23P206 (Pages: 2) Name: .....

Reg.No: .....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2024

(CBCSS - PG)

(Regular/Supplementary/Improvement)

CC19P PHY2 C05 - QUANTUM MECHANICS – I

(Physics)

(2019 Admission onwards)

Time : 3 Hours Maximum : 30 Weightage

Section A

Answer ***all*** questions. Each question carries 1 weightage.

1. Explain the one-to-one-correspondence between ket space and bra space.
2. Discuss the properties associated with multiplication of operators.
3. Discuss momentum space wave function.
4. What is an energy eigen ket?
5. What is correlation amplitude?
6. Write annihilation and creation operators in terms of position and momentum operators.
7. Discuss the properties of Pauli's spin matrices.
8. Write and explain the Hamiltonian for an isotropic harmonic oscillator.

(8 × 1 = 8 Weightage)

Section B

Answer any ***two*** questions. Each question carries 5 weightage.

9. In a continuous basis, how can Dirac notations be represented? What is translation operator? What are its properties?
10. Obtain an expression for Ehrenfest's theorem.
11. Discuss the Schrodinger equation for a central potential. Derive the radial equation.
12. Discuss the spin and statistics of quantum particles. Discuss the Pauli exclusion principle based on the symmetry of the wavefunction.

(2 × 5 = 10 Weightage)

Section C

Answer any ***four*** questions. Each question carries 3 weightage.

13. Consider a system whose state is given in terms of an orthonormal set of three kets as $(|\psi\rangle = \frac{\sqrt{3}}{3}|\phi_1\rangle + \frac{2}{3}|\phi_2\rangle + \frac{\sqrt{2}}{3}|\phi_3\rangle)$. (a) Is $(|\psi\rangle)$normalized? (b) Calculate the probability of finding the system in the state $(|\phi_1\rangle)$. (c) Consider now an ensemble of (810) identical systems, each one of them in the state $(|\psi\rangle)$. If measurements are done on all of them, how many systems will be found in each of the states $(|\phi_1\rangle)$, $(|\phi_2\rangle)$, and $(|\phi_3\rangle)$.

14. Consider an operator A such that $([A, A^\dagger] = 1)$.
Evaluate the commutators (a) $([A^\dagger A, A])$ (b) $([A^\dagger A, A^\dagger])$ (c) $([A^\dagger, A])$.

15. Consider a one-dimensional particle which is confined within the region $(0 \leq x \leq a)$ and whose wave function is $(\psi(x,t) = \sin(\pi x/a) exp(-i\omega t))$. Find the potential (V).

16. A particle of mass (m), which moves freely inside an infinite potential well of length (a), has the following initial wave function at
$(t = 0)$; $(\psi(x,0) = \frac{A}{\sqrt{a}}\sin(\pi x/a) + \frac{\sqrt{3}}{5a}\sin(3\pi x/a) + \frac{1}{\sqrt{5}a}\sin(5\pi x/a))$, where (A) is a real constant. (a) Find (A) so that (ψ) is normalized. (b) If measurements of the energy are carried out, what are the values that will be found and what are the corresponding probabilities? (c) Find the wave function at a later time t.

17. Calculate the commutator between the x and y components of the orbital angular momentum operator.

18. Consider a system with total angular momentum $(j = 1)$. Evaluate the angular momentum operators (j_x), (j_y), and (j_z).

19. Discuss the connection between symmetry and degeneracy.

(4 × 3 = 12 Weightage)

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