d. In a Millikan-type apparatus the horizontal plates are 1.5 cm apart. With the electric field switched off an oil drop is observed to fall with the steady velocity 2.5×10^{-2} cm/s. When the field is switched on the upper plate being positive, the drop just remains stationary when the potential difference between the plates is 1500 V. Calculate the radius of the drop and the number of electronic charges. (Given: density of oil = 900 kgm^{-3} and viscosity of air $1.8\times10^{-5} Nsm^{-2}$, neglecting the air density. **[1.51×10^{-6}m, 8]** 3

4. Millikan's oil drop experiment utilizes the electric field in a viscous fluid to analyze the speed of charge oil drop.
   a. Mention and sketch the types of forces that play an important role during the motion of drop in the viscous medium in the absence of electric field. 2
   b. What happens if the falling drop suddenly experiences net force zero in the vertical path. 1
   c. Calculate the radius of a water drop which would just remain suspended in an electric field of 300V/cm and charge with one electron **[4.9×10^{-7}m]** 2
   d. Calculate the p.d. in volt necessary to be maintained between two horizontal conducting plates, one 5mm above the other so that a small oil drop of mass 1.31×10^{-14}kg with two electrons attached to it, remains in equilibrium. **[2046.86 V]** 2
   e. An oil drop of mass $3.25 \times 10^{-15} Kg$ fall vertically with uniform velocity, throughout the air between vertical parallel plates which are 2cm apart. When a potential difference of 1000V is applied to the plates the drop moves to the negatively charged plate, its path being inclined at 45° to the vertical. Calculate the charge on the drop. **[6.37×10^{-19} C]** 2

Photon

Photon is the small packet of energy of electromagnetic radiations.

Energy of a photon: $\boldsymbol{E = hf = \frac{hc}{\lambda}}$

$f = \frac{c}{\lambda}$

Energy of N photons: $\boldsymbol{E = Nhf = \frac{Nhc}{\lambda}}$

Power: $P = \frac{Nhf}{t} = \frac{Nhc}{\lambda\, t}$

$hc = 2 \times 10^{-25}$

Intensity, $I = \frac{P}{A}$

Mass of a photon: $\boldsymbol{m = \frac{hf}{c^2}}$

➢ Mass of photons is not same. [**γ photon have maximum mass**]

E_{max} f_{max} λ_{min}

γ ray
X ray
UV ray
Visible ray → V I B G Y O R
IR ray
MW ray
RW ray

Einstein's Photoelectric equation:

$$E = \phi + KE$$

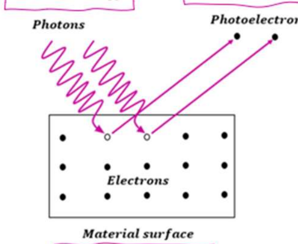
Here, KE indicates maximum Kinetic energy. (KE_{max}).

Note: Minimum KE of photoelectron is **zero**.

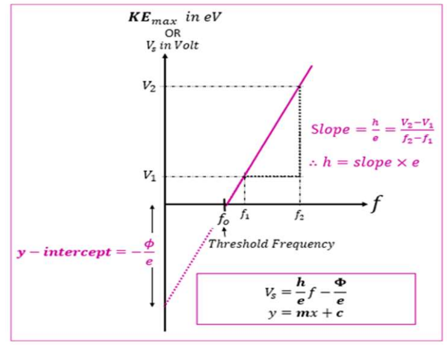
- The KE of photoelectron (also Stopping potential) **depends** upon **frequency** of radiation but **does not** depend upon the **intensity** of radiation.
- The photoelectric current (also number of photoelectrons) **depends** upon **intensity** of radiation but **does not** depend upon the **frequency**

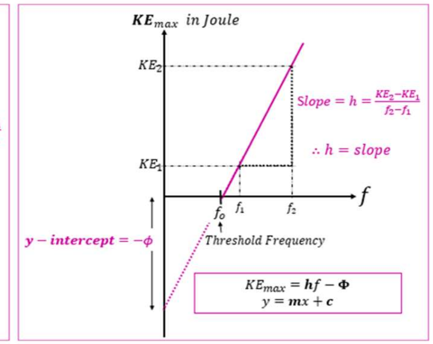
$E = hf = \frac{hc}{\lambda}$

$KE = \frac{1}{2}mv^2 = eV$



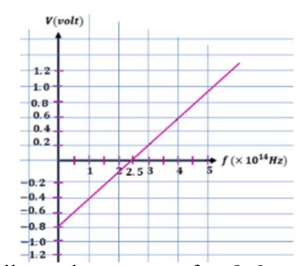
$\phi = hf_o = \frac{hc}{\lambda_o}$





1. a. Define the photoelectric effect. 1
   b. Why alkali metals are used in the generation of solar energy? 2
   c. What happens to the kinetic energy of photoelectrons if the work function of surface is increased? Explain with suitable relation. 1
   d. What is photon? Can you say photons of light with different frequency have equal mass? 2
   e. A 1 mW laser produces red light of wavelength $6.68 \times 10^{-7} m$. Calculate how many photons the laser produces per second. **[3.24×10^{15}]** 2
   e. The metal surface having work function of 2eV is illuminated by the radiation of frequency 10^{15}Hz. What would be the maximum kinetic energy of the emitted electrons? 2
   f. An electron at the surface of the metal of work function 1.9eV is emitted with a kinetic energy of 4.5 × 10−19 J. Calculate the energy and frequency of the incident photon. 2
   g. The maximum kinetic energy of the electrons emitted from a metallic surface is 1.6×10^{-19}J, when the frequency of the radiation is 7.5×10^{14} Hz. Calculate the minimum frequency of the radiation for which electrons will be emitted. 2

2. a. Define the term work function and threshold frequency of a metal. 2
   b. What is meant by stopping potential? How would the stopping potential be changed if the distance between source of light and the target surface is increased? 2
   c. Derive Einstein's photoelectric equation.
   d. The threshold frequency of a metal is f_o. When the light of frequency $2f_o$ is incident on the metal plate, the maximum velocity of electrons emitted is v_1. When the frequency of the incident radiation is increased to $5f_o$, the maximum velocity of electrons emitted is v_2. Find the ratio of v_1 to v_2. 3
   e. The threshold frequency of Cesium and Potassium metals 5.07×10^{14}Hz and 5.55×10^{14}Hz respectively. Which one of the two metals has a higher work function? Give a reason for the answer. 2
   f. The work function of the sodium is 2.3 eV. Does an orange light of wavelength 6800 A° eject photoelectron from its surface? Explain with appropriate calculations. 2



3. a. When ultraviolet light with a wavelength of 400 nm falls on a certain metal surface, the maximum kinetic energy of the emitted electrons is 1.10eV. What is the maximum kinetic energy of the photoelectron, when light of wavelength 300 nm falls on the same surface? 2
   b. From the given graph, find the value of plank constant, threshold (cut-off) wavelength and work function. 3