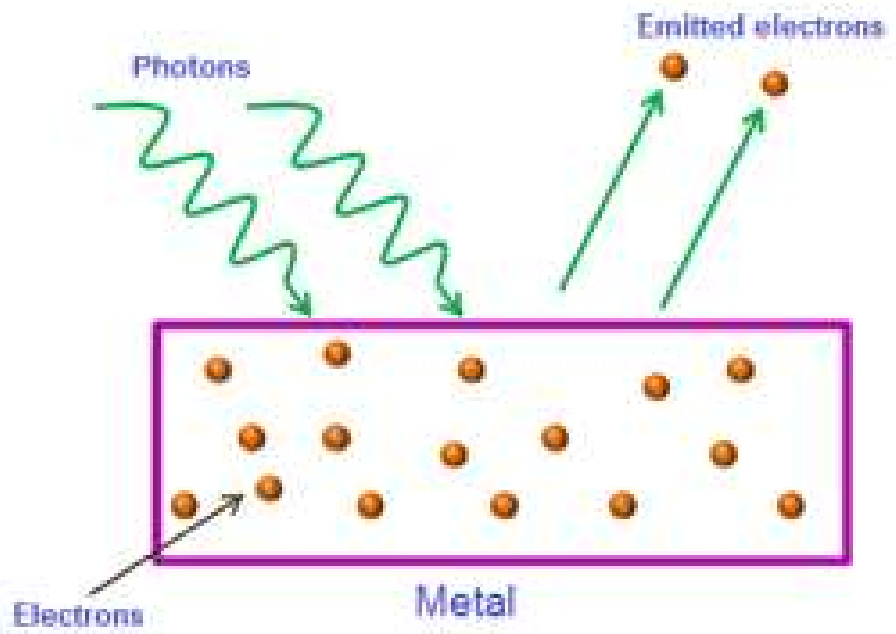
Date: 11.10.2023

OUTLINES

- Photoelectric Effect
- Photocurrent and work function
- Kinetic energy
- Stopping potential

Photo Electric Effect:

In 1887 physicist Heinrich Hertz discovered in an experiment that when a metal surface is illuminated with light, electrons can be eliminated from the surface. This phenomenon is known as photoelectric effect. And the emitted electrons are called photoelectrons.

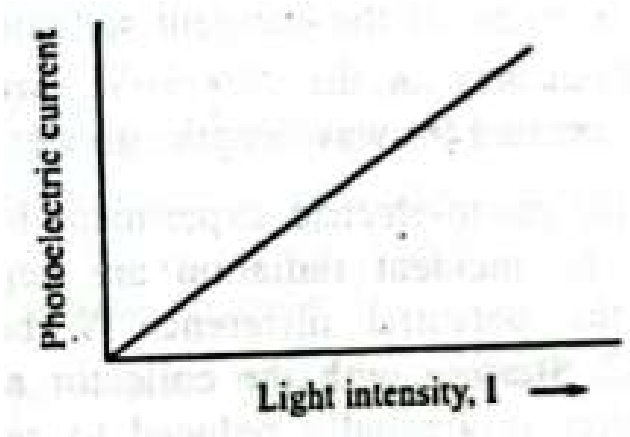


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Photo electric work function: The minimum energy required to eject an electron from the surface is called the photoelectric work function.

The threshold frequency (cutoff frequency): Threshold frequency is defined as the minimum frequency of incident light which can cause photo electric emission.

Photocurrent: When a metal surface is exposed to a monochromatic electromagnetic wave of sufficiently short wavelength (or equivalently, above a threshold frequency), the incident radiation is absorbed and the exposed surface emits electrons then the electricity is induced is called photocurrent.



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kinetic energy: In the photoelectric effect, light incident on the surface of a metal causes electrons to be ejected. The number of emitted electrons and their kinetic energy can be measured as a function of the intensity and frequency of the light.

Stopping potential: Stopping potential is the minimum negative voltage applied to the anode to stop the photocurrent. The maximum kinetic energy of the electrons equals the stopping voltage, when measured in electron volt.

Observations of Photoelectric Effect / Characteristics of photoelectric effect:

- The Maximum kinetic energy (determined from the stopping potential) is totally independent of the intensity of the light source.
- The photoelectric effect doesn't occur at all if frequency of the light source is below a certain value (cut-off frequency). maximum kinetic energy of electron increases linearly with increasing frequency.
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- The first photoelectrons are emitted virtually instantaneously (within$10^{-9}\ s$).

EINSTEIN'S EXPLANATION (PHOTOELECTRIC EQUATION):

Einstein explained the photoelectric effect based on Planck's theory of light. According to quantum theory, radiation is regarded as quanta of photons each of energy moving in space with the velocity of light.

$$E = h\nu$$

Where, h = Planck's constant & v = frequency of radiation.

When a photon of energy hv is incident on a certain metallic surface, it is completely absorbed and imparts its energy to a single electron. Thus, the photon energy is utilized in two purposes:

- Partly for getting the electron free from the atom and away from the metal surface.

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- The balance of the photon energy is used up in giving the electron a kinetic energy. The above phenomena can be written as:

$$h\nu = K_{max} + \phi \ldots\ldots\ldots\ldots (1)$$

where,

$h\nu$ is the photon energy

K_{max} is the maximum photoelectron energy

ϕ is the work function, the minimum energy needed for an electron to leave the metal.

Cutoff Frequency:

Now, consider that the photon supplies exactly the minimum energy needed to release an electron. Then there will be no excess energy for kinetic energy.

$$K_{max} = h\nu - \phi$$
$$0 = h\nu_c - \phi$$
$$\phi = h\nu_c$$

$$\therefore \nu_c = \frac{\phi}{h}$$

Here, ν_c is the cutoff frequency.

