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[A-86] SADAR PATEL UNIVERSITY

Sixth Semester B. Sc. Examination – 2016

Monday, 28th March, -2016

Time: 2:30pm to 5:30 pm

PHYSICS: US06CPHY01 (Quantum Mechanics)

Total Marks: 70

Note: All the symbols have their usual meaning.

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

(1) According to de-Broglie hypothesis the relation between energy of a particle and frequency of associated wave is E= ________.
(a) $\hbar\nu$ (b) $h\omega$ (c) $h^2\nu^2$ (d) $h\nu$

(2) Energy momentum relation is given by $E =$ ________ .
(a) $\frac{p^2}{2m}$ (b) mv^2 (c) $\frac{1}{2}mv^2$ (d) $\frac{p}{2m}$

(3) Total probability of finding a particle in space is ___________ .
(a) zero (b) One (c) infinity (d) one third

(4) For a bound state of a particle energy E_________ .
(a) < 0 (b) $= 0$ (c) > 0 (d) $= \infty$

(5) In the time independent Schrodinger equation $Hu(x) = Eu(x)$, E is called __.
(a) heat energy (b) potential eigen value (c) energy eigen value
(d) potential

(6) Each dynamical variable in quantum mechanics is represented by _____ .
(a) a number (b) non-linear operator (c) gradient of vector
(d) linear operator

(7) Expectation value of a self adjoint operator is ________ .
(a) real (b) infinite (c) imaginary (d) always0

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

(9) Hamiltoniam operator for a simple harmonic oscillator is $H =$ _______.
(a) $\frac{p^2}{2m} + \frac{1}{2}kx^2$ (b) $\frac{p^2}{2m}$ (c) $\frac{1}{2}kx^2$ (d) $\frac{p^2}{2m} + kx$

(10) Energy eigen value of an oscillator is given by E = __________.
(a) $\hbar\nu$ (b) $n\hbar\nu$ (c) $\left(n + \frac{1}{2}\right)\hbar\omega$ (d) $\hbar\omega$

Que-2 [20]

Answer briefly **any ten** of the following questions.

(1) Explain briefly the concept of wave packet.

(2) What is normalizable wave function?

(3) State admissibility conditions for a wave function.

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

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

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

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

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

(9) Explain briefly Dirac delta function.

(10) What is a rigid rotator? State the expression for its energy level separation. What is importance of studying rigid rotator?

(11) Write down expressions of potential energy and energy eigen value of an isotropic oscillator. What is the difference between isotropic and anisotropic oscillator?

(12) Show that the x-component L_x of angular momentum L commutes with L^2.

Que-3 (a) For a free particle, obtain one dimensional Schrodinger wave equation. [06]

(b) Obtain three dimensional Schrodinger equation for a particle subjected to a force. Also discuss operator correspondence. [04]

OR

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

(b) Explain the concept of conservation of probability. [04]

Que-4 Obtain time independent Schrodinger equation and show that probability density is time independent. Also write down fundamental postulates of wave mechanics. [10]

OR

Que-4 Using the admissibility solutions of a square well potential graphically show that in a square well potential energy levels are finite and discrete. Also briefly discuss parity of eigenfunctions. [10]

Que-5 (a) Show that the eigen function belonging to discrete eigen values are normalizable and the eigen functions belonging to continuous eigenvalues are of infinite norm. [06]

(b) Discuss the physical interpretation of eigen values and eigen functions [04]

OR

Que-5 (a) Explain uncertainty principle for quantum mechanical observables and show that the product of uncertainty in observables is of the order of commutator. [06]

(b) Obtain eigen function in momentum space and discuss box normalization of this momentum eigen function. [04]

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

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

And write down an expression for its energy eigen value.

(b) Write down the expression of Hamiltonian of an anisotropic oscillator in three dimension and obtain the Schrodinger equation as [04]

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

OR

Que-6 (a) Obtain operator form of L^2in 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) Define central potential and obtain Schrodinger equation for a system of two particle moving in such a potential field. [04]

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