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Section :- 5

(1) What is schrodinger wave equation. Derive time dependent schrodinger wave equations.

Schrodinger wave equation:- Schrodinger's equation, which is the fundamental equation of quantum mechanism is a wave equation in the variable ψ.

Time Dependent Schrodinger wave equation.

(1) We know that wave function is $\psi = \psi_0 e^{-i\omega t}$

(2) On differentiating w.r.t time, we get

$$\frac{\partial \psi}{\partial t} = -i\omega \psi_0 e^{-i\omega t}$$

(or)

$$\frac{\partial \psi}{\partial t} = -i\,(2\pi\nu)\,\psi$$

(3) But = $E = h\nu$ = $\nu = \frac{E}{h}$

(4) So eq. (3.13.11) becomes)

$$\frac{\partial \psi}{\partial t} = -i\,2\pi\left(\frac{E}{h}\right)\psi$$

$$\frac{\partial \psi}{\partial t} = \frac{-i}{\hbar} E\psi \quad \left[\because \hbar = \frac{h}{2\pi}\right.$$

Or

$$E\psi = -\frac{\hbar}{i}\frac{\partial \omega}{\partial t}$$

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or $E\psi = i\hbar \dfrac{\partial \psi}{\partial t}$

(5) Now time independent Schrodinger wave equation is

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

$$\nabla^2 \psi + \frac{2m}{\hbar^2}[E\psi - V\psi] = 0$$

using e.q , we get

$$\nabla^2 \psi = \frac{2m}{\hbar^2}\left[i\hbar \frac{\partial \psi}{\partial t} - V\psi\right] = 0$$

$$\nabla^2 \psi - \frac{2m}{\hbar^2} V\psi = -\frac{2m}{\hbar^2} i\hbar \frac{\partial \psi}{\partial t}$$

$$\left(\nabla^2 - \frac{2m}{\hbar^2} V\right)\psi = -\frac{2m}{\hbar^2} i\hbar \frac{\partial \psi}{\partial t}$$

or $\left(-\dfrac{\hbar^2}{2m}\nabla^2 + V\right)\psi = i\hbar \dfrac{\partial \psi}{\partial t}$

This is required time dependent Schrodinger wave equation

$-\dfrac{\hbar^2}{2m}\nabla^2 + V = H \rightarrow$ is know as Hamiltonium operator

and, $i\hbar \dfrac{\partial \psi}{\partial t} = E\psi \rightarrow$ energy operator

Then $\boxed{H\psi = E\psi}$