[54/A-17] SEAT No.________ No. of Printed Pages : 3

Sc

SARDAR PATEL UNIVERSITY

Sixth Semester B. Sc. Examination – 2019

Monday, 25th March,-2019

Time: 10:00 am to 1:00 pm

PHYSICS: US06CPHY01 (Quantum Mechanics)

Total Marks: 70

Que-1 Choose correct option to answer the question. **[10]**

(1) The relation between momentum of a particle and wave vector is given by $\vec{p}$ = ________.

(a) $\hbar\vec{k}$ (b) $\hbar^2\nu$ (c) $\hbar\lambda$ (d) $h\vec{k}$

(2) If ψ is a normalisable wave function then its norm is ____

(a) -1 (b) 1 (c) $-\infty$ (d) ∞

(3) Wave function of a bound state of particle is __________.

(a) normalisable (b) infinite (c) zero (d) non- normalisable

(4) For non-localized state of a particle, energy E ________

(a) < 0 (b) $= 0$ (c) > 0 (d) $= \infty$

(5) In a stationary state of a particle the position probability density $|\psi|^2$ is _____

(a) independent of time (b) independent of position

(c) dependent of time (d) always infinite

(6) For any operator A and a wave function ϕ_a if $A\phi_a = a\phi_a$ then a is called _____.

(a) eigen function (b) eigen value

(c) probability density (d) probability amplitude

(7) For the wave functions ∅ and ψ and operator A the shorter notation of the integral $\int \phi^* A\psi d\tau \equiv$ _________

(a) (ϕ, ψ) (b) $(\phi^*, A\psi)$ (c) $(\phi, A\psi)$ (d) $(A\phi, \psi)$

(8) Expectation value of a self adjoint operator is ________

(a) always 0 (b) infinite (c) real (d) imaginary.

(9) Time independent Schrodinger equation in shorter form is given by Hu = _____.

(a) Eu^2 (b) E (c) EH (d) Eu

(10) Angular momentum is defined as L = _________

(a) $\vec{r}\cdot\vec{p}$ (b) $\vec{r}\times\vec{p}^2$ (c) $\vec{r}\times\vec{p}$ (d) mv

(P.T.O.)

Que-2 Answer briefly **<u>any ten</u>** of the following questions. [20]

(1) Discuss briefly de-Broglie hypothesis.

(2) Explain briefly the concept of wave packet.

(3) Write down admissibility condition on wave function.

(4) For a square well potential draw diagrams showing wave functions of even parity with proper notations.

(5) Give the interpretation of the quantity $\Delta = \frac{\hbar^2}{2ma^2}$ appearing in the discussion of square well potential. Also show that the quantity $\frac{\Delta}{V}$ is dimension less.

(6) For a square well potential draw diagrams showing wave functions of odd parity with proper notations.

(7) Define non-degenerate and degenerate eigen values.

(8) What is observable?

(9) Explain adjoint operator. Also define self adjoint operator.

(10) What is isotropic oscillator? Write down expressions for its energy.

(11) Define central potential? Write down the expression for Hamiltonian of a particle moving in a central potential field.

(12) Write down expression for ∇^2 in spherical polar coordinates

Que-3 (a) Obtain Schrodinger wave equation of a free particle in one dimension. [06]

(b) Explain box normalization of a non-normalisable wave function. [04]

OR

Que-3 (a) Discuss Ehrenfest's theorem in detail. [06]

(b) Discus Heisenberg's uncertainty principle in detail. [04]

Que-4 Discuss bound states in square well potential and obtain admissible solutions of wave functions [10]

OR

Que-4 (a) Using the admissibility solutions of a square well potential graphically show that in a square well potential energy levels are finite and discrete. [10]

Que-5 (a) Discuss the physical interpretation of eigen values, eigen functions and expansion postulates. [06]

(b) Show that any two eigen functions belonging to distinct (unequal) eigenvalues of a self adjoint operator are mutually orthogonal. [04]

OR

Que-5 (a) State uncertainty principle and discuss it for quantum mechanical observables. [06]

(b) Write a detailed note on Dirac delta function. [04]

Que-6 (a) Obtain Schrodinger equation for a simple harmonic oscillator as [06]

$$\frac{d^2u}{d\rho^2} + [\lambda - \rho^2]u = 0$$

And obtain its energy eigen value as; $E = \left(n + \frac{1}{2}\right)\hbar\omega$.

(b) Discuss rigid rotator and show that $\Delta E = E_l - E_{l-1} = \frac{\hbar^2}{I_0} l \quad l = 0, 1, 2, \ldots\ldots$ [04]

OR

Que-6 (a) Obtain operator form of L^2 in terms of spherical polar coordinates [06]

$$L^2 = -\hbar^2 \left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial}{\partial\theta}\right) + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\phi^2}\right]$$

(b) For a particle moving in a central potential $V(r)$ obtain Schrödinger time independent equation as; [04]

$$\nabla^2 u + \frac{2\mu}{\hbar^2}[E - V(r)]u = 0$$

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