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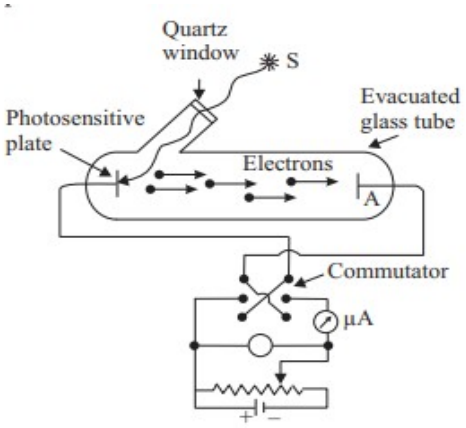
DUAL NATURE OF RADIATION AND MATTER

PHOTOELECTRIC EFFECT

The emission of electrons from metals irradiated by light of a frequency greater than a certain characteristic frequency is called photoelectric effect.

Experimental Arrangement to Study Photoelectric Effect



- The maximum velocity of photoelectrons increases with frequency of incident light and depends on the nature of emitter material.
- The maximum velocity of photoelectrons does not depend on the intensity of incident light.
- For every material, there exists a threshold frequency below which no photoelectrons are emitted.
- For a particular frequency, the number of photoelectrons emitted per unit area of the emitting surface is proportional to the intensity of the incident light.
- There is practically no time lapse ($\sim 10^{-9}$s) between the incidence of light on the metal and emission of electrons from it. photoelectric
- emission is an instantaneous process.

EINSTEIN'S THEORY OF PHOTOELECTRIC EMISSION

The work function of a conductor is the minimum energy required by an electron to come out of the conductor surface.

The energy E of a single photon is given by $E = h\upsilon$

$K_{max} = \frac{1}{2}mv^2 = h(\upsilon - \upsilon_0)$

For v_{max} to be positive, no emission can take place for $\upsilon < \upsilon_0$. That is, the incident light

must have frequency above the threshold frequency.

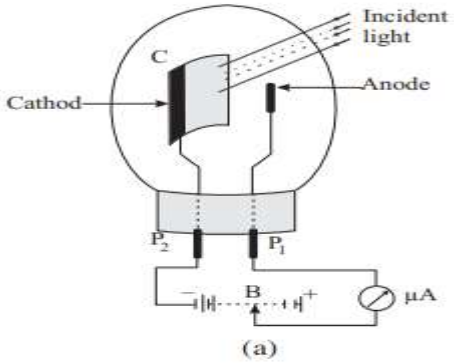
Kmax is linearly proportional to $(\upsilon - \upsilon_0)$

- An increase in the intensity of incident light of frequency υ corresponds to an increase in the number of photons.
- Each and every photon has same energy; there is no increase in the energy of photoelectrons. However, the no. of emitted electrons and hence photocurrent will increase with increase in intensity.
- The energy transfer from photons is instantaneous, i.e. there is almost no time lag.
- Since work function is a characteristic property of a material, υo is independent of the intensity of incident light.

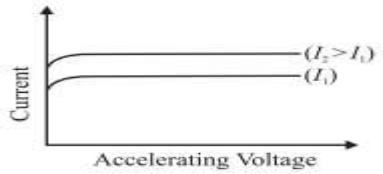
PHOTOELECTRIC TUBE

The photoelectric tube is based on photoelectric effect

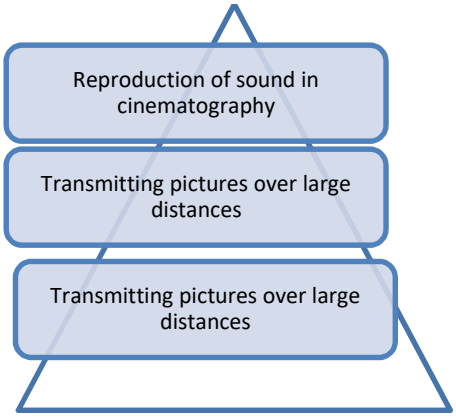
- The value of saturation current is determined by the intensity of incident light.
- If the intensity of light is increased, the saturation current also increased



(a)



Applications



THE DE BROGLIE HYPOTHESIS

"particles" such as electrons, and protons should also exhibit wave characteristics under certain circumstances Light is an electromagnetic radiation and exhibits wave-particle duality.

$$\lambda = h/P$$

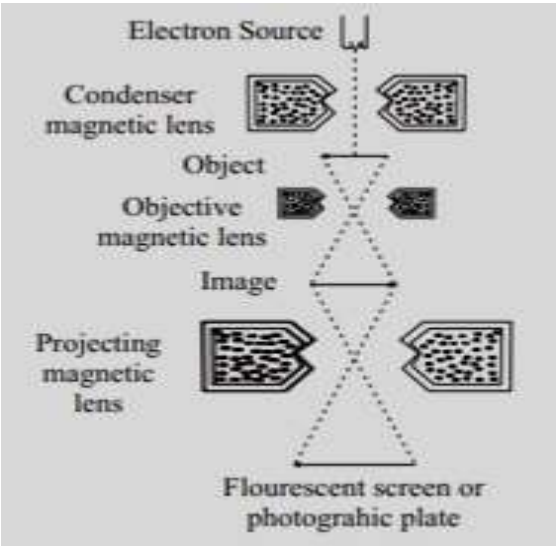
λ is called de Broglie wavelength

$$mv = p = \sqrt{2qmV}$$

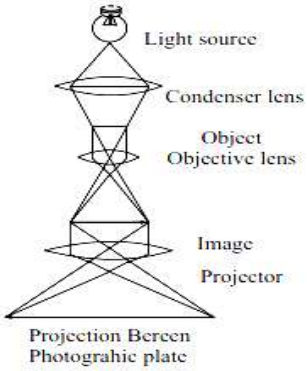
$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2qmV}}$$

Applications of de Broglie Waves

- **Electron microscope**
  Electron microscopes are scientific instruments that use a beam of highly energetic electrons to examine objects on a very fine scale



Optical microscope



Check Yourself

1. The photo electric effect predict that light is made of
   A. Photons
   B. Electrons
   C. Neutrons
   D. All the three mentioned in A,B,C
2. The work function for photoelectric effect
   A. Depends upon the frequency of incident light
   B. Is same for all metal
   C. Is different for different metal
   D. None of the above
3. The velocity of the photoelectrons depends upon
   A. Frequency of the incident photon only
   B. Intensity of the incident photon only

C. Intensity and frequency of the incident photon
D. None of the above

4. Light of wavelength $5000A^0$ falls on a sensitive plate with photoelectric work function equal to 1.9 eV. The frequency of photon is
   A. $6*10^{14}$
   B. $6*10^{10}$
   C. $3*10^{10}$
   D. $6*10^{16}$
5. In question 4 the energy of the photon in eV is
   A. 0.248
   B. 2.48
   C. 24
   D. 0.0248

Stretch Yourself

1. Calculate the maximum kinetic energy of the emitted photoelectrons when light of frequency v = 1015 Hz is incident on a zinc plate. The work function of zinc is 3.4 eV.
2. How is velocity of photoelectrons affected if the wavelength of incident light is increased?
3. Describe the salient features of Einstein's theory of photoelectric effect.
4. What was the aim of Davisson and Germer's experiment? On what principle does it depend?
5. What is the difference between a photon and a matter particle?

Hint to Check Yourself

1A 2 C 3 A 4 A 5 B