SEAT No. _____ NO. of Printed Pages: 2

[25]

SARDAR PATEL UNIVERSITY

Sixth Semester B. Sc. Examination -2022

Thursday 23 June 2022

Time: 10:00 to 12:00

PHYSICS: US06CPHY21 (Quantum Mechanics)

Total Marks: 70

Note: (i) All the symbol have their usual meaning.
(ii) Figure at the right side of the question indicate full marks.

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

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

(2) For a bound state of a particle energy is always _____
(a) $E < 0$ (b) $E > 0$
(c) $E = 0$ (d) infinity

(3) For the adjoint of the product of two operator A and B, $(A\,B)^{\dagger}$ = _____
(a) $B^{\dagger}A^{\dagger}$ (b) $A^{\dagger}B^{\dagger}$
(c) AB (d) 1

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

(5) Position operator in momentum space is given by r_{op} = _____
(a) $i\hbar k$ (b) $i\hbar p$
(c) $i\hbar r_{op}$ (d) $i\hbar\nabla$

(6) Kinetic energy of harmonic oscillator is _____
(a) mgh (b) $\frac{1}{2}kx^2$
(c) $\frac{p^2}{2m}$ (d) kx

(7) Zero-point energy of harmonic oscillator is _____
(a) 0 (b) $\hbar\omega$
(c) $-\frac{1}{2}\hbar\omega$ (d) $\frac{1}{2}\hbar\omega$

(8) The potential energy of hydrogen atom is _____
(a) 0 (b) $-\frac{Ze^2}{r}$
(c) $\frac{Ze^2}{r^2}$ (d) $\frac{1}{2}kx^2$

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

(10) Any wave function having symmetry property is said to be of _____ parity
(a) odd (b) zero
(c) even (d) infinite

(P.T.O.)

(1)

Q -- 2 (a) Fill the blanks [4]

(1)If A and B are a canonical conjugate pair of the operator, then [A, B] = _____

(2)If A is an operator and $A^{\dagger}$ is an adjoint operator of A then $(A^{\dagger})^{\dagger}$ = ____

(3) For E>0. the particle has a _____ kinetic energy

(4) Angular momentum is defined as L = _____

(b) State True or False required [4]

(1) Expectation value of self- adjoint operator is complex.

(2) Any particle with energy E<0 cannot enter in the region I and III

(3) For two system of interacting particle Hamilton

$$H(1,2) = H_1(1) + H_2(1)$$

(4) Time dependent Schrodinger wave equation in shorter form is given by

$$Hu = Eu$$

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

(1) Define square well potential.

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

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

(4) Define non degeneracy of eigen values.

(5) Write down expression for ∇^2 in spherical polar coordinate.

(6) Define rigid rotator. State the expression for its energy level separation.

(7) Define interacting particle.

(8) Show L_x x-component of angular momentum L commutes with L^2

(9) Set up the Hamiltonian for simple harmonics oscillator.

(10) State second postulate of quantum mechanics.

(11) Define central potential. Write Hamiltonian for a particle in central potential.

(12)What is rigid rotator? State the expression for its energy level separation.

Q -- 4 Answer any four of following questions. [32]

(1)Obtain the expression of energy eigen values for a particle in square well potential.

(2)Obtain admissible solutions of wave function for a particle in a square well potential for bound states

(3) Show that product of uncertainty in observables is of the order of commutator.

(4) Explain adjoint and self-adjoint operator. Show that any two eigen function belonging to unequal eigen values of a self-adjoint operator are mutually orthogonal.

(5) Obtain operator form of L^2 in terms of spherical polar co-ordinates

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

(6) Write Hamiltonian for simple harmonic oscillator and obtain expression for its energy eigen value.

(7) Write a note on isotropic oscillator.

(8) Derive dimensionless Schrodinger equation for hydrogen atom.

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