ULTIMATE KCET

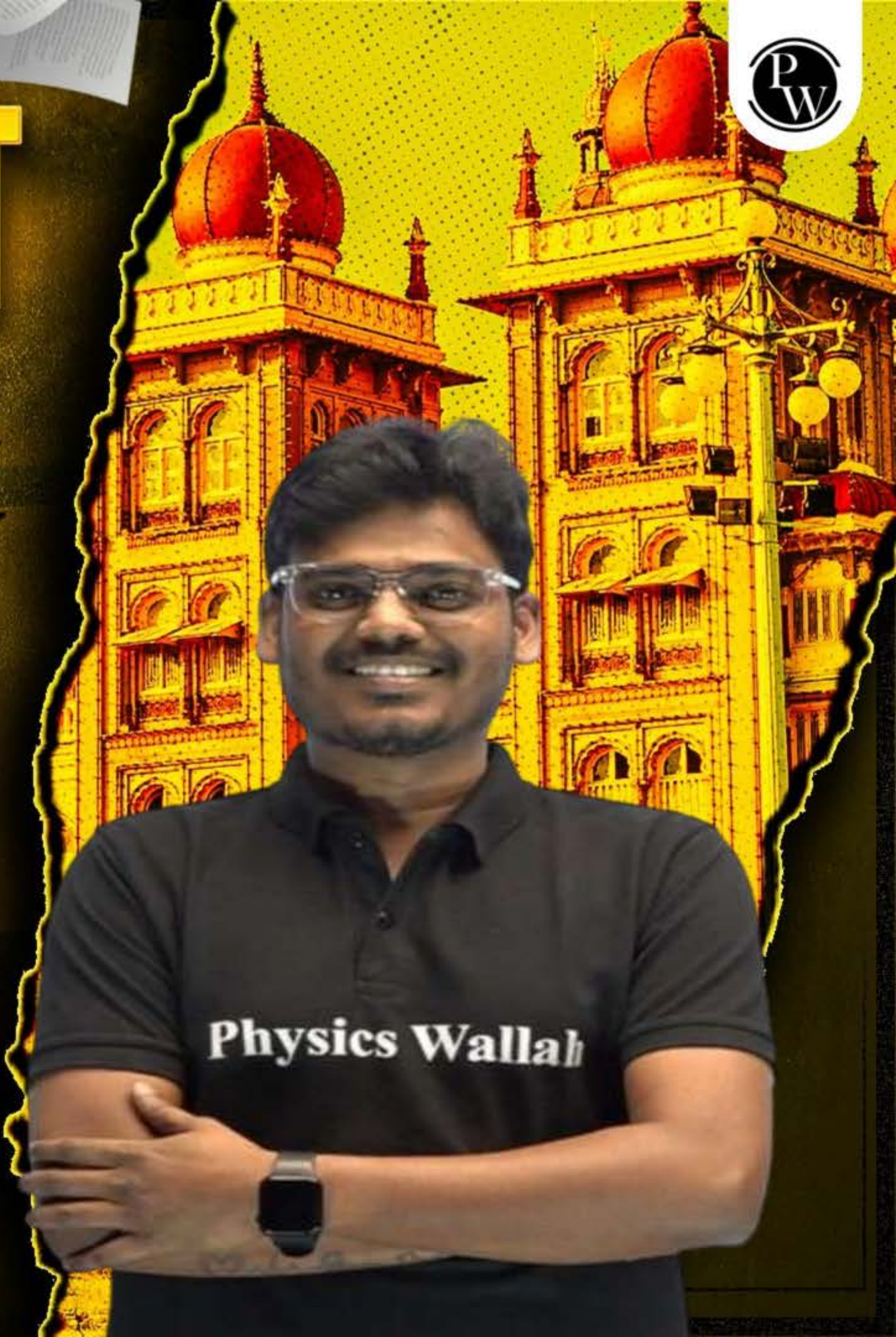
CRASH COURSE 2026

PHYSICS

Lecture : 01

ATOMS

By – AK SIR

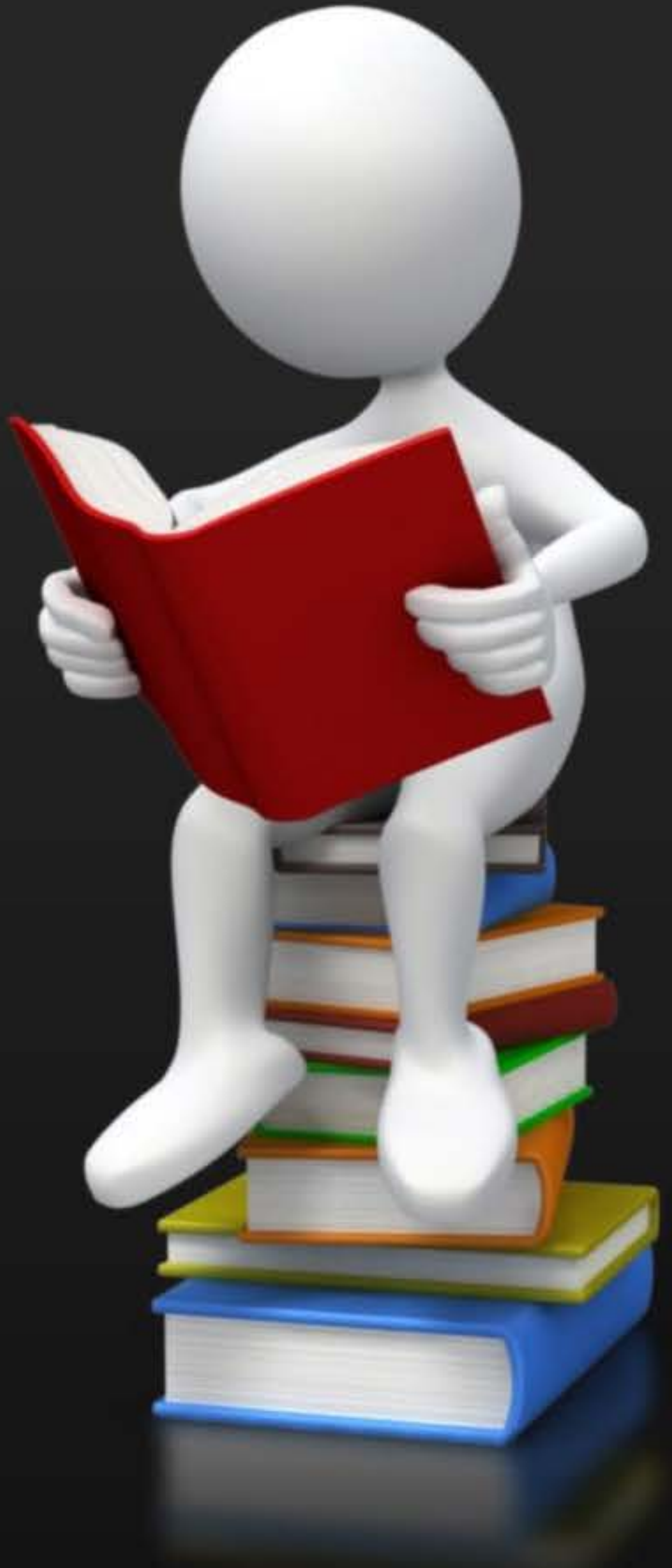


Recap *of previous lecture*

1. REFRACTION AT CURVED SURFACE AND LENSES
2. REFRACTION BY LENS
3. POWER OF LENS AND COMBINATION OF LENS
4. WAVE OPTICS

Topics *to be covered*

1. QUESTIONS ON PHOTOELECTRIC EFFECT
2. PARTICLE NATURE OF PHOTON
3. MATTER WAVES AND QUESTIONS
4. ATOMS



Test Syllabus

Ist 6 chapters - 1st Test.

↳ 5-April

→ PEE : $E = W + K.E_{max}$

$0 \le K \le K_{max}$

$h\nu = h\nu_0 + K.E_{max}$

$K = \frac{1}{2}mv^2$

$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + K.E_{max}$

$K = eV_0$

$E = \frac{1241}{\lambda(nm)}$. eV

$E = \frac{12410}{\lambda(A^\circ)}$ eV

Frequency, $\nu > \nu_0$

Wavelength. $\lambda < \lambda_0$

Energy . $E > W$

$\textcircled{c} = f\lambda$

$f \propto \frac{1}{\lambda}$

Question

In a photoelectric experiment, if both the intensity and frequency of the incident light are doubled, then the saturation photoelectric current

$i_p \propto I$

$K.E \propto \nu \propto V_0$

A is halved

B is doubled

C becomes four times

D remains constant

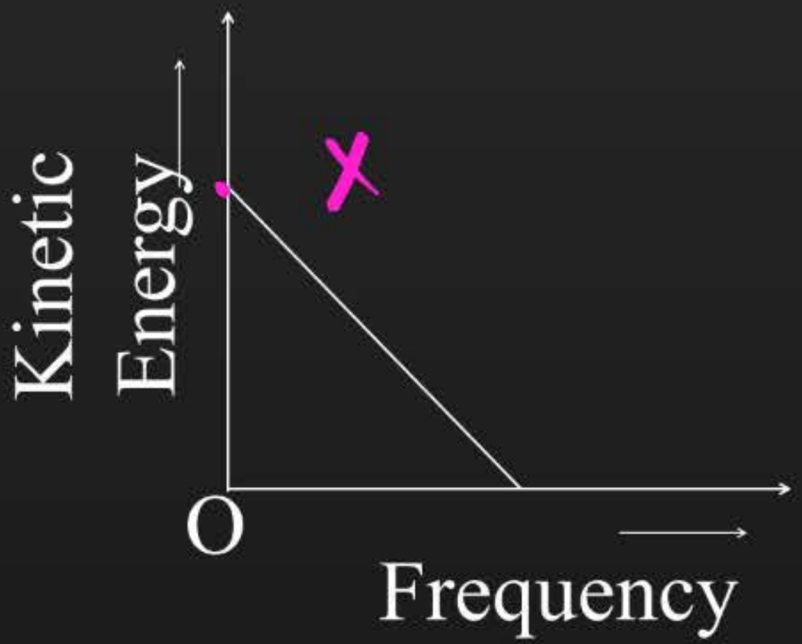
Question

According to Einstein's photoelectric equation to the graph between kinetic energy of photoelectrons ejected and the frequency of incident radiation is

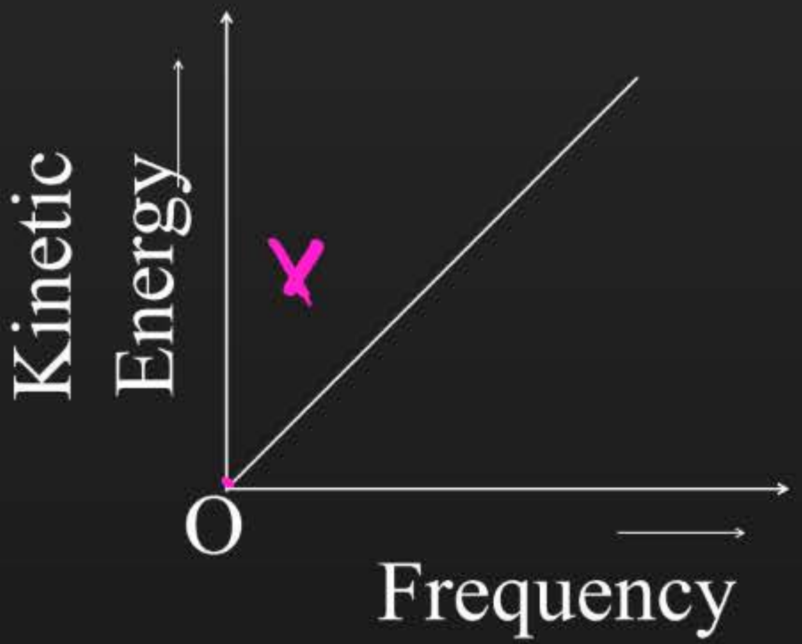
$K.E = E - W$

$\boxed{\begin{array}{c} K.E = h\nu - W \\ y = mx + c \end{array}}$

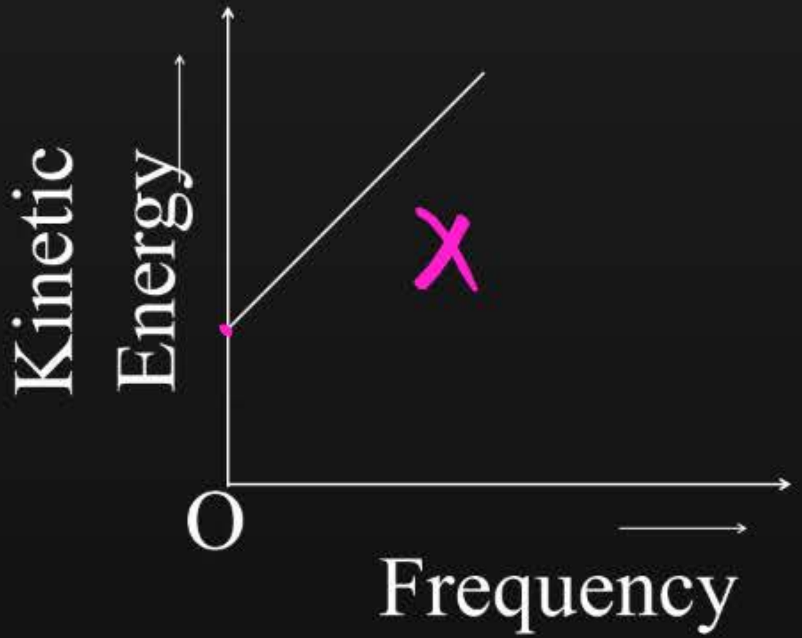
A



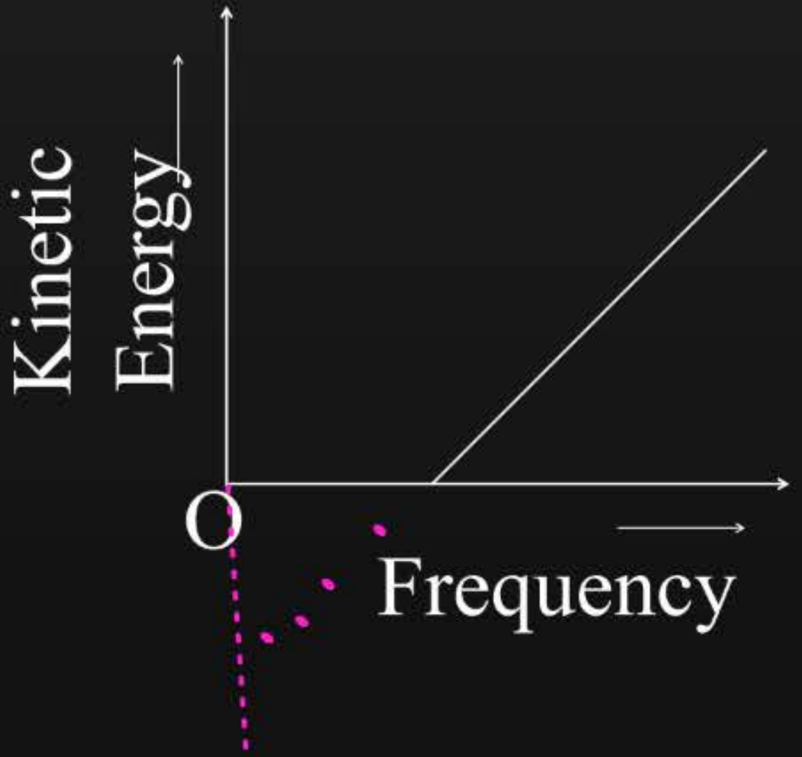
B



C



D



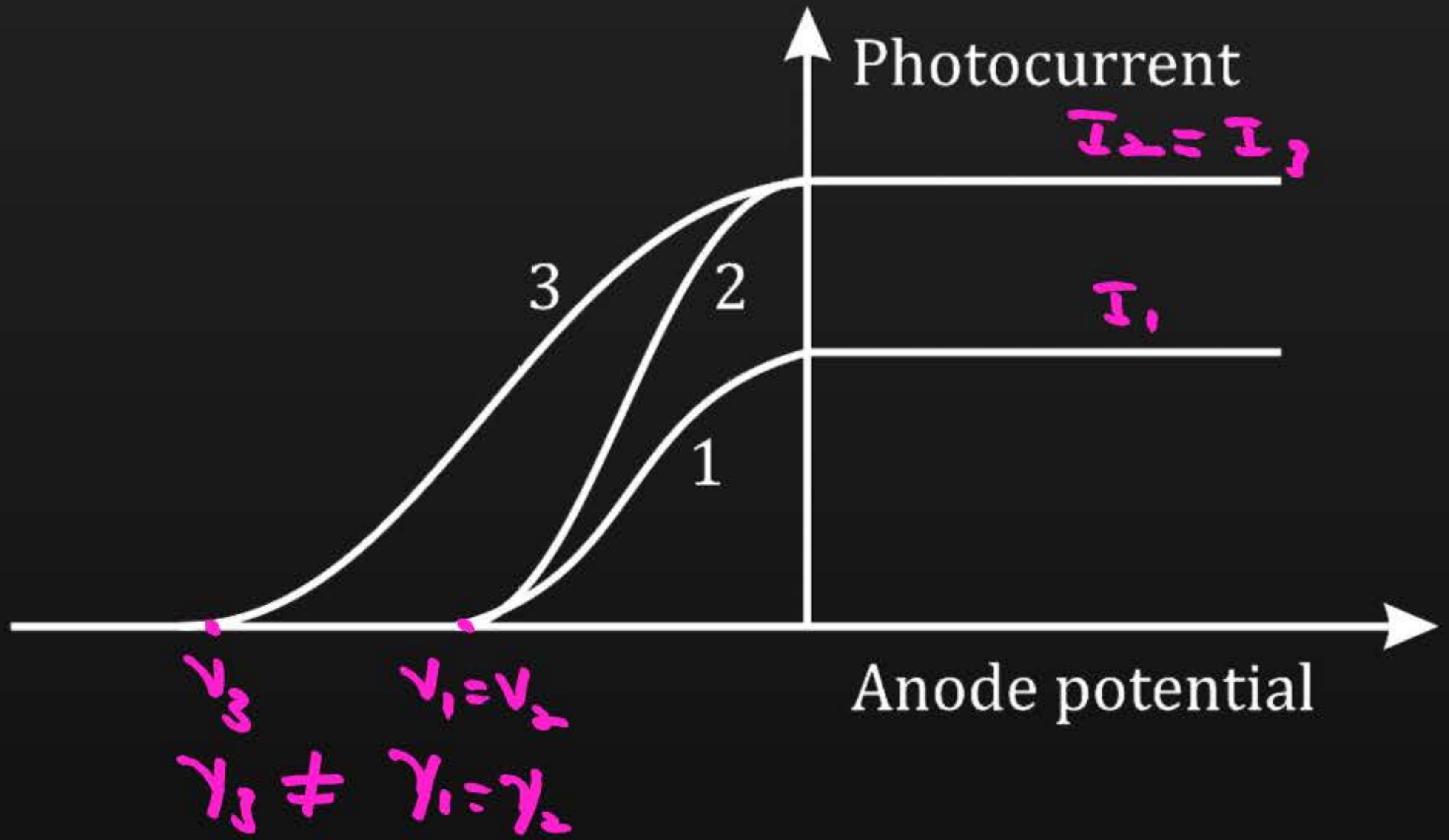
Question

The following graph represents the variation of photocurrent with anode potential for a metal surface Here, I_1, I_2 and I_3 represents intensities and $\gamma_1, \gamma_2, \gamma_3$, represent frequency for curves 1, 2 and 3 respectively, then

$K.E \propto f \propto V_0$

$I_1 \neq I_2 = I_3$

- **A** $\boxed{\gamma_1 = \gamma_2 \text{ and } I_1 \neq I_2}$ ✓ ✓
- **B** $\gamma_1 = \gamma_3$ and $I_1 \neq I_3$ ✗
- **C** $\gamma_1 = \gamma_2$ and $I_1 = I_2$ ✓ ✗
- **D** $\gamma_2 = \gamma_3$ and $I_1 = I_3$ ✗



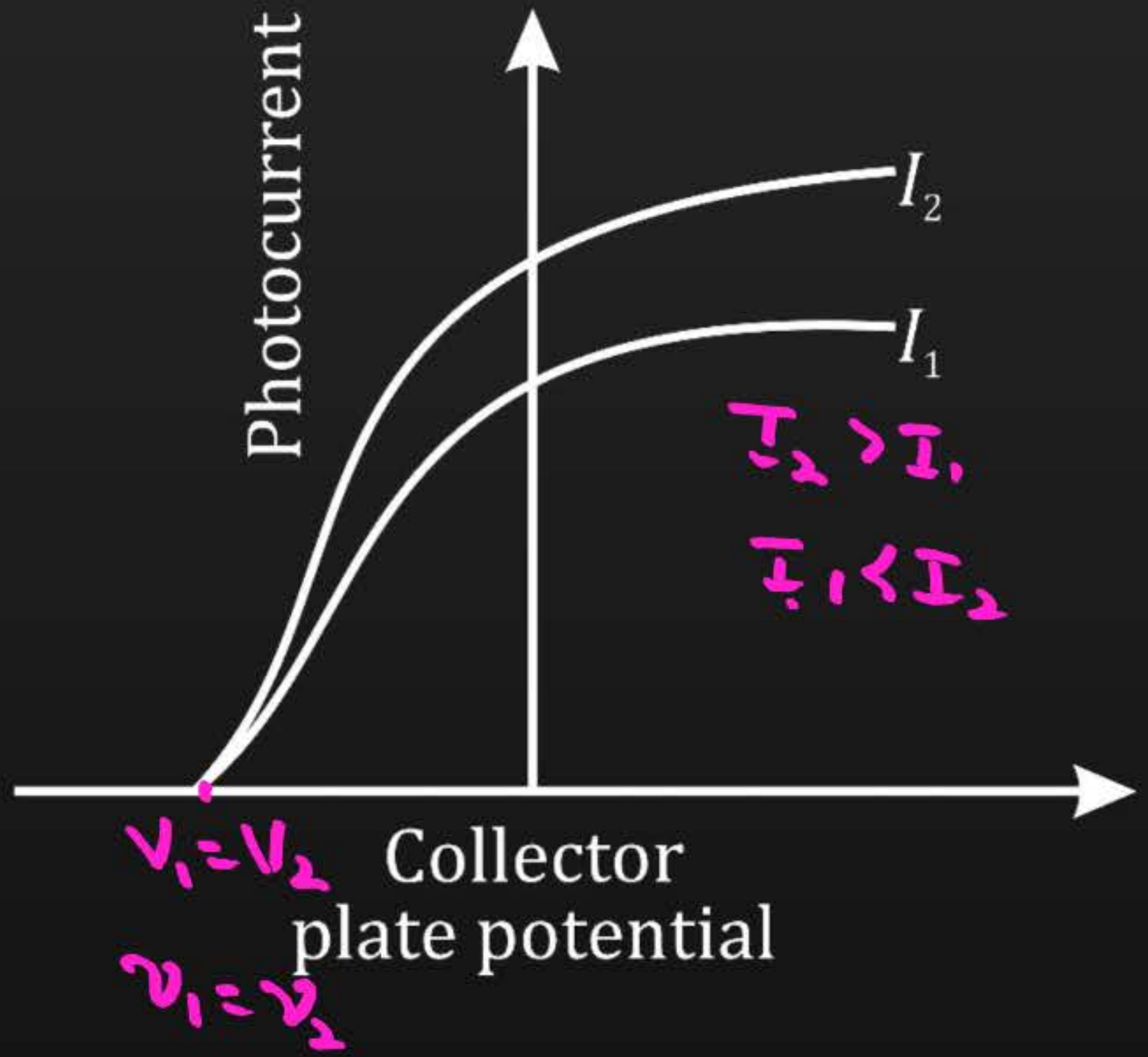
Question

The maximum kinetic energy of emitted photoelectrons depends on

- **A** Intensity of incident radiation
- **B** Frequency of incident radiation
- **C** Speed of incident radiation
- **D** Number of photons in the incident radiation

Question

From the following graph of photo current against collector plate potential, for two different intensities of light I_1 and I_2, one can conclude.



(A) $I_1 = I_2$

(B) $I_1 > I_2$

(C) $\boxed{I_1 < I_2}$

(D) Comparison is not possible

Question

The variation of photocurrent with collector potential for different frequencies of incident radiation ϑ_1, ϑ_2 and ϑ_3 is as shown in the graph, then

$\nu_1 < \nu_2 < \nu_3$

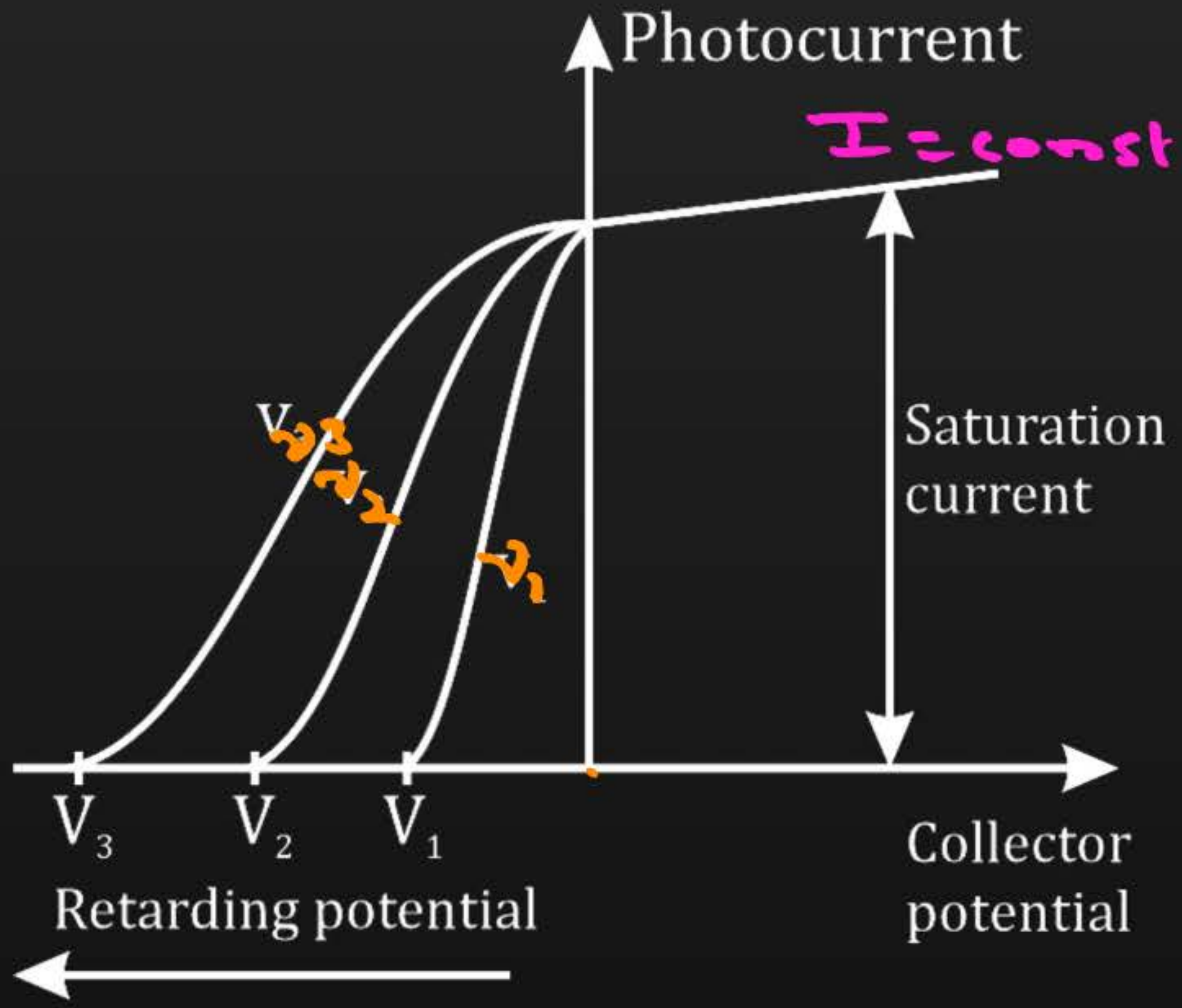
$\nu_3 > \nu_2 > \nu_1$

A $v_1 = v_2 = v_3$ ✗

B $v_1 > v_2 > v_3$ ✗

C $\boxed{v_1 < v_2 < v_3}$ ✓

D $v_3 = \frac{v_1 + v_2}{2}$ ✗



Question

The anode voltage of a photocell is kept fixed. The frequency of the light falling on the cathode is gradually increased. Then the correct graph which shows the variation of photo current i with the frequency ϑ of incident light is

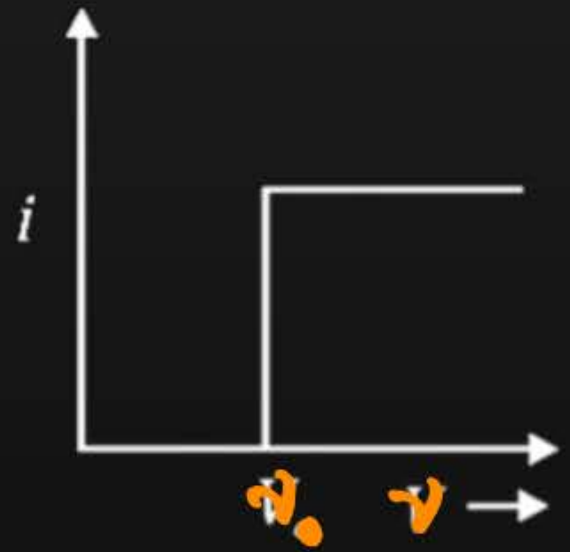
$\nu > \nu_0 \rightarrow i_p \neq 0$

$\nu < \nu_0 \rightarrow i_p = 0$

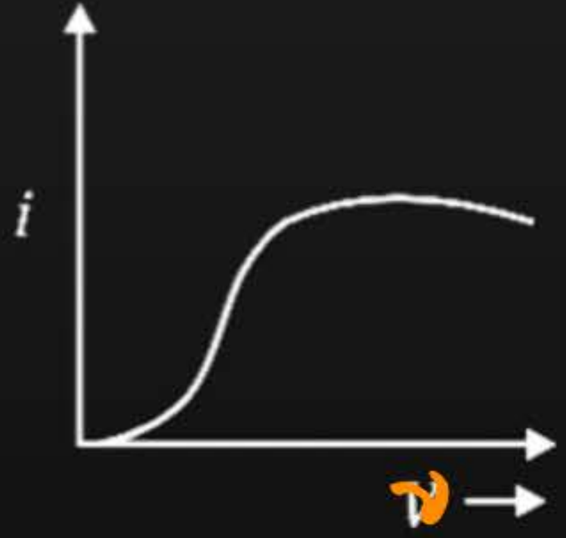
A

B

[✓ C]



D



Question

The maximum kinetic energy of emitted electrons in a photoelectric effect does not depend upon

$K.E = E - W$

$K.E = h\nu - W$

$K.E = \frac{hc}{\lambda} - W$

- **A** wavelength ✓
- **B** frequency ✓
- **C** intensity
- **D** work function ✓

Question

Light of energy E falls normally on a metal of work function $E/3$. The kinetic energies (K) of the photo electrons are

A $K = \frac{2E}{3}$ ✗

B $K = \frac{E}{3}$

C $\boxed{0 \leq K \leq \frac{2E}{3}}$

D $0 \leq K \leq \frac{E}{3}$

$$K.E_{max} = E - W$$

$$= E - \frac{E}{3}$$

$$= \frac{3E - E}{3}$$

$$= \boxed{\frac{2E}{3}}$$

$$0 \leq K \leq K_{max}.$$

$$\boxed{0 \leq K \leq \frac{2E}{3}}$$

Question

$\lambda < \lambda_0$ PEE ✓
$\lambda > \lambda_0$ PEE ×

The photoelectric work function for photo metal is 2.4 eV. Among the four wavelengths, the wavelength of light for which photo-emission does not take place is

A 200 nm ✓

B 300 nm ✓

C 700 nm

D 400 nm ✓

$E > W$

$W = \frac{hc}{\lambda_0}$

$\lambda_0 = \frac{hc}{W} = \frac{1241}{2.4}$

$\boxed{\lambda_0 = 517\ \text{nm}}$

$\lambda > \lambda_0$ PEE ×

Question

In an experiment to study photoelectric effect the observed variation of stopping potential with frequency of incident radiation is as shown in the figure. The slope and y-intercept are respectively.

A $\boxed{\frac{h}{e}, -\frac{hv_0}{e}}$

B $\frac{hv}{e}, v_0$

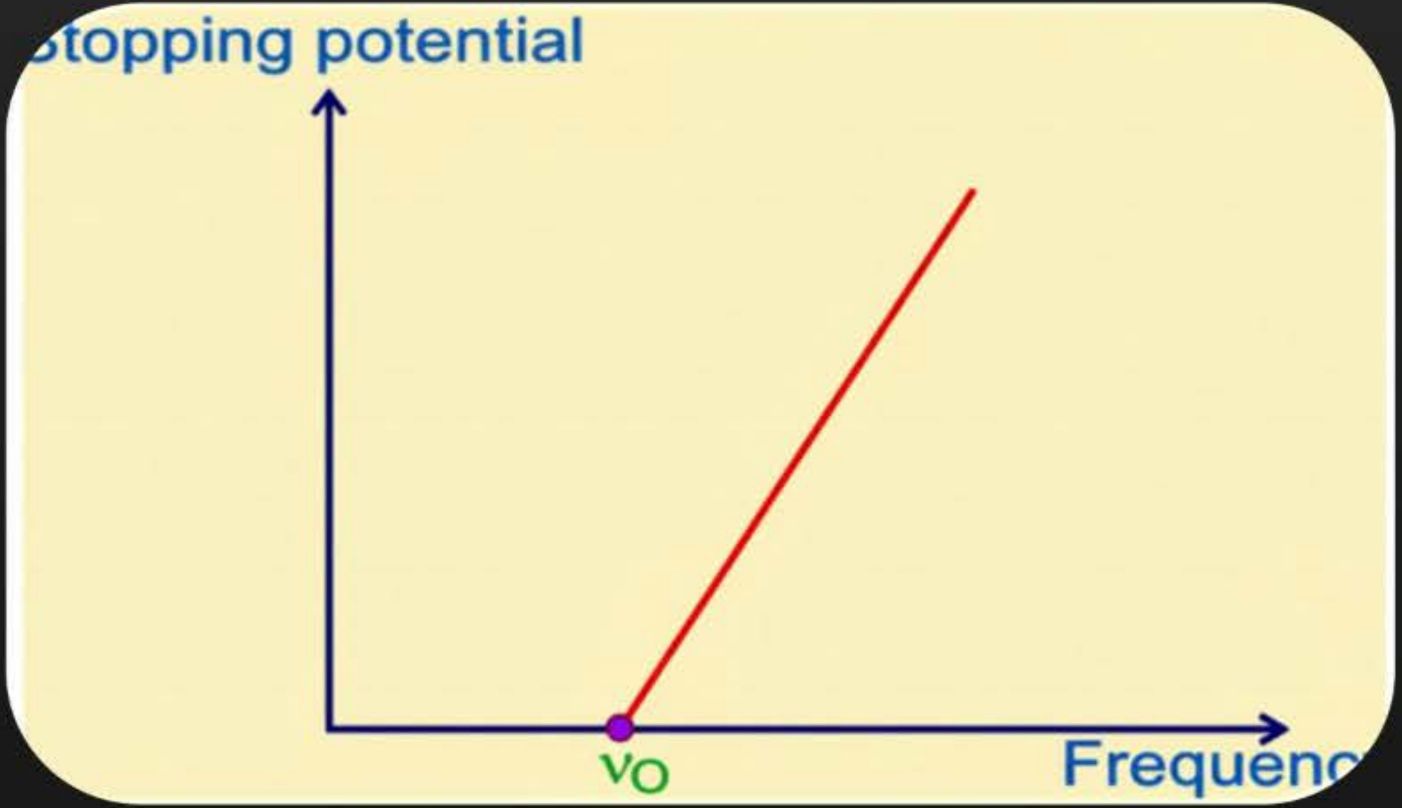
C $\frac{hv}{e}, \frac{h}{e}$

D $hv, -hv_0$

$$K.E_{max} = E - W$$

$$eV_0 = h\nu - h\nu_0$$

$$\boxed{\begin{array}{c} V_0 = \frac{h}{e}\cdot\nu - \frac{h\nu_0}{e} \\ \uparrow \qquad\quad \uparrow \\ y = m x + c \end{array}}$$



Question

ΔK

The kinetic energy of the photoelectrons increases by 0.52eV when the wavelength of incident light is changed from 500 nm to another wavelength which is approximately

λ_1 λ_2

(A) $\boxed{\text{400nm}}$

(B) 1250nm

(C) 1000nm

(D) 700nm

$$\Delta K = K_2 - K_1$$

$$\Delta K = E_2 - W - (E_1 - W)$$

$$\Delta K = E_2 - W - E_1 + W$$

$$\Delta K = E_2 - E_1 = \frac{hc}{\lambda_2} - \frac{hc}{\lambda_1}$$

$$\Delta K = hc\left[\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right]$$

$$0.52 = 1241\left[\frac{1}{\lambda_2} - \frac{1}{500}\right]$$

$$\frac{0.52}{1241} = \frac{1}{\lambda_2} - \frac{1}{500}$$

$$\frac{1}{\lambda_2} = \frac{1}{500} + \frac{0.52}{1241} = \frac{1241+260}{500\times1241} = \frac{1501}{500\times1241}$$

$$\boxed{\lambda_2 = 413.4\,nm}$$

Question

The work-function of a metal is 1eV, Light of wavelength 3000 Å is incident on this metal surface. The velocity of emitted photoelectrons will be

↳ $K.E_{max} = \frac{1}{2}mv^2$

$E = \frac{hc}{\lambda} = \frac{12410}{3000} = 4.13\,eV$

A. $10\ ms^{-1}$

B. $1 \times 10^3\ ms^{-1}$

C. $1 \times 10^4\ ms^{-1}$

D. $\boxed{1 \times 10^6\ ms^{-1}}$

$K.E_{max} = E - W$

$= 4.13 - 1$

$\frac{1}{2}mv^2 = 3.14\,eV = 3.14 \times 1.6 \times 10^{-19}$

$v^2 = \frac{2 \times 5.01 \times 10^{-19}}{9.1 \times 10^{-31}}$

$v^2 = 1.01 \times 10^{12}$ $\quad V = \sqrt{1.1 \times 10^{12}}$

$\boxed{V = 1 \times 10^{6}\ m/s}$

Question

E_1 E_2

Light of two different frequencies whose photons have energies 1 eV and 2.5 eV respectively, successively illuminate a metallic surface whose work function is 0.5 eV. Ratio of maximum speeds of emitted electrons will be

W

A $\boxed{1:2}$

B 1 : 5

C 1 : 1

D 1 : 4

$$K.E_{max} = E - W$$

$$\frac{\cancel{\frac{1}{2}}\cancel{m}v_1^2}{\cancel{\frac{1}{2}}\cancel{m}v_2^2} = \frac{1}{4}$$

$$K_1 = 1 - 0.5 = 0.5\ eV$$

$$K_2 = 2.5 - 0.5 = 2\ eV$$

$$\boxed{\frac{K_1}{K_2} = \frac{0.5}{2} = \frac{1}{4}}$$

$$\left(\frac{v_1}{v_2}\right)^2 = \frac{1}{4}$$

$$\boxed{\frac{v_1}{v_2} = \sqrt{\frac{1}{4}} = \frac{1}{2}}$$

Question

Maximum velocity of the photoelectron emitted by a metal is $1.8 \times 10^6\ \text{ms}^{-1}$. Take the value of specific charge of the electron is $1.8 \times 10^{11}\ \text{C kg}^{-1}$. Then the stopping potential in volt is

$\left(\frac{e}{m}\right)$

$$K.E_{max} = eV_0$$

$$\frac{1}{2}mv^2 = eV_0$$

$$V_0 = \frac{1}{2}\left(\frac{m}{e}\right)v^2$$

$$V_0 = \frac{1}{2}\frac{v^2}{\left(\frac{e}{m}\right)} = \frac{1}{2} \times \frac{(1.8 \times 10^6)^2}{1.8 \times 10^{11}} = \frac{1}{2} \times \frac{1.\cancel{8} \times 10^6 \times 1.8 \times 10^6}{1.\cancel{8} \times 10^{11}}$$

$$\boxed{V_0 = 0.9 \times 10^1 = 9V}$$

A 1

B 3

C 9

D 6

Question

Maximum velocity of the photoelectrons emitted by a metal surface is 1.2×10^{6} ms^{-1}. Assuming the specific charge of the electron to be 1.8×10^{11} C kg^{-1}, the value of the stopping potential in volt will be [H.W]

A 2

B 3

C 4

D 6

Question

The photoelectric threshold wavelength for silver is λ_0. The energy of the electron ejected from the surface of silver by an incident wavelength $\lambda(\lambda < \lambda_0)$ will be

A $hc\,(\lambda_0 - \lambda)$

B $\dfrac{hc}{\lambda_0 - \lambda}$

C $\dfrac{h}{c}\left(\dfrac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)$

D $\boxed{hc\left(\dfrac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$

$$K.E_{max} = E - W$$

$$= \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$$= hc\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$$

$$= \boxed{hc\left[\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right]}$$

Question

According to Einstein's photoelectric equation, the graph of K.E of the photoelectron emitted from the metal versus the frequency of the incident radiation gives a straight line graph, whose slope

$K.E = E - W$

$K.E = h\nu - W$

$y = mx + c$

A depends on the intensity of the incident radiation

B depends on the nature of the metal and also on the intensity of incident radiation

C is same for all metals and independent of the intensity of the incident radiation

D depends on the nature of the metal

Question

When a piece of metal is illuminated by a monochromatic light of wavelength λ, then stopping potential is $3V_s$. When same surface is illuminated by light of wavelength 2λ, then stopping potential becomes V_s. The value of threshold wavelength for photoelectric emission will be

- **A** $\boxed{4\lambda}$
- **B** 8λ
- **C** $\frac{4}{3}\lambda$
- **D** 6λ

$$K.E = E - W$$

$$eV_0 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$$\text{(i)} \quad e \times 3V_s = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) - ①$$

$$\text{(ii)} \quad e \times V_s = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0} = hc\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right) - ②$$

$$\div \frac{①}{②}$$

$$\frac{3\cancel{eV_s}}{\cancel{eV_s}} = \frac{\cancel{hc}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]}{\cancel{hc}\left[\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right]}$$

$$3\left[\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right] = \frac{1}{\lambda} - \frac{1}{\lambda_0}$$

$$\frac{3}{2\lambda} - \frac{3}{\lambda_0} = \frac{1}{\lambda} - \frac{1}{\lambda_0}$$

$$\frac{3}{\lambda_0} - \frac{1}{\lambda_0} = \frac{3}{2\lambda} - \frac{1}{\lambda}$$

$$\frac{3\lambda_0 - \lambda_0}{\lambda_0^2} = \frac{3\lambda - 2\lambda}{2\lambda^2}$$

$$\frac{2\cancel{\lambda_0}}{\lambda_0^{\cancel{2}}} = \frac{\cancel{\lambda}}{2\lambda^{\cancel{2}}}$$

$$\boxed{\lambda_0 = 4\lambda}$$

Question

ν_{01} ν_{02}

A and *B* are two metals with threshold frequencies 1.8×10^{14} Hz and 2.2×10^{14} Hz. Two identical photons of energy 0.825 eV each are incident on them. Then photoelectrons are emitted by (Take $h = 6.6 \times 10^{-34}$ J-s)

A *B* alone

B [✓ *A* alone]

C Neither *A* nor *B*

D Both *A* and *B*

$\nu \geq \nu_0$

$\nu > \nu_{01}$ PEE ✓

$\nu < \nu_{02}$ PEE ×

$$E = \frac{1241}{\lambda(\text{nm})} \text{ eV}$$

$$\lambda = \frac{1241}{0.825} = 1504 \text{ nm}$$

$$\nu = \frac{c}{\lambda} = \frac{3 \times 10^{8}}{1504 \times 10^{-9}} =$$

$$\nu = 0.00199 \times 10^{17}$$

$$\nu = 1.99 \times 10^{14} \text{ Hz}$$

$$\boxed{\nu \simeq 2 \times 10^{14} \text{ Hz}}$$

Question

λ_1

When light of wavelength 300 nm falls on a photoelectric emitter, photoelectrons are liberated. For another emitter, light of wavelength 600 nm is sufficient for liberating photoelectrons. The ratio of the work function of the two emitters is

λ_2

A 1 : 2

B $\boxed{2 : 1}$

C 4 : 1

D 1 : 4

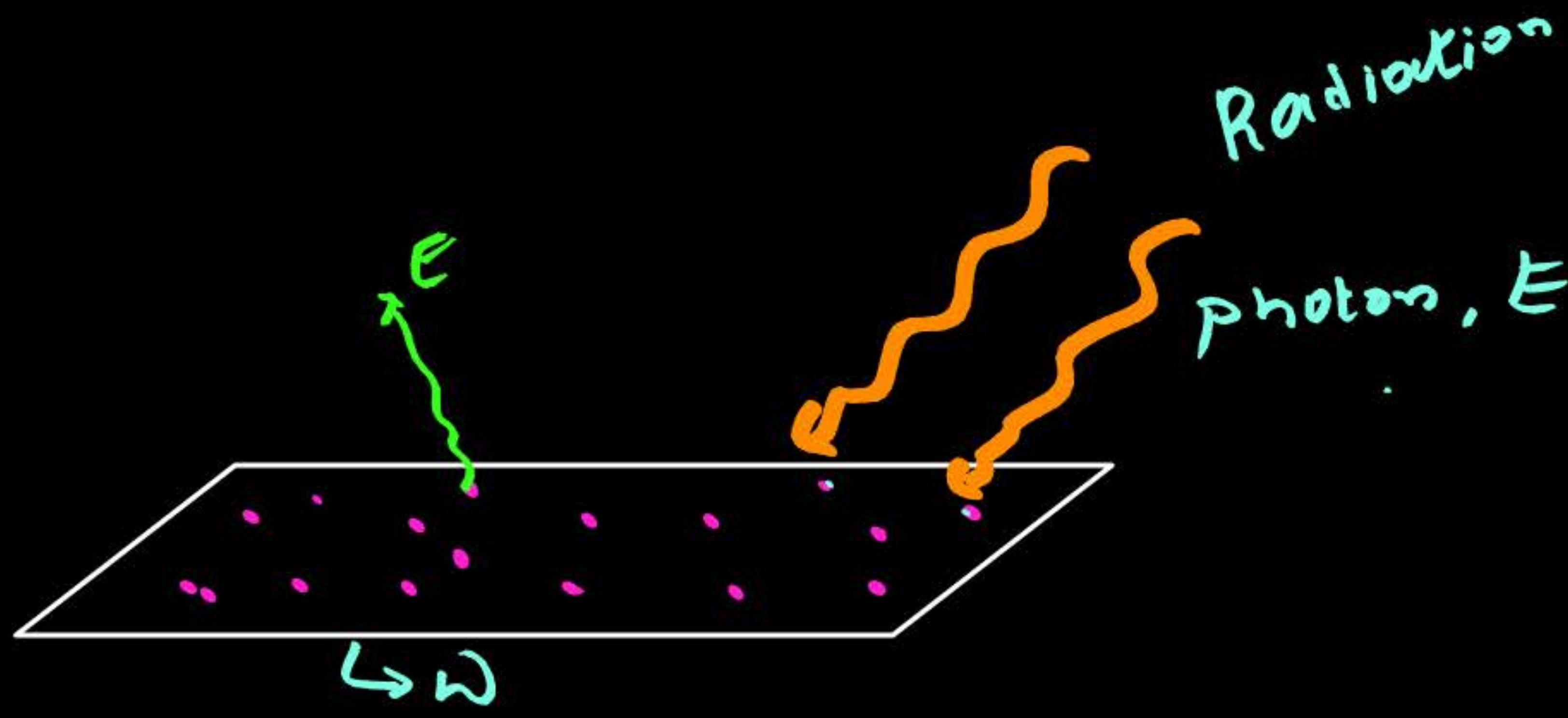
$$W = E_{min} = \frac{hc}{\lambda} = \frac{1241}{\lambda(nm)}\ eV$$

$$W \propto \frac{1}{\lambda}$$

$$\boxed{\frac{W_1}{W_2} = \frac{\lambda_2}{\lambda_1} = \frac{600}{300} = \frac{2}{1}}$$

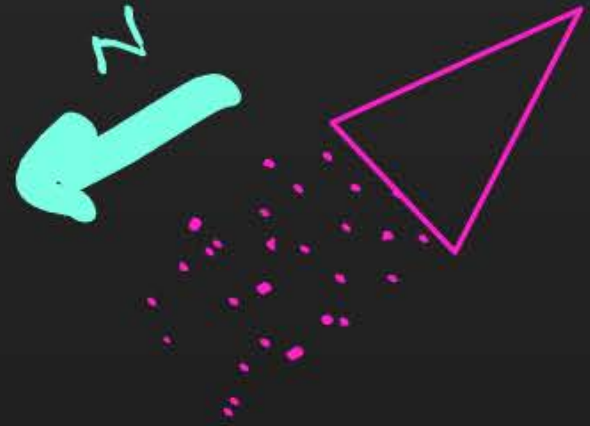
Particle Nature of Light : Photon

1) Energy of the photon is $\boxed{E = h\nu = \frac{hc}{\lambda}}$
2) Photon travel with the speed of light
3) Rest mass of the photon is zero.
4) The mass of the moving photon is $m = \frac{h\nu}{c^2} = \frac{h}{\lambda c}$
5) The momentum of the photon is $p = mc = \frac{h\nu}{c^2} \times c = \frac{h\nu}{c} = \frac{h}{\lambda}$
6) In a photon-particle collision, the total energy and total momentum are conserved.
7) Photons are not deflected by electric and magnetic field. They are electrically neutral.



photon, $E = h\nu = \frac{hc}{\lambda}$

Intensity of light- Photon counts emitted by a source per second



$$I = \frac{E}{At} = \left(\frac{E}{t}\right)\frac{1}{A} = \frac{P_0}{A} \quad — ①$$

$$I = \frac{h\nu}{At} = \frac{hc}{A\lambda t} \quad \text{- 1 photon}$$

$$I = \frac{Nhc}{A\lambda t} \quad \text{— N-photons} \quad -②$$

$$\frac{P_0}{\cancel{A}} = \left(\frac{N}{t}\right)\frac{hc}{\cancel{A}\lambda} \Rightarrow \frac{N}{t} = \frac{P_0\lambda}{hc} \Longrightarrow$$

*

$$\boxed{\frac{N}{t} = n = 5 \times 10^{24} \times P_0\lambda}$$

Question

Power of a radiator is 100 watt and its wavelength is 400 nm. Calculate No. of photon emitted in $\boxed{\underbrace{10}\text{ hrs.}}$

$t = 10h$

$t = 10 \times 1h = 10 \times 3600s$

$t = 36 \times 10^{3} s$

$$\frac{N}{t} = 5 \times 10^{24} P_o \lambda$$

$$\frac{N}{t} = \frac{N}{36 \times 10^{3} \nearrow} = 5 \times 10^{24} \times 100 \times 400 \times 10^{-9}$$

$$\frac{N}{t} = 72 \times 10^{5} \times 10^{24} \times 10^{-9} \times 10^{3}$$

$$\boxed{\frac{N}{t} = 72 \times 10^{23} = 7.2 \times 10^{24}}$$

Question

A source S_1 is producing $\overset{n_1}{10^{15}}$ photon/s of wavelength 5000 Å. Another source S_2 is producing $\underset{n_2}{1.02\times10^{15}}$ photon/s of wavelength 5100 Å. Calculate ratio of power of S_2 to power of S_1.

$$\frac{N}{t} = 5\times10^{24} P_0 \lambda$$

$$P_0 \propto \left(\frac{N}{t}\right)\times\frac{1}{\lambda} \propto \frac{n}{\lambda}$$

$$\boxed{\frac{P_2}{P_1} = \frac{n_2}{\lambda_2}\times\frac{\lambda_1}{n_1} = \frac{1.02\times10^{15}\times5000}{5100\times10^{15}} = \frac{1}{1}}$$

Question

The power of a bulb is 60 milliwatt and the wavelength of light is 6000 Å. Calculate the number of photons/second emitted by the bulb?

$$\frac{N}{t} = 5\times10^{24}\, P\lambda$$

$$= 5\times10^{24}\times60\times10^{-3}\times6000\times10^{-10}$$

$$= 18\times10^{5}\times10^{24}\times10^{-3}\times10^{-10}$$

$$= 18\times10^{16}$$

$$\boxed{\frac{N}{t} = 1.8\times10^{17}}$$

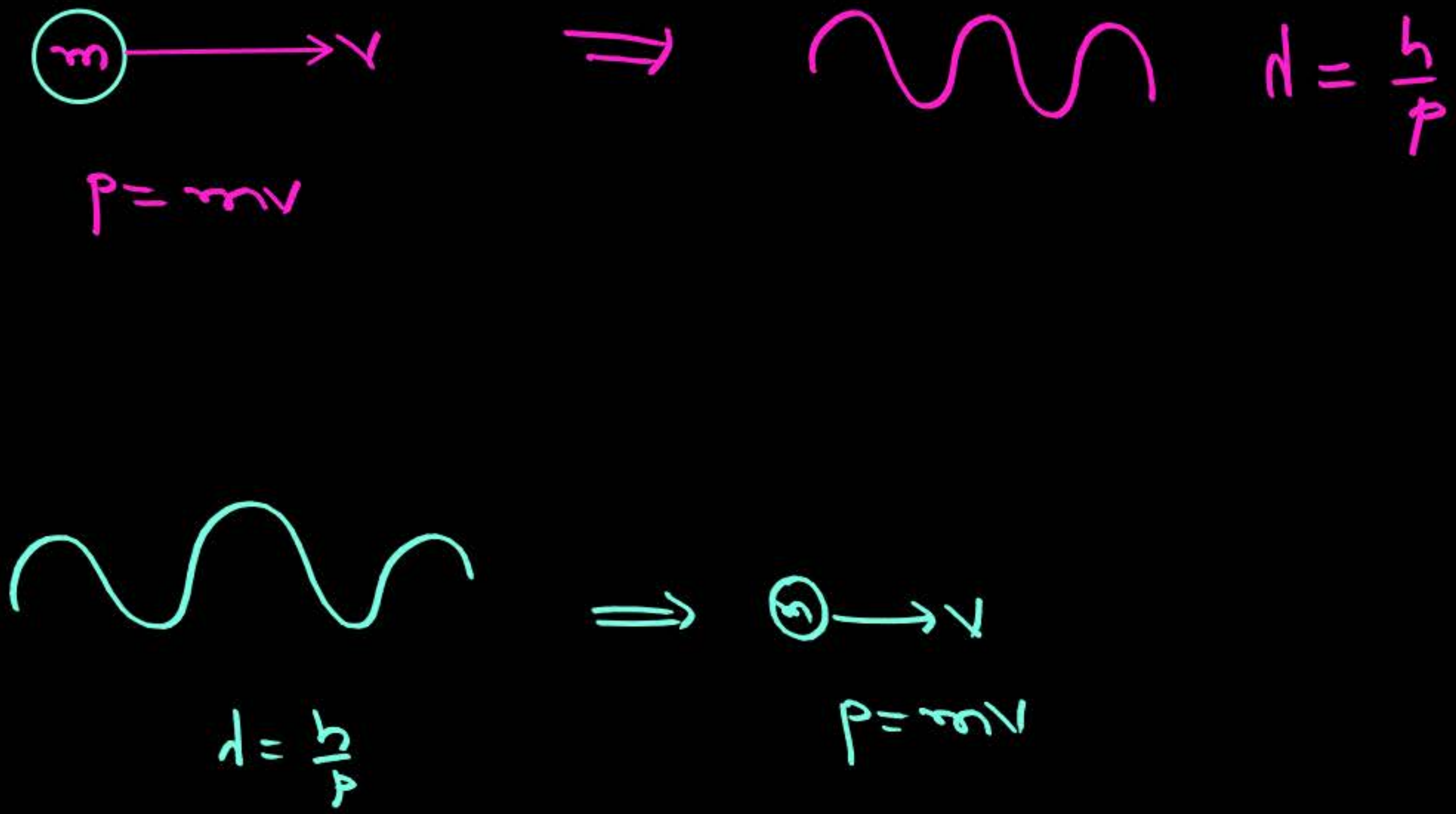
Matter Wave - Wave Nature of Matter

Introduction of matter waves

✓ 1. Waves associated with a moving particles are matter waves. (not with stationary particles).

✓ 2. Every wave has a wave function, for example EM wave has electric and magnetic field as a functions of time. Mechanical wave has medium particle's displacement as a function of time. But matter waves can not be expressed by such functions therefore it is stated that, "matter waves are neither EM waves nor mechanical waves.“

✓ 3. Matter waves are probabilistic waves because these are based on concept of probability and can be expressed by probability density functions.



$p = mv$

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

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

$p = mv$

Matter Wave - Wave Nature of Matter

4. Matter waves are also known as de-Broglie waves. Because their concept was given by physicist Louis Victor de Broglie.

5. Macroscopic objects in our daily life do not show wave-like properties because their wavelength are so small (beyond any measurement). But the wave character of microscopic particles (sub-atomic particles) is significant and measurable.

Formula for de-Broglie wavelength

*

$$\boxed{\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mq\Delta V}}}$$

$$E = \frac{1241}{\lambda(\text{nm})}\ \text{eV}$$

$$\boxed{\lambda = \sqrt{\frac{150}{\Delta V}}} = \frac{12.27}{\sqrt{\Delta V}}\ \text{Å}$$

↳ Electron

Question

With what potential an electron should be accelerated so that its de-Broglie wavelength becomes 10Å

$$\lambda = \sqrt{\frac{150}{\Delta V}}\ \text{A}^\circ$$

$$10\ \cancel{\text{A}^\circ} = \sqrt{\frac{150}{\Delta V}}\ \cancel{\text{A}^\circ}$$

$$(10)^2 = \frac{150}{\Delta V}$$

$$\boxed{\Delta V = \frac{150}{100} = 1.5\text{V}}$$

Question

Find the ratio of de-Broglie wavelengths for a proton and an alpha particle, if both have same speed

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

$$\boxed{\frac{\lambda_p}{\lambda_\alpha} = \frac{m_\alpha}{m_p} = \frac{4\cancel{m}}{\cancel{m}} = \frac{4}{1}}$$

$${}_{2}He^{4}$$

$4 = A$

$2 = Z$

Question

H_1^1 H_1^2

Find the ratio of de-Broglie wavelength for a proton and a deutron, if both have same kinetic energy

$$\lambda = \frac{h}{\sqrt{2mK}}$$

$$\boxed{\frac{\lambda_P}{\lambda_D} = \sqrt{\frac{m_D}{m_P}} = \sqrt{\frac{2m}{m}} = \frac{\sqrt{2}}{1}}$$

$$\lambda \propto \frac{1}{\sqrt{m}}$$

Question

Calculate the ratio of de-Broglie wavelengths for a proton and an alpha particle, accelerated with same potentials from rest

$$\lambda = \frac{h}{\sqrt{2 m q \Delta V}}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha q_\alpha}{m_p q_p}} = \sqrt{\frac{4\cancel{m} \times 2\cancel{q}}{\cancel{m} \times \cancel{q}}} = \frac{\sqrt{8}}{1}$$

$$\lambda \propto \frac{1}{\sqrt{mq}}$$

$$\boxed{\frac{\lambda_p}{\lambda_\alpha} = \frac{\sqrt{8}}{1} = \frac{\sqrt{4 \times 2}}{1} = \frac{2\sqrt{2}}{1}}$$

Question

A proton and an alpha particle are accelerated under the same potential difference. The ratio of de-Broglie wavelengths of the proton and the alpha particle is

- **A** 2
- **B** $\boxed{\sqrt{8}}$
- **C** $\frac{1}{\sqrt{8}}$
- **D** 1

Question

Calculate K.E. of an electron having de-Broglie wavelength 1Å

$$\hookrightarrow \lambda = \sqrt{\frac{150}{\Delta V}}\ \text{Å}$$

$$1\cancel{\text{Å}} = \sqrt{\frac{150}{\Delta V}}\ \cancel{\text{Å}}$$

$$\boxed{\Delta V = 150\,V}$$

$$K.E = eV_0$$

$$K.E = e\Delta V$$

$$K.E = e \times 150\,V$$

$$\boxed{K.E = 150\,eV}$$

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

Question

If we consider an electron and a photon with the same de-Broglie wavelength, then they will have the same

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

$$m \propto \frac{1}{v}$$

$$\lambda = \frac{h}{p} \Rightarrow p = \text{const}$$

- **A** Velocity X
- **B** Momentum
- **C** Angular momentum
- **D** Energy

Question

H.W

A 60 W source emits monochromatic light of wavelength 662.5 nm. The number of photons emitted per second is

$$\frac{N}{t} = 5 \times 10^{24} \times P_0 \lambda.$$

- **A** 5×10^{17}
- **B** $\boxed{2 \times 10^{20}}$
- **C** 5×10^{26}
- **D** 2×10^{29}

Question

The energy gap of an LED is 2.4 eV. When the LED is switched ON, the momentum of the emitted photons is

- **A** 1.28×10^{-27} kg ms^{-1}
- **B** 2.56×10^{-27} kg ms^{-1}
- **C** 1.28×10^{-11} kg ms^{-1}
- **D** 0.64×10^{-27} kg ms^{-1}

*

$$E = \frac{hc}{\lambda} = \left(\frac{h}{\lambda}\right) c$$

$$E = pc$$

$$p = \frac{E}{c} = \frac{2.4 \times 1.6 \times 10^{-19}}{3 \times 10^{8}}$$

$$\boxed{= 1.28 \times 10^{-27} \text{ kg m/s}}$$

Question

The de-Broglie wavelength of a particle of kinetic energy K is λ, the wavelength of the particle, if its kinetic energy $K/4$ is

(A) $\boxed{2\lambda}$

(B) $\frac{\lambda}{2}$

(C) 4λ

(D) λ

$$\lambda = \frac{h}{\sqrt{2mK}} \propto \frac{1}{\sqrt{K}}$$

$$\lambda' \propto \frac{1}{\sqrt{K'}} = \frac{1}{\sqrt{\frac{K}{4}}} = \frac{1}{\frac{\sqrt{K}}{2}} = \frac{2}{\sqrt{K}} = 2 \times \lambda$$

$$\boxed{\lambda' = 2\lambda}$$

Question

$F = q(\vec{v} \times \vec{B})$

An electron is moving with an initial velocity v = $v_0\,\hat{i}$ and is in a uniform magnetic field B = $B_0\,\hat{j}$. Then its de-Broglie wavelength

$\rightarrow \lambda = \frac{h}{p} = \frac{h}{mv} = \text{constant}$

A Remains constant

B Increases with time

C Decreases with time

D Increase and decrease periodically

Question

A particle is dropped from a height H. The de-Broglie wavelength of the particle depends on height as

$$\lambda = \frac{h}{p} = \frac{h}{mv} \propto \frac{1}{v}$$

$$v^2 = u^2 + 2gH$$

$$v^2 = 2gH$$

$$v = \sqrt{2gH} \propto \sqrt{H} \propto H^{1/2}$$

$$\boxed{\lambda \propto \frac{1}{H^{1/2}} \propto H^{-1/2}}$$

A $\boxed{H^{-1/2}}$

B H^0

C $H^{1/2}$

D H

Question

The de-Broglie wavelength of an electron accelerated to a potential of 400 V is approximately

- **A** 0.03 nm
- **B** 0.04 nm
- **C** 0.12 nm
- **D** 0.06 nm

$$\lambda = \sqrt{\frac{150}{\Delta V}}\ A^\circ$$

$$\lambda = \sqrt{\frac{150}{400}} = \frac{12.24}{20}$$

$$\lambda = 0.6123\ A^\circ$$

$$\lambda = 0.0612 \times 10^{-9}\ m$$

$$\boxed{\lambda = 0.0612\ nm}$$

Question

$1\,pm = 10^{-12}\,m$

Find the de-Broglie wavelength of an electron with kinetic energy of $\boxed{120\text{ eV}}$.

A $\boxed{112\text{ pm}}$

B 95 pm

C 124 pm

D 102 pm

$\hookrightarrow \lambda = \sqrt{\frac{150}{\Delta V}} = \sqrt{\frac{15\cancel{0}}{12\cancel{0}}}$

$\lambda = \sqrt{\frac{5}{4}}$

$\lambda = 1.1180\,\mathring{A}$

$\lambda = 1.1180 \times 10^{-10}\,m \times \frac{100}{100}$

$\lambda = 111.80 \times 10^{-12}$

$\boxed{\lambda = 111.8\,pm}$

$K = e\,\Delta V.$

$120\,\cancel{e}V = \cancel{e}\,\Delta V$

$\boxed{\Delta V = 120\,V}$

Question

K.V

What is the de-Broglie wavelength of the electron accelerated through a potential difference of 100V ?

A 12.27 Å

B 1.227 Å

C 0.1227 Å

D 0.001227 Å

Question

n photons of wavelength λ are absorbed by a black body of mass m. The momentum gained by the body is

(A) $\boxed{\frac{nh}{\lambda}}$

(B) $\frac{h}{m\lambda}$

(C) $\frac{mnh}{\lambda}$

(D) $\frac{nh}{m\lambda}$

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

$p = \frac{h}{\lambda} \rightarrow 1$ photon

$p = \frac{nh}{\lambda} \rightarrow n$-photons

Question

An electron of mass m_e and a proton of mass m_p are moving with the same speed. The ratio of their de-Broglie's wavelengths λ_e/λ_p is

$$\lambda = \frac{h}{mv} \propto \frac{1}{m}$$

$$\frac{\lambda_e}{\lambda_p} = \frac{m_p}{m_e} = \frac{1836\, m_e}{m_e} = \boxed{1836}$$

A 1

B $\boxed{1836}$

C $\frac{1}{1836}$

D 918

Question

H.W

The kinetic energy of an electron gets tripled, then the de-Broglie wavelength associated with it changes by a factor

A $\frac{1}{3}$

B $\sqrt{3}$

C $\frac{1}{\sqrt{3}}$

D 3

Question

If an electron and a proton have the same de-Broglie wavelength, then the kinetic energy of the electron is

A zero

B less than that of a proton

C more than that of a proton

D equal to that of a proton

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mK}}$$

$$mK = \text{const}$$

$$K \propto \frac{1}{m}$$

$$\frac{K_e}{K_p} = \frac{m_p}{m_e} = 1836$$

$$K_e = 1836 K_p$$

$$\boxed{\begin{array}{c} m_e < m_p \\ K_e > K_p \end{array}}$$

Question

The de-Broglie wavelength of a proton (charge = 1.6×10^{-19} C, mass = 1.6×10^{-27} kg) accelerated through a potential difference of 1 kV is [H.W]

(A) 600 Å

(B) 0.9×10^{-12} m

(C) 7 Å

(D) 0.9 nm

ATOMS

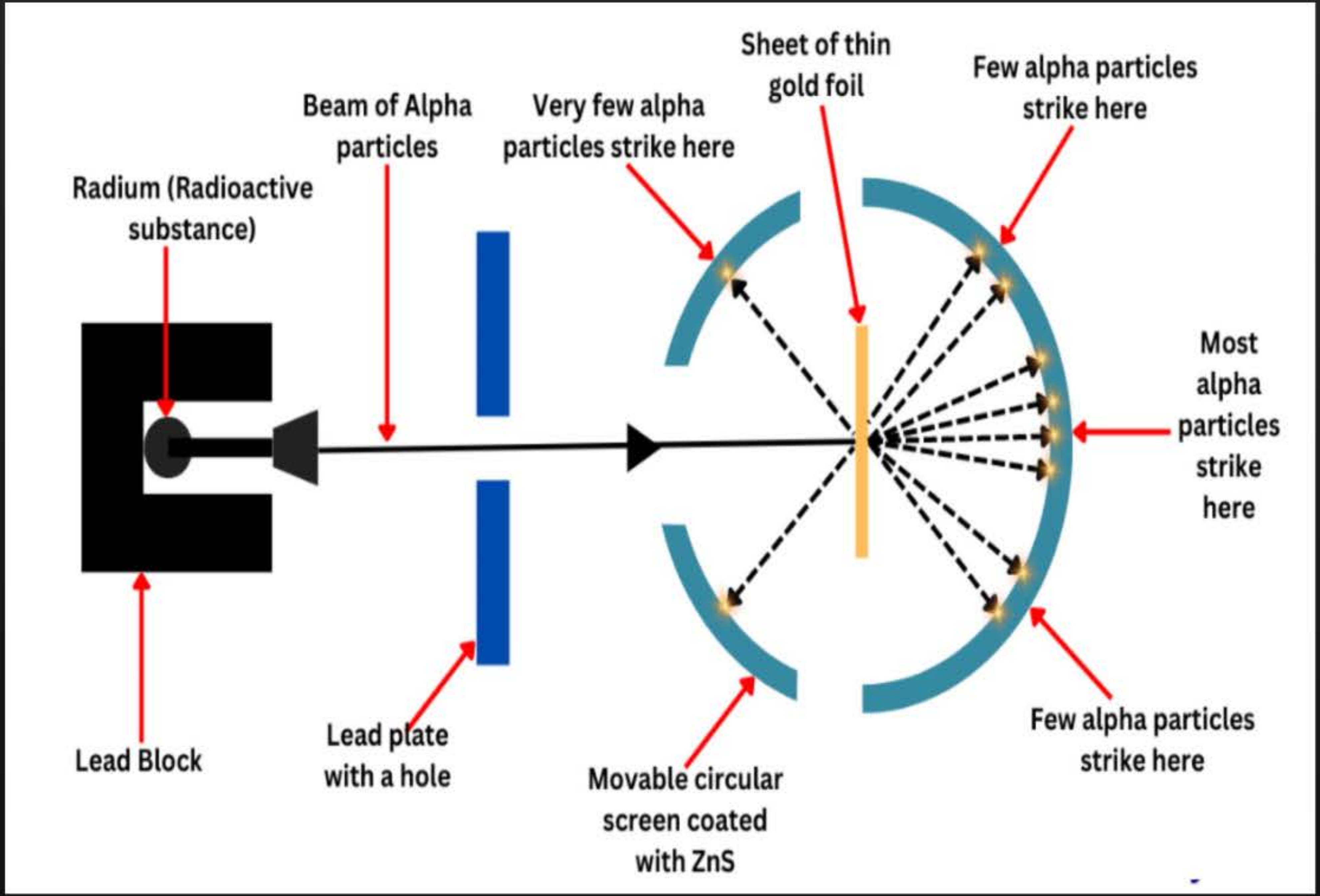
KCET analysis of chapter - Marks weightage

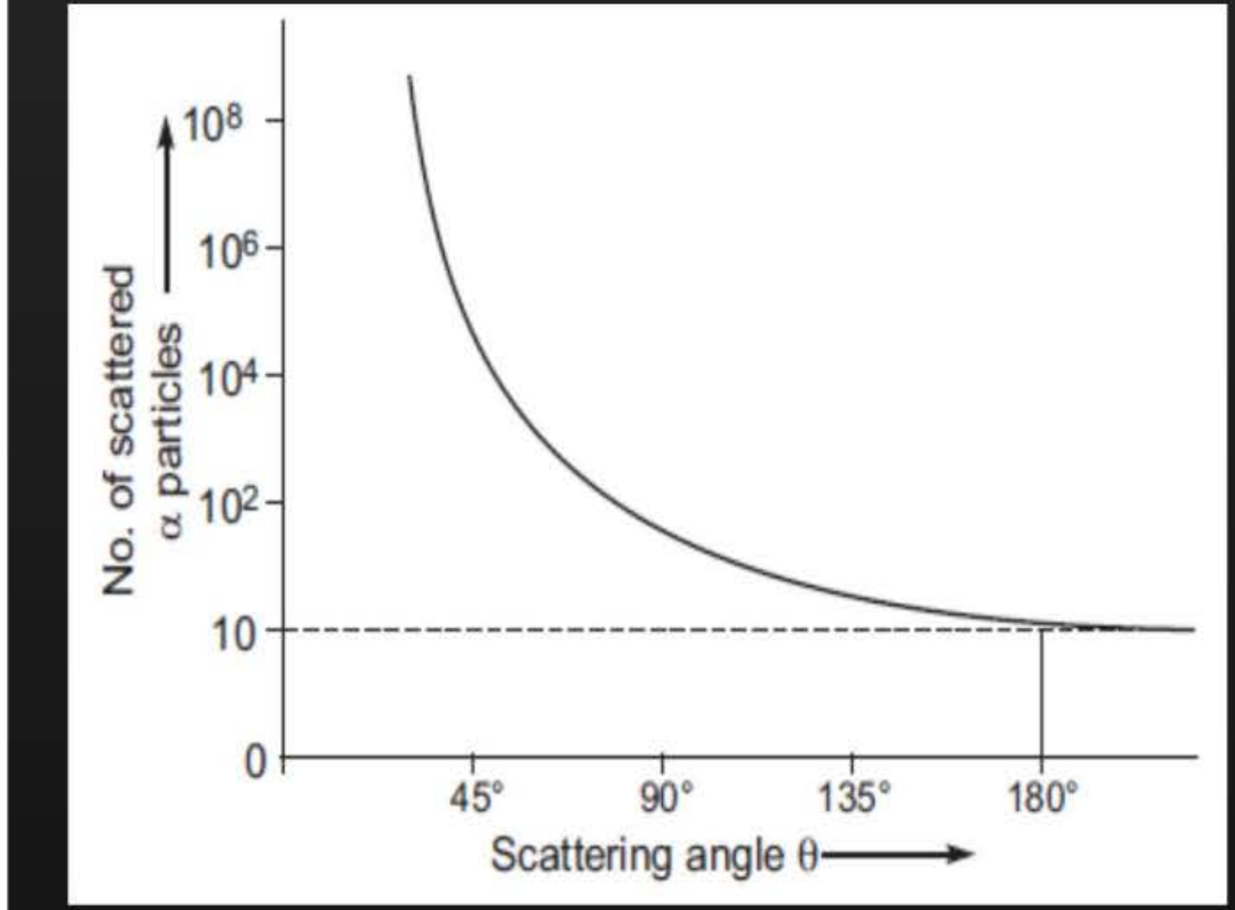
Year	Topic
2025 (1Q)	Bohr orbit
2024(2Q)	Alpha particle scattering experiment and Hydrogen atom
2023(2Q)	Alpha particle scattering experiment and Hydrogen atom
2022(4Q)	Hydrogen atom, Bohr's model, Bohr's orbit and Revolution of electron
2021(3Q)	De-Broglie of wavelength, Energy of electron and orbit radius

KCET analysis of chapter - Marks weightage

Year	Topic
2020(4Q)	De-Broglie wavelength, Period of revolution of electron, Angular momentum & Kinetic Energy and Alpha particle
2019(2Q)	Frequency of revolution and Hydrogen atom
2018 (2Q)	Total energy of electron and Period of revolution
2017(1Q)	Hydrogen atom
2016(2Q)	Energy of electron and Angular momentum
2015 (3Q)	The distance of closest approach, Hydrogen spectrum and Electron in Hydrogen atom

RUTHERFORD’S ALPHA SCATTERING EXPT





RUTHERFORD’S ALPHA SCATTERING EXPT

Rutherford Atomic Model

- ✓ The alpha particles from Bi_{83}^{214} contained in lead cavity are collimated into a narrow beam with the help of a lead plate having a narrow slit.
- ✓ The narrow beam of alpha particles then falls on a thin gold foil about $2.1 \times 10^{-7} m$ in thickness.
- ✓ The alpha-particles scattered in different directions were detected with the help of an alpha-particle detector.
- ✓ The whole apparatus was arranged inside a vacuum chamber to prevent the scattering of alpha particles from air particles

RUTHERFORD'S ALPHA SCATTERING EXPT

- ✓ Most of the alpha-particles were found to pass through the gold foil without any appreciable deflection.
- ✓ In passing through the gold foil with respect to centre of an atom, the different alpha-particles underwent different amounts of deflections, A large number of alpha-particles suffered fairly large deflection.
- ✓ A very small number of alpha-particles (about 1 in 8000) practically retraced their paths or suffered deflection of nearly 180^0.
- ✓ The graph between the total number of alpha-particles $N(\theta)$ scattered through angle θ and the scattering angle θ was found to be seen as shown

DRAWBACKS OF RUTHERFORD ATOMIC MODEL

- Rutherford atomic model failed to explain about the stability of electrons in a circular path.
- As per Rutherford's model, electrons revolve around the nucleus in a circular path. But particles that are in motion on a circular path would undergo acceleration, and acceleration causes radiation of energy by charged particles. Eventually, electrons should lose energy and fall into the nucleus. And this points to the instability of the atom. But this is not possible because atoms are stable. Hence, Rutherford failed to give an explanation on account of this-It couldn't explain the stability of atom.
- Rutherford's theory was incomplete because it did not mention anything about the arrangement of electrons in the orbit. This was one of the major drawbacks of Rutherford atomic model- It couldn't explain discrete nature of hydrogen spectra.

Distance of closest approach

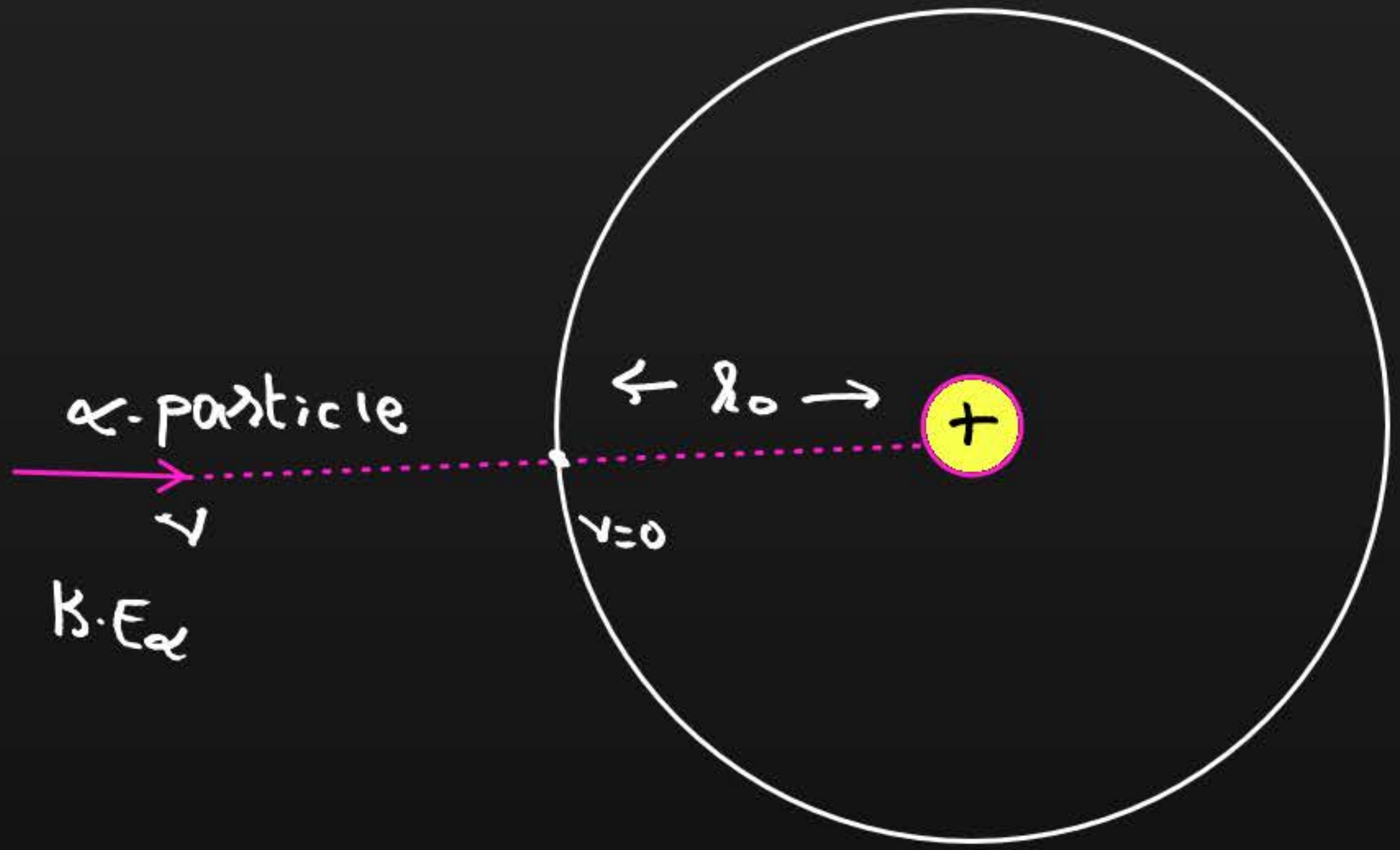
Distance of closest approach: It is the distance of the charged particle from the centre of the target nucleus, at which the whole Kinetic energy of the charged particle gets converted into potential energy(or balanced by coulombic force of repulsion).

$$K.E \Rightarrow P.E$$

$$\boxed{r_0 = \frac{2KZe^2}{K.E_\alpha}}$$

$$K.E_\alpha = \frac{1}{2} m_\alpha V_\alpha^2$$

$$Z = 79$$



Question

An α-particle of energy $\frac{1}{2}mv^2$ bombards a heavy target of charge Ze, Then the distance of closet approach for the α- particle will be proportional to

- **A** $\frac{1}{Ze}$ ✗
- **B** v^2 ✗
- [✓ **C** $\frac{1}{m}$]
- **D** $\frac{1}{v^4}$ ✗

$$r_0 = \frac{2KZe^2}{K.E_\alpha} = \frac{2KZe^2}{\frac{1}{2}mV^2}$$

$$r_0 \propto \frac{1}{m}$$

$$r_0 \propto \frac{1}{V^2}$$

$$r_0 \propto Ze^2$$

Question

In alpha particle scattering experiment, if v is the initial velocity of the particle, then the distance of closest approach is d. If the velocity is doubled, then the distance of closest approach becomes

- **A** 4d
- **B** 2d
- **C** d/2
- **D** $\boxed{d/4}$

$r_0 \propto \frac{1}{v^2}$

$d \propto \frac{1}{v^2}$ ✓

$v' = 2v$

$d' \propto \frac{1}{v'^2} = \frac{1}{(2v)^2} = \frac{1}{4v^2}$

$$\boxed{d' \propto \frac{1}{4v^2} \propto \frac{d}{4}}$$

Question

An α-particle of energy 5 MeV is scattered through 180° by gold nucleus. The distance of closest approach is of the order of

A 10^{-14} cm

B 10^{-10} cm

C 10^{-16} cm

D $\boxed{10^{-12}\text{ cm}}$

$$r_0 = \frac{2KZe^2}{K.E_\alpha}$$

$$K.E_\alpha = 5\times10^{6}\times1.6\times10^{-19}\text{ J}$$

$$K.E_\alpha = 8\times10^{-13}\text{ J}$$

$$r_0 = \frac{2\times9\times10^{9}\times79\times(1.6\times10^{-19})^2}{8\times10^{-13}}$$

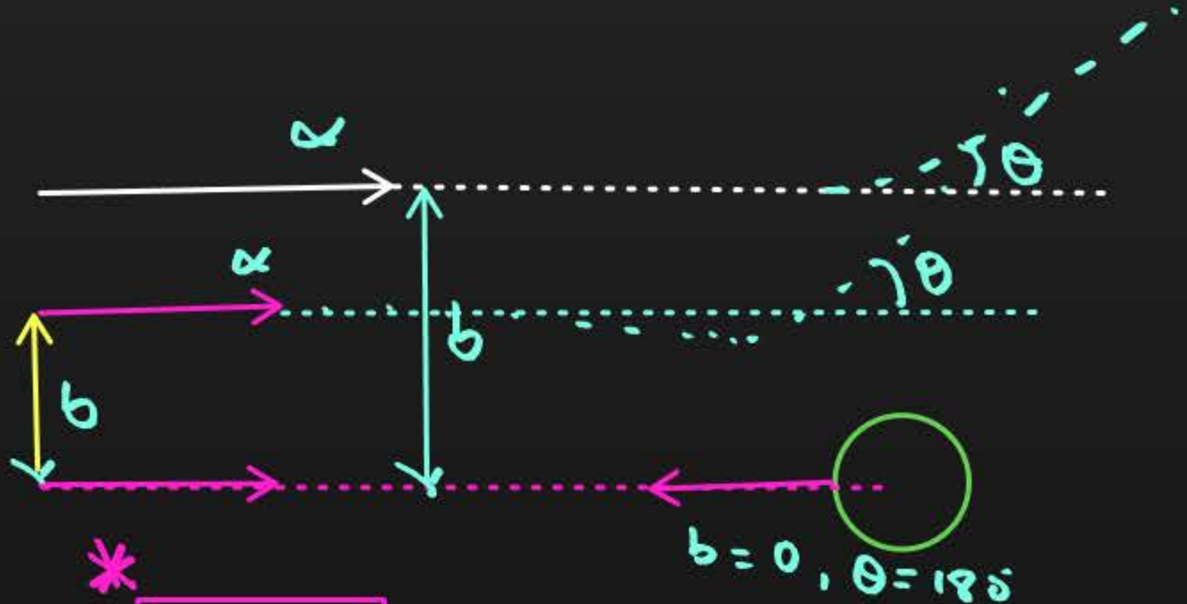
$$r_0 = 455.04\times10^{-16}\text{ m}$$

$$r_0 = 455\times10^{-14}\text{ m}$$

$$\boxed{r_0 = 4.55\times\boxed{10^{-12}\text{ cm}}}$$

Impact Parameter

The impact parameter is the perpendicular distance between the path of a projectile and the center of a Nucleus (i.e potential field) when it is far away from the atom)



* $\boxed{b \propto \frac{1}{\theta}}$

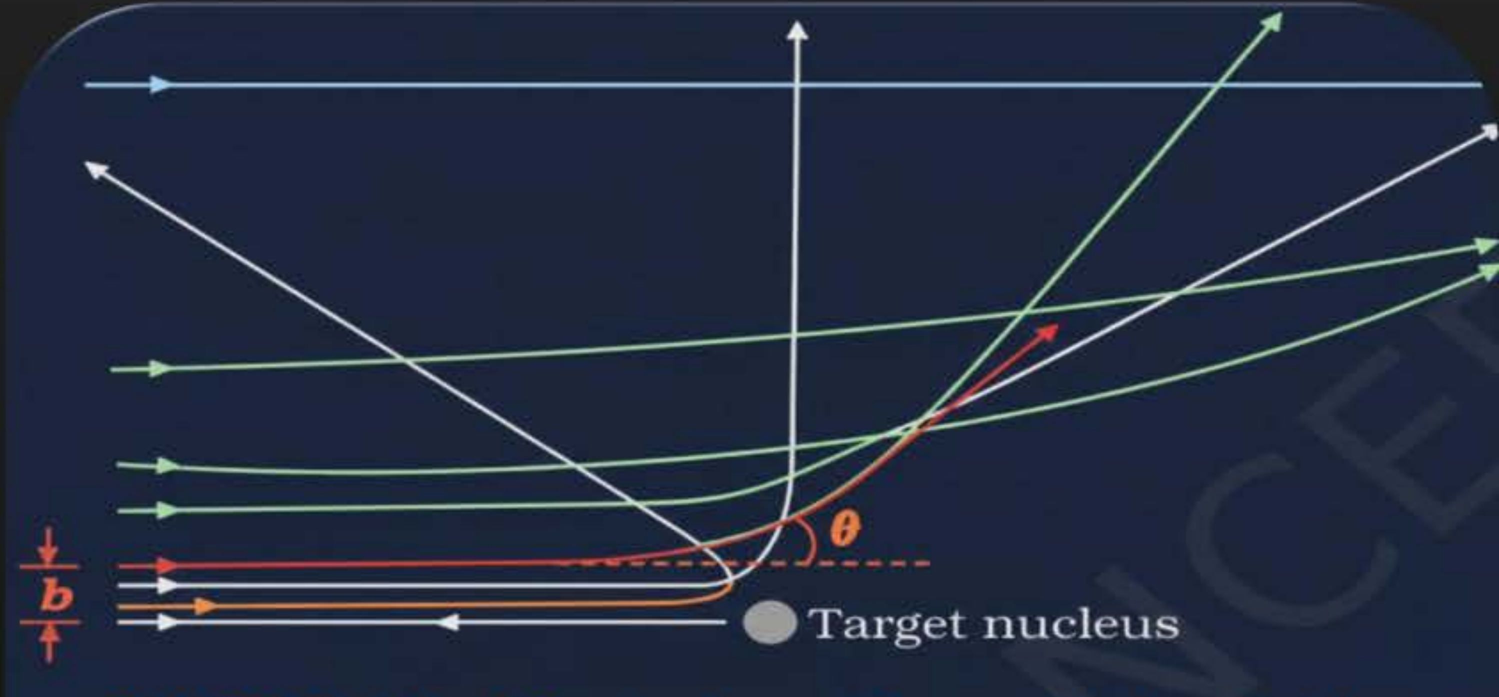


FIGURE 12.4 Trajectory of α-particles in the coulomb field of a target nucleus. The impact parameter, *b* and scattering angle *θ* are also depicted.

Question

In Rutherford scattering experiment, what will be the correct scattering angle for α-scattering for an impact parameter $\boxed{b = 0}$?

- **A** 90°
- **B** 270°
- **C** 0°
- **D** $\boxed{180^\circ}$

Question

In the Rutherford's alpha scattering experiment, as the impact parameter increases, the scattering angle of the alpha particle

$$\boxed{b \propto \frac{1}{\theta}}$$

- **A** remains the same
- **B** is always 90°
- **C** decreases
- **D** increases

Radius of the Electron orbit- Electron orbit

According to Rutherford model,

The Kinetic Energy of Electron, $K.E = \frac{Ke^2}{2r}$

The potential energy of Electron, $P.E = -\frac{Ke^2}{r}$

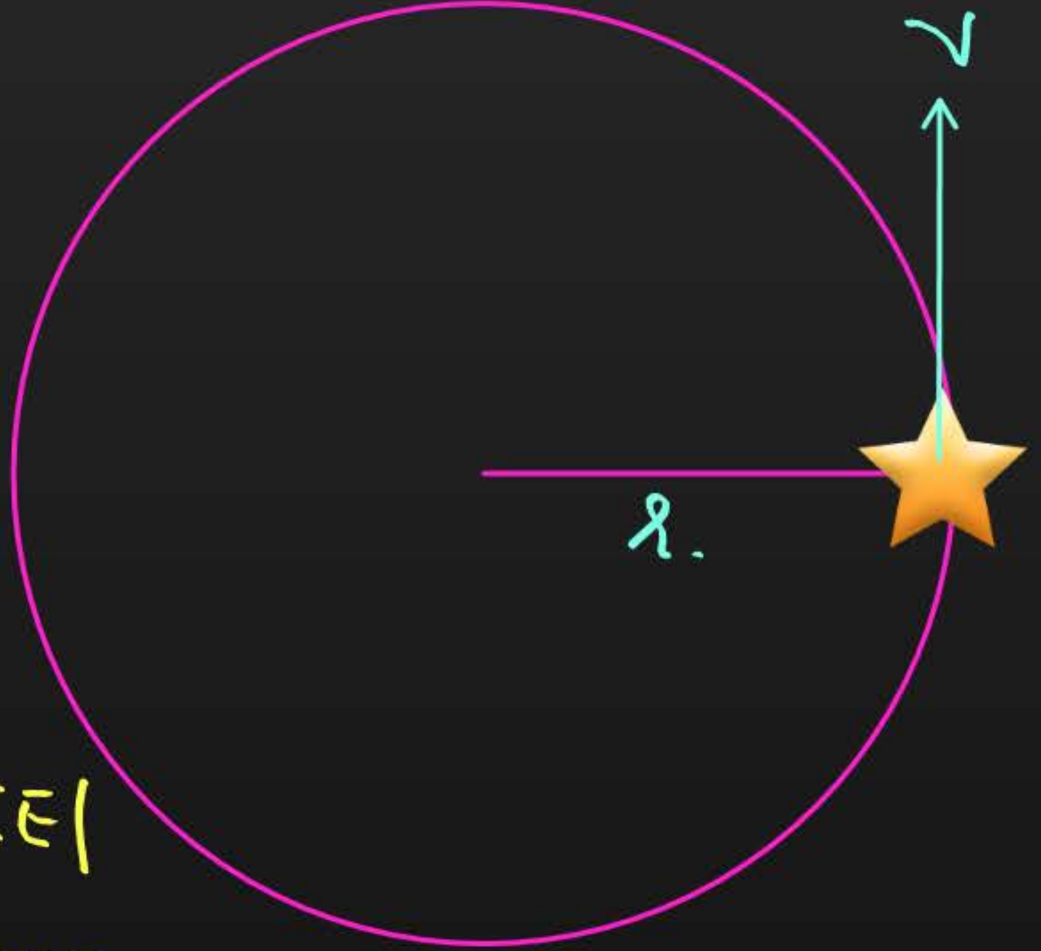
Total Energy $T = K.E + P.E$

$$\boxed{T = \frac{Ke^2}{2r} + -\frac{Ke^2}{r} = -\frac{Ke^2}{2r}}$$

*

$K.E = |T.E|$

$P.E = -2K.E$



BOHR MODEL OF THE HYDROGEN ATOM

(i) An electron in an atom revolve round the nucleus in certain permitted orbits called stationary orbits. An electron in a stationary orbit does not radiate energy.

$$\boxed{F_c = F_{cp}} \Rightarrow \frac{1}{4\pi\varepsilon_0}\frac{Ze.e}{r^2} = \frac{mv^2}{r}.$$

(ii) An electron can revolve round the nucleus only in those orbits for which the angular momentum is integral multiple of $\frac{h}{2\pi}$,i.e., angular momentum $\boxed{L = \frac{nh}{2\pi}}$ or $\boxed{mvr = \frac{nh}{2\pi}}$

h is called Planck's constant.

BOHR MODEL OF THE HYDROGEN ATOM

(iii) An atom can radiate energy only when the electron undergo transition from an orbit of higher energy level (E_i (to an orbit of lower energy level (E_f(

$\Delta E = E_f - E_i$

$$h\nu = E_i - E_f \quad ✓$$

or

$$\boxed{\nu = \frac{E_i - E_f}{h}} \quad ✓$$

where h is called Planck's constant

H, He, Li

Bohr's theory of Hydrogen- Like Atom

A hydrogen-like atom consists of a tiny positively-charged nucleus and an electron revolving in a stable circular orbit around the nucleus.

Bohr's Radius : Let $m, e,$ and v be respectively the charge, mass and velocity of the electron and r the radius of the orbit. The positive charge on the nucleus is Ze, where Z is the atomic number (in case of hydrogen atom, $Z = 1$).

Helium atom, $Z = 2$

Lithium atom, $Z = 3$

$$\boxed{r_n = a_0 \frac{n^2}{Z}}$$

a_0 = Bohr's radius

$a_0 = 0.53$ Å

$$\boxed{r_n = a_0 n^2} \rightarrow \text{H-atom}$$

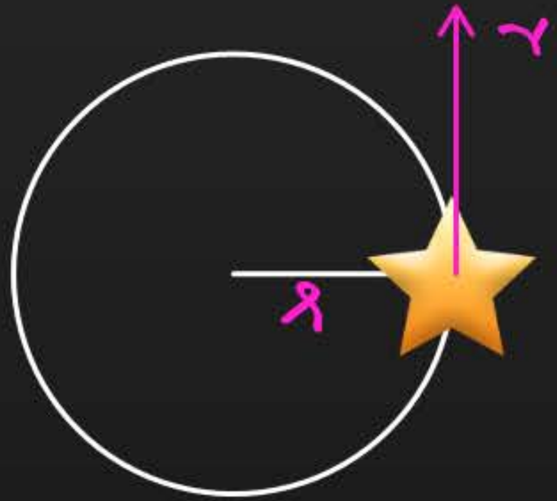
$Z = 1$

Bohr's theory of Hydrogen- Like Atom

Orbit → Number as it is.

Velocity of Electron : Velocity of Electron in Stationary Orbits: We can obtain formula for the velocity of electron in permitted orbits.

$r_n = a_0 n^2$



$$\boxed{v_n = v_0 \frac{Z}{n}}$$

$v_0 = 2.2 \times 10^6$ m/s

Energy of Electron in stationary orbits : The energy "E" of an electron in an orbit is the sum of kinetic and potential energies.

$$\boxed{E_n = -13.6\left(\frac{Z}{n}\right)^2} \Rightarrow \boxed{E_n = -\frac{13.6}{n^2}\,\text{eV}}$$

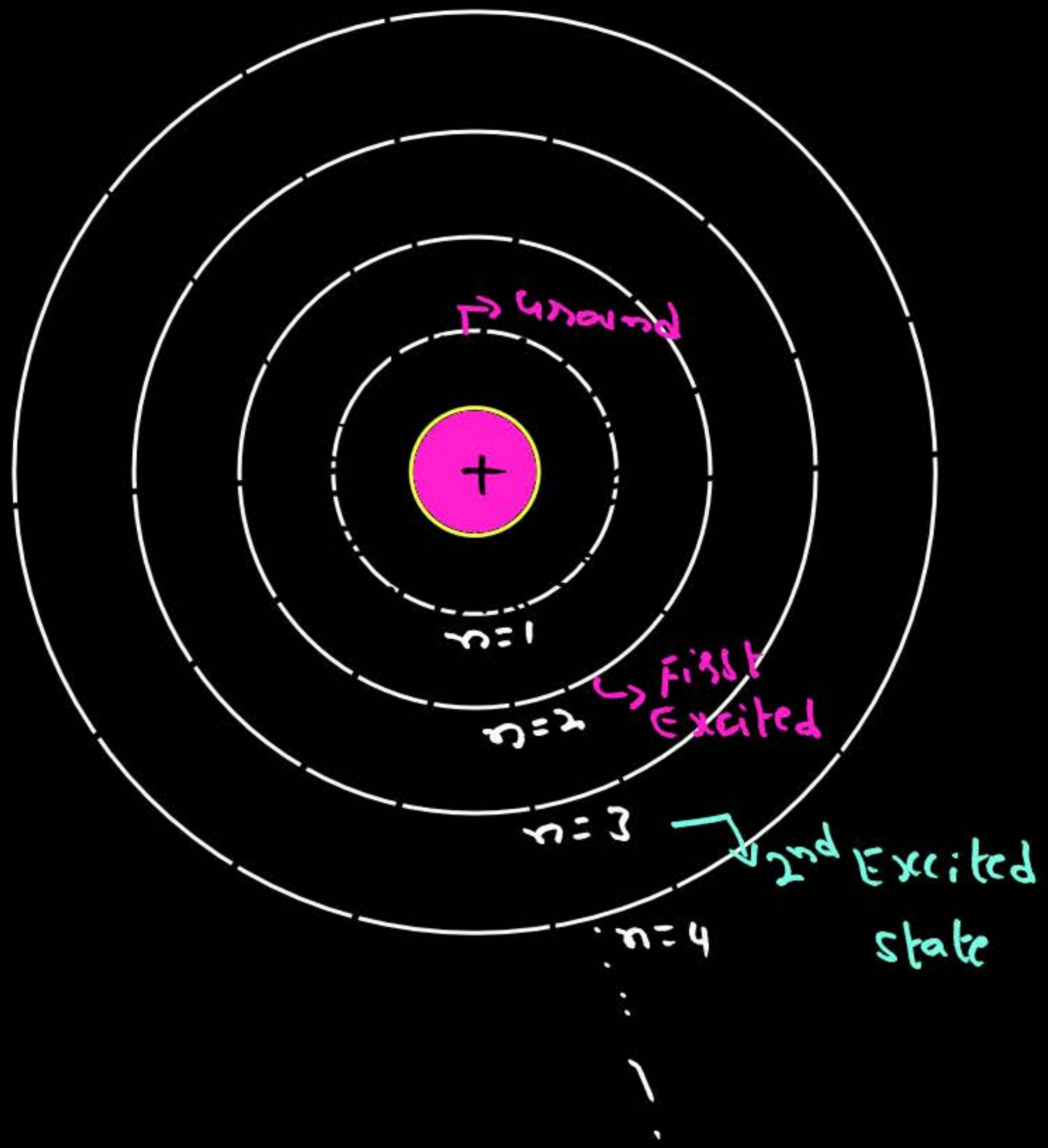
H-atom

$Z = 1$

H-atom, $Z = 1$

He-atom. $Z = 2$

Li^{++}-atom $Z = 3$



Question

If the radius of the first Bohr orbit is r, then the radius of the second Bohr orbit will be

A $3/2\,r$

B $2\,r$

C $8\,r$

D $\boxed{4\,r}$

$r_n \propto n^2$

$\frac{r_2}{r_1} = \frac{n_2^2}{n_1^2} = \frac{(2)^2}{(1)^2} = \frac{4}{1}$

$\frac{r_2}{r} = 4$

$\boxed{r_2 = 4r}$

Question

$n=2$ $n=1$

The ratio of area of first excited state to ground state of orbit of hydrogen atom is

$r_n \propto n^2$

$r_n^2 \propto n^4$

$$\frac{A_2}{A_1} = \frac{\cancel{\pi} r_2^2}{\cancel{\pi} r_1^2} = \frac{r_2^2}{r_1^2} = \frac{n_2^4}{n_1^4} = \frac{2^4}{1^4}$$

$$\boxed{\frac{A_2}{A_1} = \frac{16}{1}}$$

A 1:16

B 1:4

C 4:1

D $\boxed{16:1}$

Question

If an electron is revolving in its Bohr orbit having Bohr radius of $\boxed{0.529\text{Å}}$ then the radius of third orbit is

- (A) 4496Å
- (B) $\boxed{4.761\ \text{Å}}$
- (C) 5125 nm
- (D) 4234 nm

$$r_n = a_0 n^2$$

$$r_3 = 0.529 \times (3)^2 = 0.529 \times 9$$

$$\boxed{r_3 = 4.761\ \text{A}^\circ}$$

Question

$E_n = -13.6\left(\frac{Z}{n}\right)^2$

Energy of an electron in the second orbit of hydrogen atom is E_2. The energy of electron in the third orbit of He^+ will be

- **A** $\frac{9}{16}E_2$
- **B** $\boxed{\frac{16}{9}E_2}$
- **C** $\frac{3}{16}E_2$
- **D** $\frac{16}{3}E_2$

H-atom $E_2 = -\frac{13.6}{2^2} = \frac{-13.6}{4}$ eV

He^+-atom, $E_{He} = -13.6 \times \frac{4}{9}$ eV

$Z = 2$

$$\frac{E_{He}}{E_2} = \frac{-\cancel{13.6}\times\frac{4}{9}}{-\frac{\cancel{13.6}}{4}} = \frac{16}{9}$$

$$\boxed{E_{He} = \frac{16}{9}E_2}$$

Question

The total energy of an electron revolving in the second orbit of hydrogen atom is

A –13.6 eV

B –1.51 eV

C $\boxed{-3.4 \text{ eV}}$

D zero

$$E_n = -\frac{13.6}{n^2}$$

$$E_2 = -\frac{13.6}{2^2} = -\frac{13.6}{4}$$

$$\boxed{E_2 = -3.4 \text{ eV}}$$

Question

$$\Delta E = E_2 - E_1 = \frac{-13.6}{n_2^2} - \left(-\frac{13.6}{n_1^2}\right)$$

The energy (in *eV*) required to excite an electron from $n = 2$ to $n = 4$ state in hydrogen atom is

A –0.85

B +4.25

C –3.4

D $\boxed{+2.55}$

$$E_2 - E_1 = -13.6\left[\frac{1}{4^2} - \frac{1}{2^2}\right]$$

$$= -13.6\left[\frac{1}{16} - \frac{1}{4}\right]$$

$$= -13.6\left(\frac{1}{16} - \frac{4}{16}\right)$$

$$= -13.6 \times \frac{-3}{16}$$

$$\boxed{= +2.55\,\text{eV}}$$

Question

E

The energy of electron in an excited state of hydrogen atom is –3.4 eV. the kinetic and potential energy of electron in this state are

$K.E = -E = -(-3.4) = \underline{+3.4\text{eV}}$

$U = -2K.E = -2 \times 3.4$

$= \underline{\underline{-6.8\text{eV}}}$

A ✗ $K = -3.4 \text{ eV}, \quad U = -6.8 \text{ eV}$

B ✓ $\boxed{K = 3.4 \text{ eV}, \quad U = -6.8 \text{ eV}}$

C ✗ $K = -6.8 \text{ eV}, \quad U = +3.4 \text{ eV}$

D ✗ $K = +10.2\, eV, \quad U = -13.6 \text{ eV}$

Question

$n=3$ H.W

What is the energy of the electron revolving in third orbit expressed in eV?

- **A** 1.51 eV
- **B** 3.4 eV
- **C** 4.53 eV
- **D** 4 eV

Energy Levels

The minimum energy required to free the electron from the ground state of the hydrogen atom is 13.6 eV. It is called the ionisation energy of the hydrogen atom. This prediction of the Bohr's model is in excellent agreement with the experimental value of ionisation energy.

$n = 1$

At room temperature, most of the hydrogen atoms are in ground state. When a hydrogen atom receives energy by processes such as electron collisions, the atom may acquire sufficient energy to raise the electron to higher energy states. The atom is then said to be in an excited state

Question

$n=1$

The radius of hydrogen atom in the ground state is 0.53Å. After collision with an electron, it is found to have a radius of 2.12Å, the principal quantum number n of the final state of the atom is

n

A $\boxed{n = 2}$

B $n = 3$

C $n = 4$

D $n = 1$

$$r_n \propto n^2$$

$$\frac{r_n}{r_1} = \frac{n^2}{1^2}$$

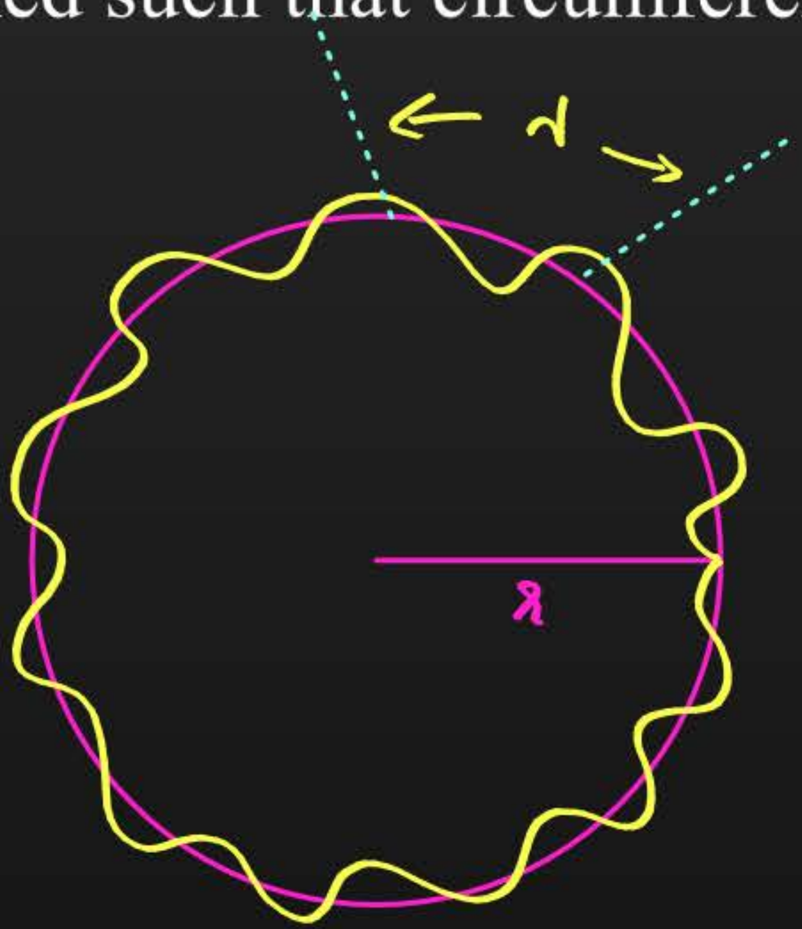
$$\frac{2.12}{0.53} = n^2$$

$$n^2 = 4$$

$$\boxed{n = \sqrt{4} = 2}$$

DE BROGLIE'S EXPLANATION OF BOHR'S SECOND POSTULATE OF QUANTISATION

In the allowed Bohr orbit, stationary waves are formed such that circumference of the orbit is equal to integral number of the wavelength.



$$2\pi r = n\lambda$$

$$2\pi r_n = n\lambda = \frac{nh}{p} = \frac{nh}{mv}$$

$$\underbrace{mvr_n} = \frac{nh}{2\pi}$$

$$\boxed{L_n = mvr_n = \frac{nh}{2\pi}}$$

Drawbacks of Bohr Model

- This model is valid only for single electron systems. (can not explain electron-electron interaction)
- This model is based on circular orbits of electrons whereas in reality there is no orbit
- Electron is presumed to revolve round the nucleus only whereas in reality motion of electron can not be described.

Question

H.W

In accordance with the Bohr's model, the quantum number that characterises the Earth's revolution around the Sun in an orbit of radius 1.5×10^{11}m with orbital speed 3×10^{4} ms^{-1} is [given, mass of Earth = 6×10^{24} kg]

$$L = mvr = \frac{nh}{2\pi}$$

- **A** 2.57×10^{38}
- **B** 8.57×10^{64}
- **C** 2.57×10^{74}
- **D** 5.98×10^{86}

Question

Hw

The de-Broglie wavelength associated with electron of hydrogen atom in this ground state is

(A) 0.3Å

(B) 3.3Å

(C) 6.26Å

(D) 10Å

Question

HW

Angular momentum of an electron in hydrogen atom of $3h/2\pi$ (h is the Planck's constant). The K.E of the electron is

- **A** 4.35 eV
- **B** 1.51 eV
- **C** 3.4 eV
- **D** 6.8 eV

Question

Ans =

A hydrogen atom is ground state absorbs 10.2 eV of energy. The orbital angular momentum of the electron is increased by

(A) 1.05×10^{-34} J-s

(B) 2.11×10^{-34} J-s

(C) 3.16×10^{-34} J-s

(D) 4.22×10^{-34} J-s

Question

H.W

When electron jumps from $n = 4$ level to $n = 1$ level, the angular momentum of electron changes by

A $h/2\pi$

B $2h/2\pi$

C $3h/2\pi$

D $4h/2\pi$

Thank

You