Module-2.
Quantum Mechanics

EMw have both $\underbrace{\text{wave nature}}$ and $\underbrace{\text{particle nature}}$.

Interference, diffraction, Polarisation

Photo electric effect, Comptons effect, black body radiation spectrum

De-Broglie Hypothesis.

for a particle of mass 'm' moving with velocity 'V' are associated with a waves and these waves are called "de-broglie matter waves"

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

Characteristics of matter wave :-

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

2) de broglie waves are not Electro magnetic in nature

3) The amplitude of de broglie matter waves gives the probability of finding the particle at a given point & at a given time.

4) particle velocity is equal to velocity of de broglie waves.

i.e., $V_{Particle} = V_{de\text{-}broglie}$

W.K.T,

$$E = KE = \frac{1}{2} mv^2 = \frac{m^2v^2}{2m} = \frac{(mv)^2}{2m} = \frac{p^2}{2m} \Rightarrow \frac{p^2}{2m} = E$$

$$p^2 = 2mE$$

root on b.s

$$\sqrt{p^2} = \sqrt{2mE}$$

$$\boxed{P = \sqrt{2mE}}$$

•). $\Delta E \, \Delta t \geq \frac{\hbar}{2}$ •). $\underset{\downarrow}{\Delta L} \, \Delta \theta \geq \frac{\hbar}{2}$

angular momentum

It is impossible to make measurements

• Applications of uncertainity principle :-

Prove that 1) electron is present inside the atom

2) proton is present inside the nucleus $_{10^{-14} \text{metre}}$

Using uncertainity principle.

1). $E = \frac{p^2}{2m}$

$$\Delta x \cdot \Delta P \geq \frac{\hbar}{2}$$

or $\Delta x \cdot \Delta P \cong \hbar$

$$\Delta P \propto \frac{\hbar}{\Delta x} \rightarrow \Delta P = \frac{h/2\pi}{\Delta x}$$

$$\Delta P = \frac{\frac{6.626 \times 10^{-34}}{2 \times 3.14}}{\Delta x}$$

$$\Delta P = \frac{1.04 \times 10^{-34}}{\Delta x} \, Js$$

dimension of atom is 10^{-10}

$$\therefore \Delta P = \frac{1.04 \times 10^{-34}}{10^{-10} \, m}$$

$$\Delta P = \underline{1.04 \times 10^{-24}} \, m$$

$$E = \frac{(1.04 \times 10^{-24})^2}{2 \times 9.1 \times 10^{-31}}$$

$$E = \frac{1.0816 \times 10^{-48}}{18.2 \times 10^{-31}} \times \frac{1}{1.6 \times 10^{-19}} \, eV$$

$$E = \frac{1.0816 \times 10^{-48}}{29.12 \quad 10^{-50}}$$

$$E = 0.0375 \times 10^{-2}$$

$$E = 3.75 \, eV$$

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} \times 36\cancel{00}}{15\cancel{0} \times \cancel{10^{-3}} \times 15\cancel{0} \times \cancel{10^{3}}}$$

$$\lambda = \frac{23853.6 \times 10^{-34}}{22500}$$

$$\lambda_{ball} = 1.\underline{06016} \times 10^{-34}\ m$$

Nature of de-broglie matter waves :-

→ Individual wave

Wave velocity = $V_{phase} \neq V_{particle}$

$$V_{group} = V_{particle}$$

$$V_{phase} = \frac{\omega}{k} \rightarrow \text{omega}$$

$$= \frac{2\pi f}{\frac{2\pi}{\lambda}} = f\lambda = \frac{c}{\lambda} \cdot \lambda = c$$

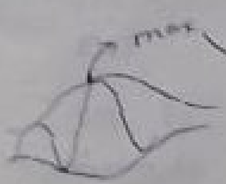
$$\therefore V_{group} = \frac{d\omega}{dk}$$

* wave group represents de Broglie matter waves.

$$V_G = \frac{d\omega}{dk} = V_{Particle}$$

↓

group velocity



[indicates the probability of finding the position of a particle.]

It is impossible to make ~~possible~~ to a measurements for any 2 con care mic~~al~~ conjugate. Physical parameters like position and ~~mover~~ momentum

$$-\Delta x \; \Delta p \geq \frac{\hbar}{2}$$

The ~~proecet~~ product of the unsureity involved in the measurement shld be greater than or equal to $\hbar = h/2\pi$

$p = \sqrt{2mE}$ $\quad \boxed{E = eV}$

$p = \sqrt{2meV}$

$$\therefore \lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2meV}}$$

Calculate or express de broglie wavelength for electrons accelerated to a potential 'V'

$\longrightarrow$ λ = Mass of $e^- = 9.1 \times 10^{-31}$ kg

$e = 1.6 \times 10^{-19}$ C

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

$$\lambda = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19}}}$$

$$\lambda = \frac{6.626 \times 10^{-34}}{\sqrt{29.12 \times 10^{-50}}}$$

$$\lambda = \frac{6.626 \times 10^{-34}}{5.3 \times 10^{-35}} \times \frac{1}{\sqrt{V}}$$

$$\lambda = \frac{1.226}{\sqrt{V}} \text{ nm} ^{***}$$

Calculate debroglie wavelength of a cricket ball 150 g moving with a velocity of 15 km/h

$\longrightarrow$ mass of ball = 150 gram = 150×10^{-3} kg

Velocity = 15 km/h

$= \frac{150 \times 10^{3}}{3600}$ m/s

$$\lambda = \frac{\cancel{6.626 \times 10^{-34} \times 3600}}{\sqrt{2 \times 150 \times 10^{-3} \times 150 \times \cancel{10^{3}}}}$$