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Degree - III, Paper - V Group - C 15/02/2024

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Topic:- The Postulates of Quantum Mechanics

There are six postulates of Quantum Mechanics:-

* Postulate (1) :- The state of a quantum mechanical system is completely specified by the function $\psi(r, t)$ that depends on the coordinates of the particle, r and the time, t . This function is called the wavefunction or state function and has the property that $\psi^*(r, t) \psi(r, t) d\tau$ is the probability that the particle lies in the volume element $d\tau$ located at r and time t .

$$\int_{-\infty}^{+\infty} \psi^*(r, t) \psi(r, t) d\tau = 1$$

This is the normalisation condition of postulate 1.

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Postulate (2) :- TO every observable in classical mechanics there corresponds a linear, Hermitian operator in quantum mechanics.

Some Examples of Hermitian operators are:

Observable	Classical Symbol	Quantum operator	operation
position	x	\hat{x}	multiply by x
momentum	p	\hat{p}	$-i\hbar \left(i \frac{\partial}{\partial x} + i \frac{\partial}{\partial x} \right)$
Kinetic energy	T	\hat{T}	$\frac{\hbar^2}{2m} \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \right)$

Postulate (3) :- In any measurement of the observable associated with operator \hat{A} , the only values that will ever be observed are the eigenvalues, a , that satisfy the eigenvalue equation.

$$\hat{A}\psi = a\psi$$

This is the postulate that the value of dynamical variables are quantized in quantum mechanics.

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Although measurement will always yield a value, the initial state does not have to be an eigenstate of \hat{A} . An arbitrary state can be expanded in the complete set of eigenvectors of \hat{A} , $\hat{A}\psi_i = a_i\psi_i$, as

$$\psi = \sum_i^n c_i \psi_i$$

Where n may go to infinity.

Postulate (4) :- If a system is in a state described by the normalised wavefunction, ψ , then the average value of the observable corresponding to \hat{A} is given by

$$\langle \hat{A} \rangle = \int_{-\infty}^{+\infty} \psi^* \hat{A} \psi d\tau$$

Postulate (5) :- The wave function or state function of a system evolves in time according to the time-dependent Schrödinger

$$\mathcal{H}\psi(r,t) = i\hbar \frac{\partial \psi}{\partial t}$$

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Postulate (6) :- The total wavefunction must be antisymmetric with respect to the interchange of all coordinates of one fermion with those of another. Electronic spin must be included in this set of coordinates

Note:- The Pauli exclusion principle is a direct result of this antisymmetry postulate.

H-N

d. Write all the postulates of Quantum mechanics.