SBG STUDY

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06/09/17 Chapter :

Modern Physics

* **Photoelectric effect :**

Light is constitute of small particles known as photons

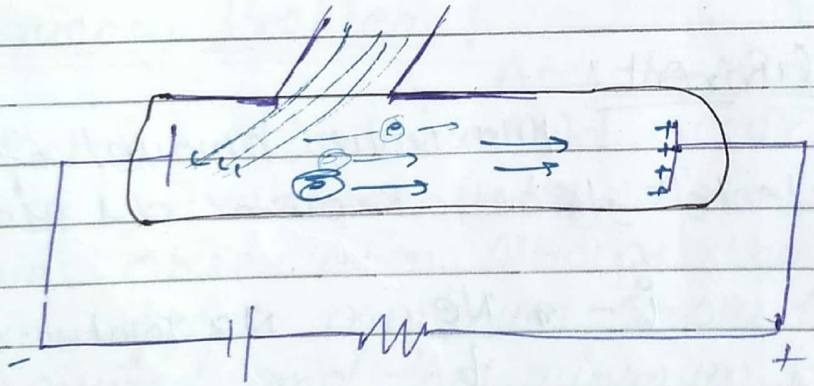
* Photones have Rest mass = 0
* Photones have momentum = $p = \frac{h}{\lambda}$

$p = \frac{E}{c}$

* Photones have energy $E = \frac{hc}{\lambda}$

* Photoelectric effect shows that light have Particle nature and its Particles are known as Photones

⇒



* **Some Important Definations :**

1) **Work function :** minimum amount of energy required for the removal of electron from metal is known as work function.

Work function is minimum for Cesium and It is Relatively for Alkali metals.

(2) Photo electrons:

Electrons Removed from metal on the Incidence of light is known as Photo electrons

(3) Photo current:

Current due to flow of these $e^{\ominus}$ (Photo electrons) is known as Photo Current

$$V = IR \rightarrow X$$

$$i = \frac{Q}{t} = \frac{ne}{t}$$

n = no. of photo $e^{\ominus}$

* Saturation Current:

Maximum amount of Current in a photo electric tube known as saturation Current.

$$i = \frac{Ne}{t}$$

N ⇒ Total no. of $e^{\ominus}$

* Stopping Potential:

Reverse amount of Potential applied across Photo tube. So that None of the electron can reach other Plate is known as Stopping potential

$$KE_{max} = q\Delta V_s$$

V_s = Stopping Potential

$f \propto V_0 \propto \varepsilon$

Observation made by Einstein :-

(1) Time delay :-

(1) Intensity Problem :-

Int. $\propto$ Electric f.

Acc. to wave theory intensity of light depends on amplitude of electric field as amplitude / as intensity of light will increase and amplitude of light will increase which result will increase force on electron.

Due to which kinetic energy of $e^{\ominus}$ must increase. And stopping potential also increase However observation shows that maximum K.E is independent from Intensity of light.

(2) Frequency Problem :-

Acc. to wave theory Photoelectric effect should occur for any frequency (wavelength of light) provided However observation shows that for photo-electric effect minimum amount of Energy is required and this minimum amount of frequency is known as Threshold frequency and it was observed that Photo-electric effect shown as light of wave length less than a particular maximum wave length known as Threshold hold wave lengh.

$\varepsilon = h\nu_0$ — Threshold frequency

Board

Threshold Energy = $h\nu_0$

(3) Time delay :-

There was no time delay b/w Emittion of Photo electron and Incidene of light which Proves that Light as Particle nature

* Einstine eqn for Photo electric effect :-

Acc. to Photone theory of Einstin's Energy of ~~Phot~~ Light is Quantised and the small Packets of Energy are known as Photones

Energy Carred by one Photones $= \frac{hc}{\lambda}$

$$I = nh\nu$$

$\bar{\nu} = \frac{c}{\lambda}$

I = Energy Per unit Area per unit time.

$$I = nh\nu \quad \text{Or} \quad h\nu$$

where n is no. of Photone Per unit Area or Per unit time.

$$E = h\nu_0$$

ν_0 = Theshold frequency

Imp $\quad E = \phi_0 + K.E$

$$h\nu = \phi_0 + K.E_{max}$$

ϕ_0 → Threshold Energy

$\nu > \nu_0$

H.w & Rael
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16 1.6

$$E = \frac{12400}{\lambda \text{ in } A^\circ} = \frac{1230}{\lambda} \text{ eV.}$$

$$\frac{hc}{\lambda} = \frac{1.6\times10^{-19}}{\lambda}$$

$h = 6.6\times10^{-34}$

$c = \frac{3\times10^{8}}{1.6\times10^{-19}}$ for convert in eV.

Que: A wave length
Light having wave length of 4000 A° falls on metal surface having work function 2eV. find max. kinetic energy. also find stopping potential

$$h\nu = \phi_0 + KE_{max}$$

~~$KE = h\nu - \phi_0$~~

$KE_{max} = h\nu - \phi$

$= \frac{hc}{\lambda} - \phi$

$= \frac{\cancel{\times 3\times10^{8}}}{\cancel{\lambda}} - 2$

$= \frac{1.6\times10^{-19}}{4000\times} - 2$

1.6

$\frac{hc}{\lambda}$

$h = \frac{6.6\times10^{-3}\times3\times10^{8}}{4\times10^{-10}}$

$= \frac{19.2\times10^{-17}}{A}$

Ans: $E = \frac{hc}{\lambda} = \frac{12.4000}{4000} = 3.1 \text{ eV.}$

$= \frac{1.1 \text{ eV}}{1.1 \text{ V}}$

$E = \phi + K.E_{max}$

$3.1 = 2eV + K.E_{max}$

$1.1 eV = KE_{max} = eV_s$

$\Rightarrow$

$1.6 \times 10^{-19}\ J = 1\ eV$

$= \frac{19.2 \times 10^{-6}}{A[1.6 \times 10^{-19}} = \frac{19.2 \times 10^{3}}{A\ 1.6}$

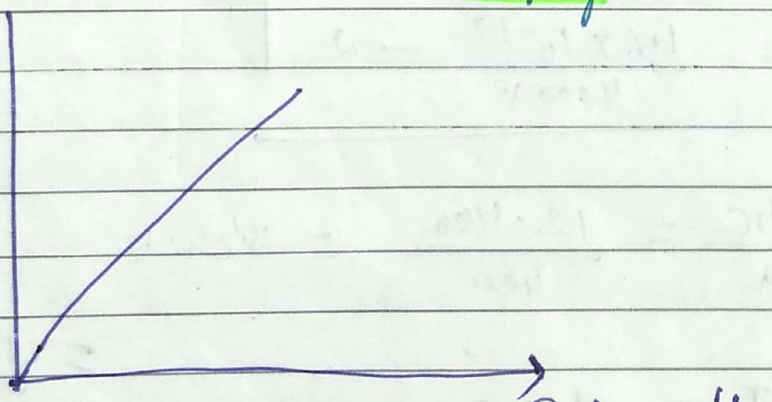
$= \frac{12340}{A} \Rightarrow$

where A is any no. in A°.

$$E = \frac{hc}{\lambda} = \frac{12400}{\lambda \text{ in } A^{\circ}}$$

* Some Important terms / graphs / observation :- for Photo electric effect:

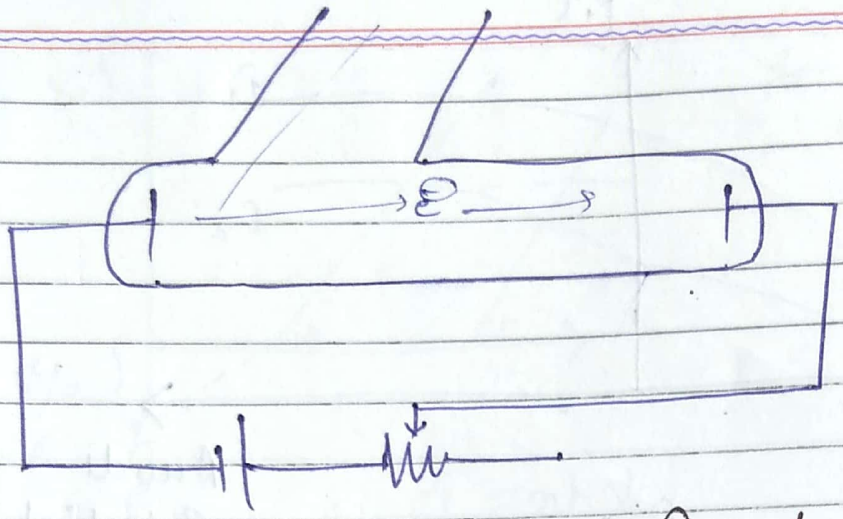
(1) Variations of Photo Current with the Various of Intensity keeping frequency const.



$I = nhv$

Current $\propto$ no. of photons $\propto$ Intensity

λ - frequency



Einstine Photon theory or Quantum theory :-

$$E = \frac{nhc}{\lambda} = nh\nu$$

According to Einstine Energy of light is Quantised in form of photones which behaves as Paticles. When photons collides with electron total Energy of a photone will be absorved by electons (as this energy cannot be further divided).

not very important part

$$I = \frac{ne}{t}$$

$$I \uparrow = n \uparrow$$

Voltage ↑ Current ↑

$n \uparrow$

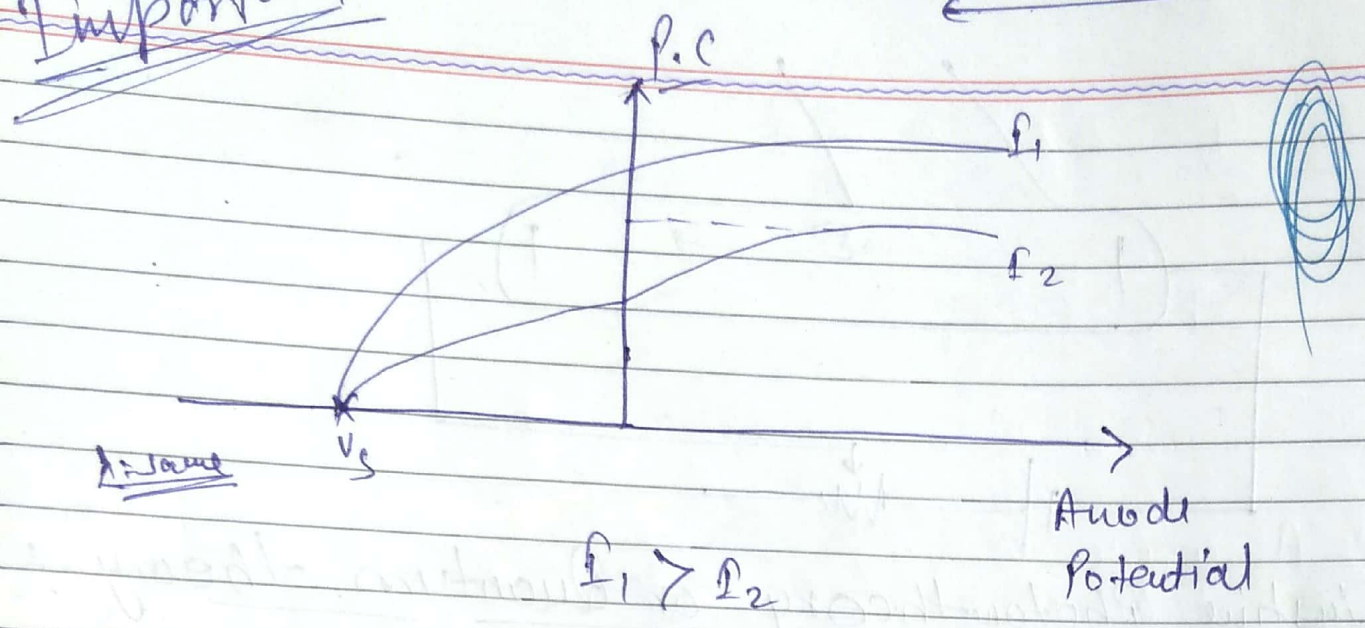
$(n=0)$ / $\left(\frac{I=0}{\text{current}}\right)$

(2) Variation of photo current with Potential difference applied across tube

A) Keeping frequency Constant. colour fixed.

Important

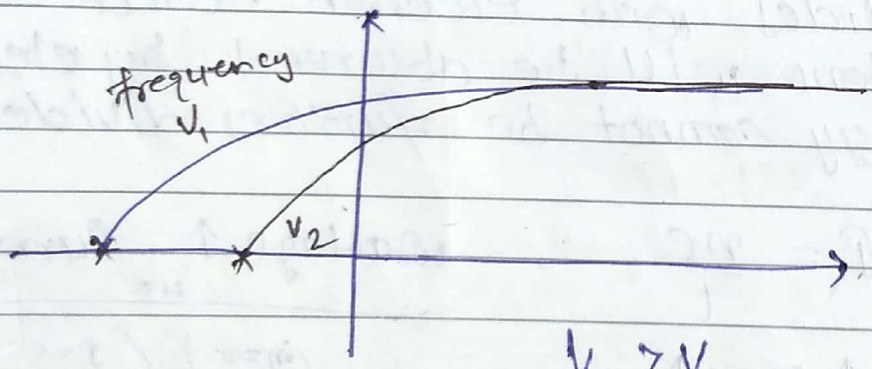
VIBGYOR



$f_1 > f_2$

(B) Keeping Intensity Constant.
Changing frequency — n Same

$$E = \frac{n h c}{\lambda}$$



$V_1 > V_2$

* Variation of Stopping potential with frequency :

$$h\nu = \phi_0 + eV_s$$

$E = eV_s$

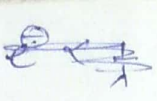
$$V_s = \frac{h}{e}\nu - \frac{\phi_0}{e}$$

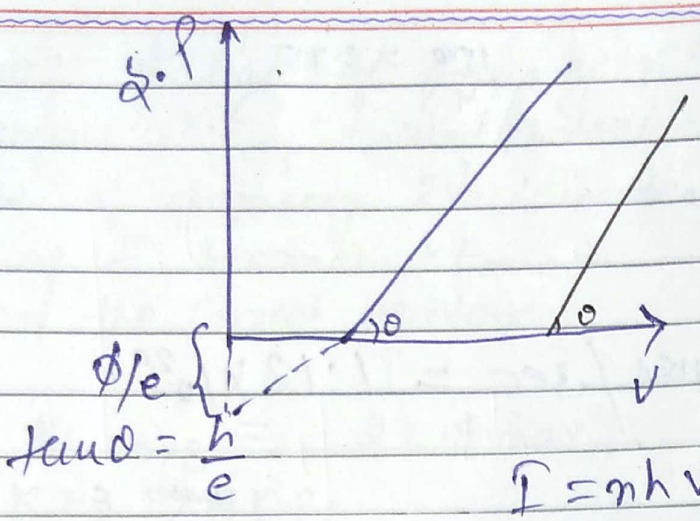
$V_s = m\nu + c$

Slope

$1.6 \times 10^{-}$

$e^{\ominus}$ Remove





$\tan\theta = \frac{h}{e}$

$I = nhv$

for any metal.
Slope is not Change

$e^{\ominus}$ Remove ∝ Speed

minimum freq. = Threshold fr

Que: A Yellow light having wavelength 5000 A° is used for photo electric effect source having wattage of ~~1000~~ 40 watt is used (Power)

find

(i) no. of photones emitted by source

(ii) no. of photones which will strike metallic plate of Area $1m^2$

(iii) if work fn of metal is 2 ev. find maximum Kinetic Energy of $e^{\ominus}$ and stopping potential

(iv) if efficiency of emittion is 80%. find saturation current.

$E = \frac{nhc}{\lambda} =$ $\quad n = \frac{Et}{hc} = \frac{E\,5000\phi}{1234\phi} =$ $\quad E = \frac{hc}{\lambda} = \frac{5000\phi}{1234\phi} = \frac{1234\phi}{5000\phi} = \frac{1234}{5000}$

$$I = \frac{nhc}{\lambda} = \frac{12.4000}{5.00} = 2.48 \text{ ev.}$$

$$I = 40 \frac{\text{Joule}}{\text{sec}} = n\left[2.48 \times 1.6 \times 10^{-9} \text{ Joule}\right]$$

$$\frac{40}{1.6 \times 2.48} \times 10^{19} = n$$

$h\upsilon = \phi_0 + eV_s$.

O-1
Photo electric effect
O-2 - EMI

$\frac{2.48 \times 1.6}{3.8} =$ $\frac{1540}{4} = 3.75$

1.12×10^{20}

no. of photones / sec $= 1.12 \times 10^{20}$

(ii) $\frac{P}{sec} = \text{watt}$ watt = E

$\frac{1.12 \times 10^{20}}{m^2 \text{ sec}}$

$\frac{\text{no. of Photo}}{t \times e}$

$\frac{nhc}{\lambda}$

$= 0.56 \times 10^{20}$
or 5.6×10^{19}.

(3)

S.V =

Current

(iv) 80% efficiency → 80 $e^{\ominus}$ Removed.

$5.6 \times 10^{19} \times 0.8$

$= 4.48 \times 10^{18}$ $e^{\ominus}$

$i = \frac{ne}{t}$ $= 4.48 \times 1.6 \times 10^{-1}$

$i = 0.7$ A

* Que: A light of frequency ν_0 is incident on a metal surface K.E of emitted photoelectron is $KE_{max\cdot A}$ if light of frequency $2\nu_0$ is incident on same metal surface. K.E of e$^\ominus$ becomes $KE_{max\,B}$.
Select the correct statement.

(A) $KE_{max\,B} = 2K.E_{max\,A}$

(B) $K.E_B > 2K.E_A$

(C) $K.E_B < 2K.E_A$

D) None.

$$E = \phi + KE$$
$$\downarrow \quad\quad \downarrow$$
$$4 \quad 2 + KE.$$

$$8 = 2 + K.E$$

Que: Light of wavelength 1.98×10^{-7} m if incident on a metal surface it has been observed that stopping potential is 2.5 Volt find
(i) Maximum speed of the photo electron, work function and Threshold frequency.

$$h\nu = \phi + K.E$$

$$2.5\,V = 1980 \times 10^{-10}$$

Ans: $2.5\,eV = E$

$$2.5 \times 1.6 \times 10^{-19} = \frac{1}{2} m v^2$$

$$2.5 \times 1.6 \times 10^{-19} = \frac{1}{2} \times 9 \times 10^{-31} \times v^2$$

Vκ̇ Stopping potential

$\frac{e}{q} \times 10^{12} = v^2$ 0.99

$10^6 = V$

(ii) $h\upsilon = \phi_0 + K.E$

$h\upsilon = \phi_0 + 2.5 eV$

$\frac{12400}{1980} = \phi + 2.5 eV.$

$6.2 = \phi + 2.5$ $\phi =$

$6.2 - 2.5 = \phi$

$\phi = 3.76 eV$

$\phi = \frac{3.7 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} = 9.1 \times 10^{14}$

single cloud

Qu: A metallic surface is irradi with monochromatic light of variable wave length. below a wave length of 5000 A°. No. of Photo e⊖s are emitted from the surface. with an. @ untnocon stopping potential of 3 volt is obtained find wave length of untnocon source.

= eV. = KE max

KE=

Sol^n:

$\lambda = 5000 A^\circ$

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

Threshold

$\frac{nhc}{\lambda} = \text{watt}$

Sol^{n}: $E_{light} = \phi_{metal} + K.E$

$\frac{12400}{\lambda} = \frac{12.400\phi}{5.000} + 3ev$

$\frac{12400}{5.5} = \lambda$

IIT

Que: Eliminating of the surface of certain metal alternately with light of wave length $\lambda_1 = 0.35\,\mu m$, $\lambda_2 = 0.54\,\mu m$ it was found at corresponding max velocity of photo e⊖ have a ratio 2:1 find Thres hold energy of metal.

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

$= \frac{1}{2} \times 1.6 \times 10$

Sol^{n}:

$E_1 = \phi + KE_{max.}$

$\frac{12400}{0.35} = \phi + 2$ $\quad E_2 = \phi + KE$

$\frac{12400}{0.54} = \phi + 1$

$\frac{12400}{3500} - 2 = \phi$ $\quad \frac{12400}{5400} - 1 = \phi.$

A° or 10^{-10} then the then the 12400/1.

on Next Page

use λ in A^0

S-1 Photo-Ele. Effect

Photo cell or sph.

Sol: E_{light} = metal + K.E

E_{light} = Metal = $k \cdot \varepsilon$

$\varepsilon_1 - \phi = k \cdot \varepsilon_1$

$\varepsilon_2 - \phi = k \cdot \varepsilon_2$

$$\frac{\frac{12400}{3500} - \phi_0}{\frac{12400}{5400} - \phi_0} = \frac{4}{1}$$

$$\frac{3.7 - \phi_0}{2.3 - \phi_0} = \frac{4}{1}$$

$$3.7 - \phi_0 = 9.2 - 4\phi_0$$

$$3\phi_0 = 5.5$$

$$\phi_0 = \frac{5.5}{3} = \frac{55}{30} = 1.$$

(checked calculation)

$E_{light} = \phi_{metal} + KE$ $\quad I = \frac{ne}{t}$

Last Year Ka Chem

Que: A beam of light consist of four wave length 4000 A°, 4800 A°, 6000 A°, 7000 A° each of the intensity $I = 1.5 \times 10^{-3}$ watt/m^2 The beams falls normally on an Area $10^{-4}\ m^2$ of a metal having work function 1.9 eV. Calculate no. of photons emitted And also find Saturation Current.

Sol:

$$E_1 = \frac{hc}{\lambda} = E_1 = \frac{12400}{4000} = \frac{31}{10} = 3.1$$

$$E_2 = \frac{12400}{4800 A^\circ} = \frac{31}{12} = 2.58 = 2.6$$

$$E_3 = \frac{12400}{6000} = \frac{124}{60} = 2.06$$

$$E_4 = \frac{12400}{7000} = 1.8$$

$$I = n(\epsilon_{photo})$$

watt, eV × 1.6×10^{-19}

$$1.5 \times 10^{-3} = n[3.1 \times 1.6 \times 10^{-19}]$$

$$\frac{1}{3.2} \times 10^{16} = 0.33 \times 10^{16} = n$$

$$= 3.3 \times 10^{15} = n_1$$

$n = n_1 + n_2 + n_3$

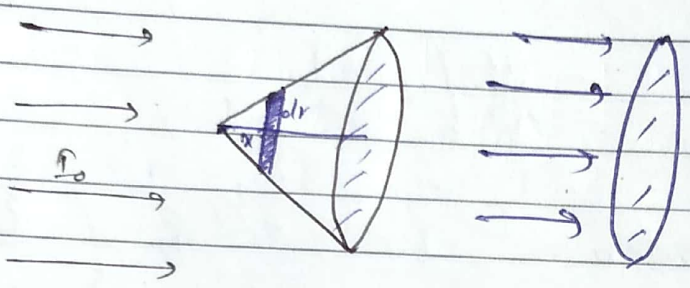
Threshold fr

$n_1 = 3.3 \times 10^{15} \times 10^{-4}$

$= 3.3 \times 10^{15} \times 10^{-4}$.

(because in m^2.)

Q. In the given diagram find force on the conical surface if absorvitte of cone is one :-

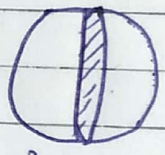


Valid only for

$$F = \frac{I_0 A}{c}$$

A = Area of Circle

$$F = \frac{I_0 \pi R^2}{c}$$



$$F = \frac{I_0 \pi R^2}{c}$$

If Light is Reflected

$$df = \frac{2 I A \cos^2\alpha}{c}$$

$\alpha = (90 - \theta)$

$$A = (2\pi r)\frac{dr}{\sin\theta}$$

$$df = 2I \frac{2\pi r dr}{c \sin\alpha} \sin^2\alpha$$

$m = 9.1 \times 10^{-31}$

* De-brogly :

Acc. to De brogely, if light has dual nature i.e particle nature and wave nature it emplies that Particle are also have dual nature.

De Broglay, suggested that wave is associated with each metal and the associated wave is known as metal wave.

$$P = \frac{h}{\lambda}$$

$$\lambda = \frac{h}{P}$$

$$\lambda_{M.W} = \frac{h}{P} = \frac{h}{MV} = \frac{h}{\sqrt{2m\,K.E}} = \frac{h}{\sqrt{2mqV}}$$

K.E → Kinetic Energy

V → Accelerating Potential

for $e^{\ominus}$ ⇒ $\lambda = \sqrt{\frac{150.1}{V}}$ in A° or $\frac{12.27}{\sqrt{V}}$ Å

De wave length

K.E of molecules ⇒ $KE = \frac{3}{2} K.t$

$$\lambda_{gas} = \frac{h}{\sqrt{2m\frac{3}{2}kT}} = \frac{h}{\sqrt{3mkT}}$$

T is in kelvin

Que: An $e^{\ominus}$ is Accelerated by potential diff. of 50 V. find de-Broglie wave length associated with it

Ans: $\sqrt{3}$

$$\lambda = \sqrt{\frac{150.1}{50}} = \sqrt{3}\ \text{Ans}$$

$$= \sqrt{3}$$

Q. Find the Ratio of de-Broglie wave length of molecules of Hydrogen and Helium which are at temp. 27°C and 127°C.

300 400 27 273

$$\lambda_{gas_H} = \frac{6.6 \times 10^{-34}}{\sqrt{3 \times 1 \times 300 \times}}$$

$$\lambda = \sqrt{\frac{2 \times 400}{1 \times 300}} = \sqrt{\frac{8}{3}}$$

8. Find the de Broglie wave length of a pallatop 10g having a velocity of 10 m/s.

Ans: $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{10 \times 10}$ (10 grams)

$= \frac{h}{mv}$

$\frac{}{0.01 \times 10}$

Q. A Uranium ^{238} nucleus decay into α-Particle (mass = 4) and its Daughter nuclei find the Ratio of de-Broglie wave length of the emitted α Particle and daughter nuclei.

Ans 1:1

$U_{mass} = 238, \quad \alpha_{mass} = 4.$

$\lambda = \frac{h}{p}$

$p = \frac{h}{\lambda} = \lambda = \frac{h}{p}$ $p =$

(238) ⟵ ○ (4) ⟶ v

Initial $p = 0 = p_1 + p_2$