[22] SEAT No. ______

SARDAR PATEL UNIVERSITY

Six Semester B. Sc. Examination -2022
Physics US06CPHY01
Quantum Mechanics

Total Marks: 70

Time: 3:30 to 5:30

Date: 29 - 9 - 22

N. B. (i) All the symbols have their usual meaning.
(ii) Figure at the right of questions indicate full marks.

Q – 1 Choose correct option to answer the question. [10]

(1) Expectation values of self-adjoint is______
(a) Always zero (b) real
(c) infinite (d) complex

(2) The square of magnitude of wave function is called ______density
(a) current (b) mass
(c) probability (d) volume

(3) If the particle moving in a____ potential then the solution of the wave equations are described as stationary state
(a) time independent (b) time dependent
(c) velocity dependent (d) velocity independent

(4)In the time independent Schrodinger equation HU = EU, E is called _____
(a) heat energy (b)potential eigen value
(c) energy eigen value (d) potential

(5) The limit of region I for square well potential is _____
(a) $-\infty < x < 0$ (b) $-a < x < a$
(c) $a < x < \infty$ (d) $-\infty < x < -a$

(6) If A Is an operator and $A^{\dagger}$ is an adjoint operator of A then$(A^{\dagger})^{\dagger}$= _____
(a) A (b) $A^{\dagger}$
(c) I (d) none of these

(7) Each dynamical variable in quantum mechanics is represented by____
(a) number (b) non-linear operator
(c) gradient of vector (d) linear operator

(8)Energy eigen value of an oscillator is E = ____
(a) $(n+\frac{1}{2})\hbar\omega$ (b) $\hbar\omega$
(c) $\hbar\nu$ (d) $n\hbar\nu$

(9) In shorter notation of integral $\int \phi^*\psi d\tau$ =_____
(a) (ϕ, ψ) (b)(ϕ^*, ψ)
(c) $(\phi, A\,\psi)$ (d) $(A\,\phi, \psi)$

(10) Angular momentum is defined as L = _____
(a) $\vec{r}\cdot\vec{p}$ (b) $\vec{r}x\vec{p}$
(c)$\vec{r}x\vec{p}^2$ (d) none of these

Q – 2 Fill in the blanks [8]

(1)According to Heisenberg's uncertainty principle the product $(\Delta x)(\Delta p) \geq =$ ____
(2)For E > 0 the particle has a _______ kinetic energy.
(3)For a bound state of a particle energy is always _____
(4) The ground state energy of simple harmonic oscillator is ______

Identify true or false

(5) For a self-adjoint operator A = $A^{\dagger}$
(6)The non-normalized wave function must have finite norm.
(7) Energy of an isotropic oscillator is discrete
(8) In a rigid rotator the distance between particles is constant.

P.T.O.

Q – 3 Answer briefly any ten of following question. [20]

(1)What is wave packet?

(2)Write the three dimensional Schrodinger wave equation for a free particle.

(3) Describe normalizable wave function in brief.

(4) Draw diagram of square well potential and write down an expression of potential energy for its different region.

(5) Show that the quantity$\Delta = \frac{\hbar^2}{2ma^2}$ appearing in discussion of square well potential has unit of energy

(6) Define degeneracy of eigen values.

(7) Explain adjoint operator and self-adjoint operator.

(8) Prove that $[x, p] = i\hbar$

(9)Draw energy level diagram of simple harmonic oscillator.

(10) What is rigid rotator? Write the expression for its energy level separation.

(11) What is central potential?

(12) Obtain component of angular momentum in Cartesian co-ordinates.

Q – 4 Answer the following questions. (Attempt any four) [32]

(1) For a free particle, Obtain one dimensional Schrodinger wave equation.

(2) Discuss Ehrenfest's theorem in detail.

(3) Obtain an expression of energy eigen valuefor a particle in square well potential using admissiblesolution.

(4) Obtain an expression of energy eigen function for a particle in square well potential using admissible solution.

(5) Discussuncertainty principle for quantum mechanical variables.

(6)Prove that any two eigen functions belonging to un equal eigen values of a self-adjoint operatorare mutually orthogonal.

(7) Derive the dimension less Schrodinger equation forsimple harmonic oscillator.

(8) Derive the radial equation for motion of particle in central potential.

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