ARJUNA NEET BATCH

Structure of Atom

LECTURE - 9

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Quick Recap

← orbit / shell / period / level / stationary state

② Orbit Angular Momentum

$$\boxed{mvr = \frac{nh}{2\pi}} \text{ or } n\hbar$$

① $r \propto \frac{n^2}{Z}$

② $v \propto \frac{Z}{n}$

③ $\nu \propto \frac{Z^2}{n^3}$

④ $T \propto \frac{n^3}{Z^2}$

⑤ T.E. = − K.E.

⑥ T.E. = − I.E.

⑦ T.E × 2 = P.E.

⑧ $E = -13.6 \frac{Z^2}{n^2}$

⑨ $n \uparrow$ $E \uparrow$

$\Delta E \downarrow$

$E_3 - E_2$ $E_3 - E_1$ $n_1 \downarrow$

$E \uparrow$

$n_2 \uparrow$ $\Delta E \uparrow$

Objective of today's class

Dual Nature of Matter, Heisenberg Uncertainty principle

Dual Nature of Matter

→ No. of waves made by $e^{\ominus}$ in a given shell is equal to 'n'

→ Dual nature of matter is only applicable for moving object but not for stationary objects, matter waves associated with moving object do not posseses any Electric and Magnetic field.

can be deflected by External E.F. & M.F.

require medium for propagation. posseses speed equal to moving object.

Acc. to Planck's Quantam Theory

$$E = h\nu \quad \text{— (1)}$$

Acc. to Einstein Eq^n

$$E = mc^2 \quad \text{— (2)}$$

On Equating (1) & (2)

$$h\nu = mc^2$$

$$\frac{h\cancel{c}}{\lambda} = mc^{\cancel{2}}$$

$$\boxed{\lambda = \frac{h}{mc}}$$

$$\lambda = \frac{h}{mc} \rightarrow \text{for Light}$$

$$\boxed{\lambda = \frac{h}{mv}} \rightarrow \text{for any particle.} \quad \text{—} (1)$$

$\lambda \rightarrow$ Wavelength. (debroglie)

$m \rightarrow$ mass of particle (Kg)

$c \rightarrow$ speed of light $\Rightarrow 3 \times 10^{8}$ m/s

$v \rightarrow$ velocity of particle.

$$K.E. = \frac{1}{2} m v^{2}.$$

$$v^{2} = \frac{2 K.E.}{m}$$

$$v = \sqrt{\frac{2 K.E.}{m}} \quad \text{—} (2)$$

from (1) & (2)

$$\lambda = \frac{h}{m\sqrt{\frac{2 K.E.}{m}}} = \frac{h}{\sqrt{2 m K.E.}}$$

$$\boxed{\lambda = \frac{h}{\sqrt{2m\,K.E.}}}$$

$\lambda \rightarrow$ wavelength

$h \rightarrow 6.626 \times 10^{-34}$ Js

$m \rightarrow$ mass

K.E $\rightarrow$ Kinetic Energy

$$\boxed{\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{(K.E.)_2}{(K.E.)_1}}}$$

Kinetic Energy (K.E.) = Charge (q) × Potential difference (V)

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

For same particle

$$\boxed{\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}}}$$

For Cathode Rays ($e^{\ominus}$)

$$\Rightarrow \boxed{\lambda = \frac{1.23}{\sqrt{V}}}$$

Q. Arrange following in decreasing order of their debroglie wavelength of $e^{\ominus}$, proton, neutron & α-particle moving with same velocity.

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

if velocity is same

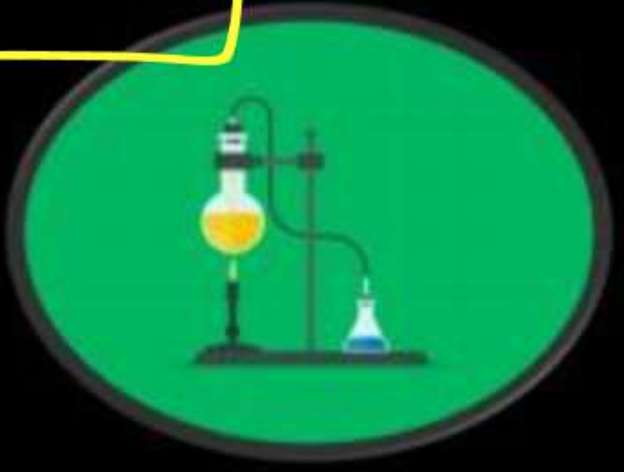
$$\boxed{\lambda \propto \frac{1}{m}}$$

	$e^{\ominus}$		proton		neutron		α-part (^4_2He)
Mass	9.1×10^{-31} kg	<	1.66×10^{-27} Kg	<	1.67×10^{-27} kg	<	$4\times m_p$

$$\boxed{\lambda \rightarrow \lambda_{e^{\ominus}} > \lambda_p > \lambda_n > \lambda_\alpha}$$

mass

m ↑ λ ↓



Q. Find ratio of λ_1 & λ_2 of 400V & 200V potential difference as applied respectively.

$V_1 = 400V$

$V_2 = 200V$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}}$$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{2\cancel{00}}{{}_{2}\cancel{4}\cancel{00}}} = \frac{1}{\sqrt{2}}$$

Q. Find debroglie wavelength associated with the cricket ball of mass 100 gm travelling at a speed of 100 cm/s. Report your answer in metre.

$\lambda = ?$

$m = 100\ gm$

$V = 100\ Cm/s$

$h = 6.626 \times 10^{-34}\ Js$

$\Rightarrow \lambda = \dfrac{h}{mv}$

$\Rightarrow \dfrac{6.626 \times 10^{-34}\ Js}{10^{-1} \times \cancel{100} \times \cancel{10^{-2}}\ m/s}$

$\Rightarrow \boxed{6.626 \times 10^{-33}\ m}$

$100\ gm = ?\ kg$

$\Rightarrow \dfrac{100}{10^3} \Rightarrow 10^{-1}$

Q. Find the ratio of debroglie wavelength of proton to that of α-particle is accelerated in E.F. of $\boxed{Vp = 10V}$ & $\boxed{V_\alpha = 40V.}$

$$\frac{\lambda_p}{\lambda_\alpha} = \frac{\sqrt{\cancel{2} \times m_\alpha \times q_\alpha \times V_\alpha}}{\sqrt{\cancel{2} \times m_p \times q_p \times V_p}}$$

$$\lambda = \frac{h}{\sqrt{2mq \times V}}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \frac{\sqrt{4 \times 2 \times 4\cancel{0}}}{\sqrt{1 \times 1 \times 1\cancel{0}}}$$

$m_\alpha = 4m_p$

$q_\alpha = 2 \times q_\alpha$

$\rightarrow \sqrt{32} : 1 \rightarrow 4\sqrt{2} : 1$

$\alpha \rightarrow {}^4_2He$

$p \rightarrow {}^1_1H$

Heisenberg Uncertainty principle

→ It is impossible to determine two dependent variable at same time.

→ ΔE & Δt (Energy and time)

→ $\Delta \omega$ & $\Delta \theta$ (Angular speed and displacement)

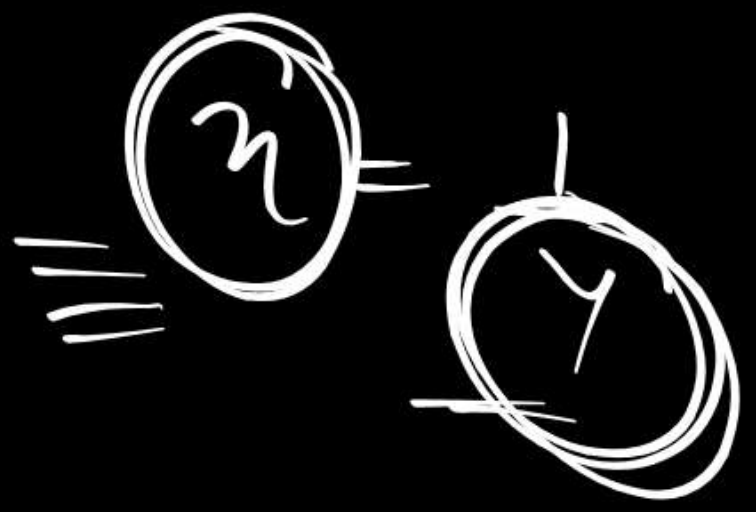
→ Δx & Δp (position and mome)

⇒ If Uncertainity in one of the quantity is maximum, minimum, ∞, zero than Uncertainity in other quantity is minimum, maximum, zero and ∞ respectively.

→ Both dependent variables are measured in same direction or same axis.

→ This principle is applicable to both micro and macroscopic particles but it is significantly only for microscopic

$x \times y = \text{constant}$



→ If two particles have same value of Δx then their Δp are also equal.

\#\# → According to Heisenberg Uncertainity Principle $e^{\ominus}$ cannot Exist inside nucleus because if it is present inside nucleus ($\Delta x = 10^{-15}$ m) then Uncertainity in its speed is 5.88×10^{10} m/s Very high from the speed of light which is not possible.

$\Delta x \rightarrow$ Uncertainity in position

$\Delta p \rightarrow$ Uncertainity in momentum.

$$\boxed{\Delta x . \Delta p \geq \frac{h}{4\pi}}$$

$h \rightarrow$ planck's constant

$\Rightarrow 6.626 \times 10^{-34}$ JS

$\pi = 3.14$

or

$$\boxed{\Delta E \times \Delta t \geq \frac{h}{4\pi}}$$

or

$$\boxed{\Delta \omega \times \Delta \theta \geq \frac{h}{4\pi}}$$

$\Rightarrow \Delta x \cdot \Delta p \geq \frac{h}{4\pi}$

$p = mv$

$\Delta p = m \Delta v$

$\Rightarrow \Delta x \cdot m \Delta v \geq \frac{h}{4\pi}$

$$\boxed{\Rightarrow \Delta x \cdot \Delta v \geq \frac{h}{4\pi m}}$$

$\Delta x \rightarrow$ Uncertainity in position.

$\Delta v \rightarrow$ Uncertainity in velocity

$h \rightarrow 6.626 \times 10^{-34}$ Js

$\pi \rightarrow 3.14$

$m \rightarrow$ mass of particle.

Q. Calculate the minimum value of $\Delta x \times \Delta p$ = ?

$$\Rightarrow \Delta x \times \Delta p \geq \frac{h}{4\pi}$$

$$\Rightarrow \frac{6.626 \times 10^{-34}}{4 \times 3.14}$$

$$\Rightarrow \underline{\underline{\qquad\qquad}} \quad (\text{H.W.})$$

Q. If $\Delta x = \Delta v$ then Δv = ?

$$\Rightarrow \Delta x \times \Delta v \geq \frac{h}{4\pi m}$$

if $\Delta x = \Delta v$

$$\Rightarrow \Delta v \times \Delta v = \frac{h}{4\pi m}$$

$$\Rightarrow (\Delta v)^2 = \frac{h}{4\pi m}$$

$$\Rightarrow \Delta v = \sqrt{\frac{h}{4\pi m}}$$

$$\Rightarrow \boxed{\Delta v = \frac{1}{2}\sqrt{\frac{h}{\pi m}}}$$

Q. A particle of 100 mg is moving with velocity 10% of light. If uncertainty in velocity is 0.001% then find uncertainty in position.

$m = 100\ mg$

$\text{Velocity} = 10\%\ \text{of light} = 3 \times 10^{8} \times \frac{1\cancel{0}}{10\cancel{0}} \Rightarrow 3 \times 10^{7}\ m/s$

$\Delta V = 0.001\%$

$\Delta x = ?$

$\Delta V \Rightarrow 3 \times 10^{7} \times \frac{0.001}{100 \times 1000}$

$\boxed{\Delta V \Rightarrow 3 \times 10^{2}\ m/s}$

$$\Delta x \cdot \Delta V \geq \frac{h}{4\pi m}$$

$$m = \frac{100 \times 10^{-3}}{10^{3}}$$

$$\Rightarrow$$

$$\Rightarrow \Delta x = \frac{h}{4\pi m \times \Delta V}$$

$$\Rightarrow \Delta x \Rightarrow \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 100 \times 10^{-3} \times 10^{-3} \times 3 \times 10^{2}} \Rightarrow \underline{\underline{\qquad\qquad}}$$

(H.W.)

Q. The uncertainty in position of an $e^{\ominus}$ is equal to its debroglie wavelength. Find the % error in the measurement of its velocity.

$$\Rightarrow \Delta x = \lambda = \frac{h}{mv}$$

Acc. to. Heisenberg Unc. principle

$$\Rightarrow \Delta x \cdot \Delta v \geq \frac{h}{4\pi m}$$

$$\Rightarrow \frac{\cancel{h}}{\cancel{m}v} \times \Delta v \geq \frac{\cancel{h}}{4\pi \cancel{m}}$$

$$\Rightarrow \frac{\Delta v}{v} \times 100 \geq \frac{1}{4\pi} \times 100$$

$\Rightarrow$ % error in velocity $= \dfrac{100}{4 \times 3.14}$

$\Rightarrow$ **8.1%**

Q. Find the longest wavelength in Paschen series of Li^{+2} in nm.

$Li^{+2} \Rightarrow Z = 3$

Paschen series $\Rightarrow$ $n_1 = 3$ $\quad n_2 = 4$

$$\Rightarrow \frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Rightarrow \frac{1}{\lambda} = R_H (9) \left(\frac{1}{9} - \frac{1}{16}\right)$$

$$\Rightarrow \frac{1}{\lambda} = R_H \cancel{9} \left(\frac{7}{\cancel{9} \times 16}\right)$$

$$\Rightarrow \lambda = \frac{1}{R} \times \frac{16}{7}$$

$$\lambda = 91.2 \times \frac{16}{7}$$

$$\Rightarrow \underline{208.4 \text{ nm}}$$

of H atom

Q. Find the ratio of wavelength for 3rd & 4th line in Lyman series.

H- atom.

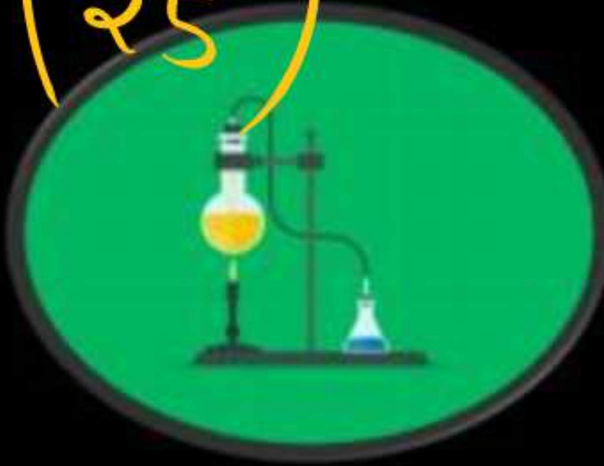
$\Rightarrow$ lyman $\rightarrow$ 3^{rd} line $\rightarrow$ $n_1 = 1$ $\quad n_2 = 4$

$\rightarrow$ 4^{th} line $\rightarrow$ $n_1 = 1$ $\quad n_2 = 5$

$$\Rightarrow \frac{\dfrac{1}{\lambda_{3^{rd}}}}{\dfrac{1}{\lambda_{4^{th}}}} = \frac{\cancel{R_H}\,\cancel{Z^2}\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)}{\cancel{R_H}\,\cancel{Z^2}\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)}$$

$$\Rightarrow \frac{\lambda_4}{\lambda_3} = \frac{\left(\dfrac{n_2^2 - n_1^2}{n_1^2 n_2^2}\right)_{3^{rd}}}{\left(\dfrac{n_2^2 - n_1^1}{n_1^2 \times n_2^2}\right)_{4^{th}}}$$

$$\Rightarrow \frac{\lambda_4}{\lambda_3} = \frac{\left(\dfrac{15}{16}\right)}{\left(\dfrac{24}{25}\right)}$$



$$\frac{\lambda_4}{\lambda_3} = \frac{15}{16} \times \frac{25}{24} \Rightarrow \frac{384}{375}$$

$$\Rightarrow \frac{375}{384}$$

$$\frac{\lambda_3}{\lambda_4} = \frac{384}{375}$$

Q. Which transition of Li^{+2} is associated with same energy change as in second line of Bracket transition in He^{+}.

Li^{+2} $\quad Z = 3$

$n_1 = ?$ $\quad n_2 = ?$

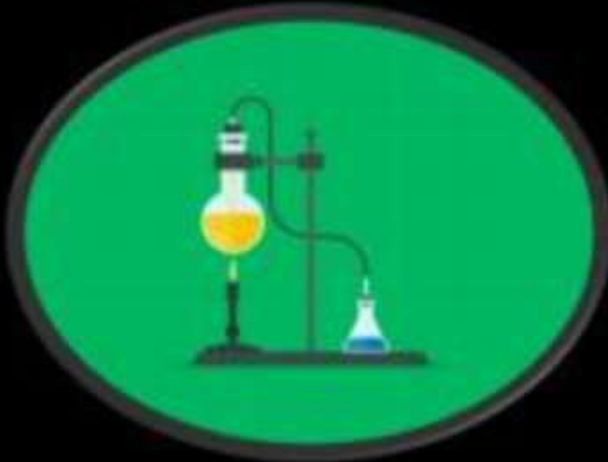
He^{+} (second line)

$Z = 2$. (Bracket series)

$n_1 = 4$ $\quad n_2 = 6$

$$\frac{1}{\lambda} \Rightarrow \cancel{R_H} Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = \cancel{R_H} Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Rightarrow 9 \times \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 4 \left(\frac{1}{16} - \frac{1}{36}\right)$$



$$\frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{4}{9}\left(\frac{1}{16} - \frac{1}{36}\right)$$

$$\frac{1}{n_1^2} - \frac{1}{n_2} \Rightarrow \frac{1}{36} - \frac{1}{81}$$

$n_1^2 = 36 \qquad n_1 = 6 \leftarrow$ Ans

$n_2^2 = 81 \qquad n_2 = 9$

Q. **If the K.E. of proton increases nine times. The wavelength of the debroglie wave associated with it would becomes.**

K.E. $\rightarrow p \rightarrow \uparrow$ 9 times

$\lambda = ?$

$$\lambda \propto \frac{1}{\sqrt{K.E.}}$$

$\lambda \propto \frac{1}{\sqrt{9}} \Rightarrow \lambda$ becomes $\frac{1}{3}$ times

H.W.

An $e^{\ominus}$ has a speed of 4×10^{5} m/s . If its velocity is accurate upto 10% then calculate uncertainty in position of $e^{\ominus}$.

$$v = 4 \times 10^{5}\ m/s$$

Q. The error in the position & velocity of moving particle are equal are equal then calculate the error in momentum.

$\Delta x = \Delta V$

$\Delta p = ?$

$\Rightarrow \Delta x \cdot \Delta v \geq \dfrac{h}{4\pi m}$

$\Rightarrow \Delta v \times \Delta v \geq \dfrac{h}{4\pi m}$

$\Rightarrow (\Delta v)^2 = \dfrac{h}{4\pi m}$

$\Rightarrow \Delta v = \dfrac{1}{2}\sqrt{\dfrac{h}{\pi m}}$

$\Delta p = m\,\Delta V$

$\Rightarrow m \times \dfrac{1}{2}\sqrt{\dfrac{h}{\pi m}}$

$\boxed{\Delta p = \dfrac{1}{2}\sqrt{\dfrac{hm}{\pi}}}$

How.

Q. When Electromagnetic Radiation of wavelength 300nm fall on surface of sodium. $e^{\ominus}$ s are emmitted with the K.E. of 1.68×10^5 J/mole. What is the minimum energy needed to remove an $e^{\ominus}$ from Na(Sodium) & what is the maximum wavelength that with cause of photo electrons to be emmitted.

thanks
for watching

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