Applied Physics ALM-2 CO4

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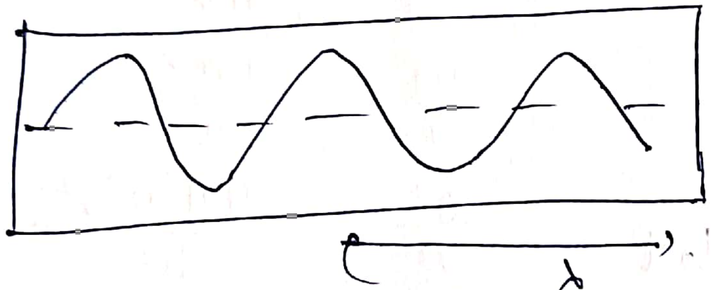
1.) According to De-Broglie, a moving particle can be associated with a wave can guide the motion of the particle.



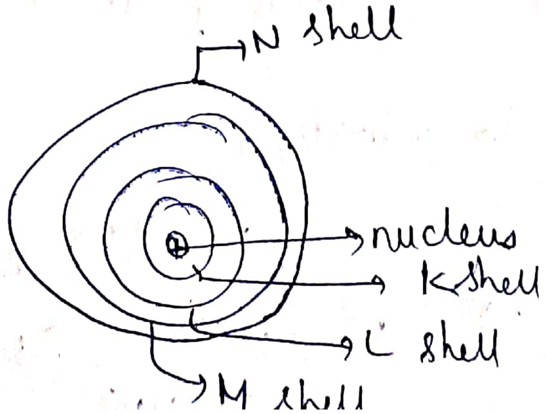
The waves associated with the moving material particles are known as debroglie wave / matter waves

Expression for de-broglie wave:
According to the eqn. from quantum theory, the energy of the photon is $E = h\nu = \frac{hc}{\lambda}$

According to Einstein's theory, the energy of the photon is $E = mc^2$

Bohr Model:

* An atom is a sphere with positive charge in the centre called nucleus
* Electrons revolve around the nucleus in discrete orbits and donot radiate energy



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So, $\lambda = \frac{h}{mc} = \frac{\lambda}{p} = \frac{\lambda}{mv}$ which is expression of debroglie wavelength

(1) Debroglie wavelength in different forms :-

→ In terms of KE :- $\lambda = \frac{h}{\sqrt{2mE}}$

→ In terms of PE :- $\lambda = \frac{h}{\sqrt{2mqV}}$

→ In terms of temperature ⇒ $\lambda = \frac{h}{\sqrt{3mKT}}$

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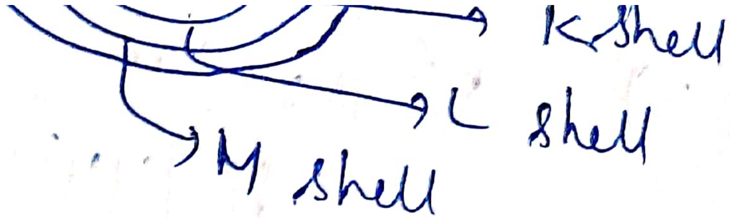

2.) Consider

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mass m, velocity v, frequency 'ω'

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

$$\nabla^2 \psi = \frac{-2m}{\hbar^2}(E - V)\psi$$

$$\frac{\hbar^2}{2m}\nabla^2 \psi = (E - V)\psi$$

$$\frac{\partial^2 y}{\partial t^2} = v^2 \nabla^2 y$$

$$\frac{\partial^2 \varphi}{\partial t^2} = v^2 \nabla^2 \varphi \rightarrow (1)$$

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$$

$$\varphi = \varphi_0 e^{-i\omega t} \longrightarrow (2)$$

diff eqn (2) with respect to t

$$\frac{\partial \varphi}{\partial t} = \varphi_0 \frac{\partial}{\partial t} (e^{-i\omega t})$$

$$\frac{\partial \varphi}{\partial t} = \varphi_0 (-i\omega) e^{-i\omega t}$$

$$\frac{\partial \varphi}{\partial t} = -i\omega \varphi$$

$$\frac{\partial}{\partial t}\left(\frac{\partial \varphi}{\partial t}\right) = \frac{\partial}{\partial t}(-i\omega \varphi)$$

$$\frac{\partial^2 \varphi}{\partial t^2} = (-i\omega)\frac{\partial}{\partial t}(\varphi_0 e^{-i\omega t})$$

$$= (-i\omega)\varphi_0(-i\omega)e^{-i\omega t} = \varphi_0 \omega^2 (-i) e^{-i\omega t}.$$

So,

$$\lambda = \frac{h}{mc} \text{ or } \lambda = \frac{h}{p} \quad (\text{where } p = mc)$$

$$\lambda = \frac{h}{mv} \quad (\text{wrt to velocity})$$

$$\frac{\partial^2 \varphi}{\partial t^2} = -\omega^2 \varphi \longrightarrow (3)$$

sub eqn (3) in (1)

$$-\omega^2 \varphi = v^2 \nabla^2 \varphi$$

$$\nabla^2 \varphi = \frac{\omega^2}{v^2} \varphi = 0$$

WKT $\omega = 2\pi \nu$

$$\frac{\omega}{v} = \frac{2\pi}{h/mv}$$

$$\frac{\omega}{v} = \frac{2\pi m v}{h}$$

$$\frac{\omega^2}{v^2} = \frac{4\pi^2 m^2 v^2}{h^2}.$$

WKT $E = PE + KE$

$$E = V + \frac{1}{2} m v^2$$

adding m on both sides

$$2m(E-V) = m m v^2$$

$$2m(E-V) = m^2 v^2$$

$$\frac{\omega^2}{v^2} = \frac{4\pi^2}{h^2} 2m(E-V)$$

→ sub in (4) we get

$$\nabla^2 \varphi = \frac{2m}{h^2/4\pi^2}(E-V)\varphi = 0$$

$$\boxed{\nabla^2 = \frac{2m}{\hbar}(E-V)\varphi = 0}$$

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