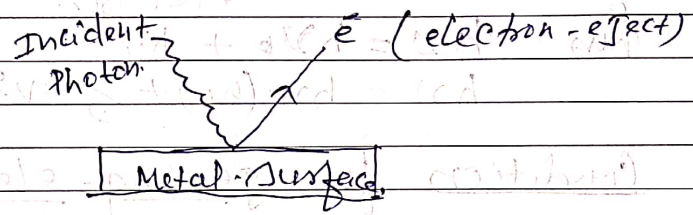
Dr. S.K. Gupta
Deptt. of Chemistry
Marwari College

Units - Atomic Structure

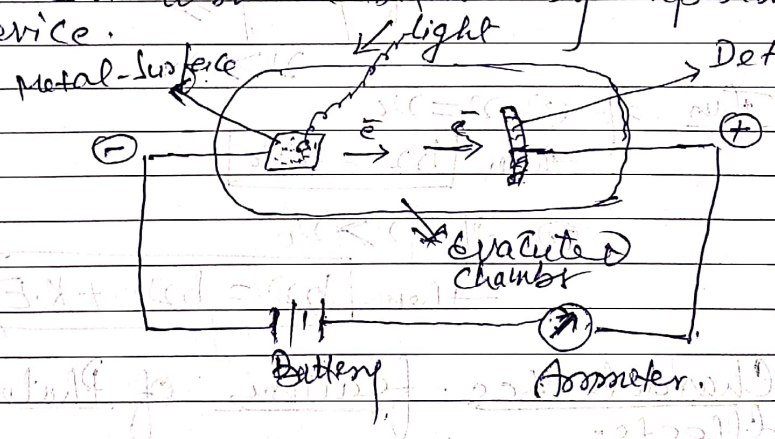
Topics - Photo-electric effect

Statement :- When light of certain frequency strikes upon the surface of some metals electrons are ejected, such phenomenon is called photo-electric effect.

The emitted electrons is called Photo-electrons.



It can also be shown by experimental-Device.



Mathematical Relation :-

It was observed by Einstein that when a photon strikes the metal-surface some of the energy used up to eject electron from the metal (equal to Binding energy) & rest energy utilised to increase the Kinetic energy of photo-electrons.

It may be expressed as

Energy of incident-Photon (Striking Photon)
= Binding-energy (Threshold-energy or work-function)
+ Kinetic-energy of ejected electron.

Thus $h\nu = h\nu_0 + K.E$

$h\nu = h\nu_0(w_0) + \frac{1}{2}mv^2$

Condition for ejecting-electron:-

Incident-frequency $\geq$ Threshold-frequency (ν_0)

$\nu \geq \nu_0$

Thus, if (1) $\nu = \nu_0$

then $\boxed{h\nu = h\nu_0}$

(2) If $\nu > \nu_0$

then $\boxed{h\nu = h\nu_0 + K.E}$

Characteristics-features of Photo-Electric effects.

(1) The emission of Photo-electrons takes-place immediately after the light is incident upon metal-surface.
There is no-time-lag b/w incident of light-beam & emission of Photo-electrons.

(2) The number of Photo-electrons ejected per-sec. is

proportional to the intensity of light used.

(3) For each metal, certain minimum frequency of light (threshold frequency) must be needed for the ejection of electrons from the metal surface.

Metal →	Li	Na	K	Mg	Cu	Ag
V_0(eV) →	2.48	2.3	2.25	3.7	4.8	4.5

Remember:- Lower the value of V_0, easy ejection of electrons.

(4) Such effects also is an evidence of Particle-Nature of electrons.

(5) ~~The number ejected electrons~~ ~~probe~~ of the potential applied (V_0) upon the metal-surface so that velocity of Photo-electrons becomes zero, the value (eV_0) is called ~~stopping~~ potential.

The numerical-value of ~~stopping~~ Potential is equal to the K.E.

$$K.E = \frac{1}{2}mv^2 = eV_0.$$

Some Numerical Problem:-

Objective:- (1) The threshold wave-length (λ_0) for Photo-electric-effect on Na is 500 A^0 its work-function (W_0) will be

(a) 1 J (b) 2×10^{-19} J (c) 3×10^{-19} J (d) 4×10^{-19} J

Solve:- $\lambda_0 = 500\ A^0$

$= 500\times10^{-10}$ m

$= 5 \times 10^{-7}$ m

Now $\nu_0 = \frac{c}{\lambda_0}$ c = velocity of light $= 3 \times 10^8$ m/s

$= \frac{3 \times 10^8}{5 \times 10^{-7}} = 6 \times 10^{14}$ s

Now work function ($W_0 = h\nu_0$)

$= 6.626 \times 10^{-34} \times 6 \times 10^{14}$

$= 39.756 \times 10^{-20}$ J

$= 3.9756 \times 10^{-19}$ J

$\simeq 4 \times 10^{-19}$ J

Ans = (d)

Question — NCERT/2.12

Electrons are emitted with zero velocity from a metal surface when it is exposed to radiation of wavelength 6800 Å. Calculate threshold frequency (ν_0) & work function (W_0) of the metal.

Solve:— given $\lambda = 6800$ Å $= 6800 \times 10^{-10}$ m

Energy of striking frequency

$E = h\nu$

$= h \cdot \frac{c}{\lambda}$

$= \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{6800 \times 10^{-10}}$

$= 2.92 \times 10^{-19}$ J

Threshold frequency (ν_0)

$= \frac{c}{\lambda_0}$

$= \frac{3 \times 10^8}{6800 \times 10^{-10}}$

$= 4.41 \times 10^{14}$ Å^{-1}

Ans

& K.E $= \frac{1}{2}mv^2$

$= \frac{1}{2} \times m \times 0^2$

$= 0$

work function (W_0) $= h\nu - K.E$

$= 2.92 \times 10^{-19}$ J $- 0$

$= 2.92 \times 10^{-19}$ J

Ans