

Notes for

B.Sc Part-III

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H. C. D. Physics

Paper - 5B : i) Postulates of Quantum mechanics.

Postulates of Quantum mechanics :— On the basis of the wave nature of moving Particle we have develop Schrodinger's wave equation. In order to use the wave equation and to obtain a quantitative description of matter on the atomic or nuclear scale like the values of linear momentum, angular momentum and energy etc of a microparticle. We have to make some assumptions which are known as Postulates of wave mechanics or quantum mechanics.

Postulates of wave mechanics or quantum mechanics.
The fundamental Postulates are :→ ① There is a linear quantum mechanical operator corresponding to every observable which describes the motion of a particle. The most important operators of wave mechanics are :—

① Cartesian co-ordinate operator :— These operators are represented as \hat{x} , \hat{y} , \hat{z} and correspond to x, y, z co-ordinates respectively. When any of these operators operates on a wave function, the result is the function multiplied by the corresponding co-ordinates. Thus $\hat{x}\psi = x\psi$.

② linear momentum operator :— These operators are represented as \hat{p}_x , \hat{p}_y , \hat{p}_z and \hat{p} corresponds to x, y, z components or total value of linear momentum respectively. Their values are — $\hat{p}_x = -i\hbar \frac{\partial}{\partial x}$; $\hat{p}_y = -i\hbar \frac{\partial}{\partial y}$

$$\hat{p}_z = -i\hbar \frac{\partial}{\partial z} \text{ and } \hat{p} = -i\hbar \nabla$$

When any of the first three linear momentum operates on a wave function. The result is the function multiplied by corresponding component of momentum. Thus →

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$$\rightarrow \hat{p}_x \psi = -i\hbar \frac{\partial \psi}{\partial x} = p_x \psi$$

when the operator \hat{p} operates on the function. We get the function multiplied by total momentum. Thus

$$\hat{p} \psi = -i\hbar \vec{\nabla} \psi = \vec{p} \psi$$

(iii) Potential energy operator:— This operator is represented as $\hat{V}(\vec{r})$ and corresponds to the potential energy $V(\vec{r})$. When it operates on a function, the result is the function multiplied by the observable $V(\vec{r})$ i.e. $\hat{V}(\vec{r})\psi = V(\vec{r})\psi$.

(iv) Total energy operator:— The operator is represented as \hat{E} and corresponds to the total energy E of the system.

Its value is $\hat{E} = \epsilon \hbar \frac{\partial}{\partial t}$

when it operates on a function the result is the function multiplied by the observable E .

$$\therefore \hat{E} \psi = \epsilon \hbar \frac{\partial \psi}{\partial t} = E \psi$$

(v) Hamilton operator:— In classical mechanics,

Hamiltonian is defined as —

$$H = \frac{\vec{p}^2}{2m} + V$$

and it gives the total energy E of the system. Hence the total energy operator for a non relativistic particle is also represented by Hamiltonian operator \hat{H} as $\hat{p} = \epsilon \hbar \vec{\nabla}$,

the Hamiltonian operator

$$\hat{H} = -\frac{\hbar^2}{2m} \vec{\nabla}^2 + V$$

when it operates on the function ψ , the result is the function multiplied by the total energy E .

$$\therefore \hat{H} \psi = \left\{ -\frac{\hbar^2}{2m} \vec{\nabla}^2 + V \right\} \psi = E \psi.$$