**24P206** (Pages: 2) Name: .....

Reg.No: .....

**SECOND SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2025**

(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. What is a state ket?
2. Discuss the measurement of two operators when they are incompatible observables.
3. Discuss momentum space wavefunction.
4. What is an energy eigenket?
5. Distinguish Schrodinger picture and Heisenberg picture.
6. What is the importance of Ehrenfest theorem?
7. Write the eigenvalue equations for $J_z$ and $J^2$
8. What is the commutation relation between angular momentum and square of position and square of momentum for systems with central potentials? Discuss the physical significance.

**(8 × 1 = 8 Weightage)**

**Section B**

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

9. Discuss the concept of measurements in quantum mechanics. Define expectation value of an operator and its dependence on eigenvalues.
10. Obtain an expression for Ehrenfest's theorem.
11. Obtain the expression for the energy of a isotropic harmonic oscillator.
12. Discuss the indistinguishability principle. Discuss the symmetry of the wave function for a two particle system.

**(2 × 5 = 10 Weightage)**

**Section C**

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

13. Distinguish between inner product and outer product. With the help of matrix representation, show that they are not the same.

14. Show that if $A^{-1}$ exists, the eigenvalues of $A$ are just the inverses of those of $A$.

15. Consider a charged oscillator, of positive charge $q$ and mass $m$, which is subject to an oscillating electric field $E_0 \cos(\omega t)$; the particle's Hamiltonian is $H = P^2/(2m) + kX^2/2 + qE_0 X \cos(\omega t)$. Calculate (a) $d\langle X\rangle/dt$. (b) $d\langle P\rangle/dt$. (c) $d\langle H\rangle/dt$.

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 $\psi$ 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. Obtain an expression for the expectation value of $S_x$ for a spin half system using the concept of infinitesimal rotation.

18. If a particle is stays in an eigen state of $J_z$, prove that $\langle J_x\rangle = \langle J_y\rangle = 0$. Also find $\langle J_x^2\rangle$ and $\langle J_y^2\rangle$.

19. Show that conservation of linear momentum of a physical system is a consequence of the translational invariance of the hamiltonian of the system.

**(4 × 3 = 12 Weightage)**

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