[133] SEAT No._____ No. of printed pages:02

SARDAR PATEL UNIVERSITY
B.Sc. (6th- Semester) Examination
Code No. US06CPHY21: [Quantum Mechanics]

Date: 04-04-2022, Monday **Time: 3:00 p.m. to 5:00 p.m.**

Note: (i) All the symbols have their usual meanings **Total Marks: 70**
(ii) Figures at the right side of questions indicate full marks

Q.1 Multiple Choice Questions (Attempt All) **[10]**

(1) For $E > 0$, the particle has a _____ kinetic energy
(a) zero (b) positive
(c) negative (d) infinity

(2) Any particle with energy _____ cannot enter in the regions I and III
(a) $E = 0$ (b) $E = \propto$
(c) $E < 0$ (d) $E > 0$

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

(4) For adjoint operator A, $(\phi, A\psi)$= _____
(a) $(\phi^*, A\psi)$ (b) $(A^+\emptyset, \psi)$
(c) $(\phi, A\psi)$ (d) $(A\, \phi, \psi)$

(5) Eigen values of a self adjoint operator is _____
(a) always 0 (b) infinite
(c) real (d) imaginary

(6) If $\delta_{m,n}$ is Kronecker delta function then $\delta_{m,n} = 1$ when _____
(a) $m = n$ (b) $m > n$
(c) $m < n$ (d) $m \neq n$

(7) If A & B are a canonically conjugate pair of operator, then $[A, B]$ = _____
(a) $i\hbar/2$ (b) $i\hbar$
(c) $\hbar$ (d) $2i\hbar$

(8) Force acting on the pendulum is proportional to _____
(a) velocity (b) time
(c) displacement (d) acceleration

(9) In a rigid rotator distance between two particles is _____
(a) constant (b) zero
(c) infinite (d) variable

(10) Energy of an isotropic oscillator is _____
(a) continues (b) discrete
(c) zero (d) infinity

Q.2 Filling the blanks and True-False **[08]**

(1) Any wave function having symmetry property is said to be of odd parity (True/False)

(2) The limit of a region-III for a square well potential is _____

(3) If A and B are non-commutative self-adjoint operators then $(AB)^+ = BA$ (True/False)

(4) The value of constant of integration for δ function normalized momentum eigen function is _____

(5) The same state of all the components of $\vec{L}$ operator is possible (True/False)

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(6) The ground state energy for simple harmonic oscillator is E = _____
(7) The H- atom is a two-particle system (True/False)
(8) Angular momentum is defined as L = _____

Q.3 Short Questions (Attempt any Ten) **[20]**

(1) Define square well potential.
(2) Write the admissible solution for a particle in a square well potential.
(3) What is the condition of the total probability of the wave function?
(4) Define adjoint and self-adjoint operator.
(5) What is Dirac delta function?
(6) Define degenerate and non-degenerate eigen values.
(7) Define simple harmonic oscillator.
(8) Define Bosons and Fermions.
(9) Write the Hamiltonian for interacting and non-interacting systems.
(10) Write down expression for ∇^2 in spherical polar coordinates.
(11) What is rigid rotator? State the expression for its energy level separation.
(12) What is isotropic oscillator? Write the expression for its energy.

Q.4 Long Questions (Attempt any four) All questions carry equal marks **[32]**

(1) Derive the time independent Schrodinger equation and find its solution. Also state the physical significance.
(2) Using the admissible solutions derive the equation of energy eigen values for a particle in a square well potential.
(3) Discuss the fundamental postulates of wave mechanics with properties.
(4) Derive eigen function in momentum space and normalized it by δ function normalization method.
(5) State uncertainty principle and prove it for any pair of quantum mechanical observables
(6) Derive the expression of energy eigen value of simple harmonic oscillator
(7) Derive the expression of angular momentum operator L^2 in terms of spherical polar coordinates
(8) Derive the radial wave equation for H-atom

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