SECOND SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2020
(CUCSS - PG)
CC17P PHY2 C05 - QUANTUM MECHANICS I
(Physics)
(2017, 2018 Admissions – Supplementary/improvement)

Time: Three Hours   Maximum:36 Weightage

Section A

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

1. Define linear vector space. How is it related to Hilbert's space?

2. Write the fundamental postulates of State of a system and probability density

3. Write a note on classical view of particle wave duality.

4. Discuss the significance of time energy uncertainty relationship.

5. Write a brief note on time evolution operator.

6. Write the equations of motion in Heisenberg picture and interaction picture.

7. Orbital angular momentum is the generator of rotation. Explain.

8. What are spinors? Show that spinors are complete and orthonormal.

9. How spherical harmonics are related to the wave functions of hydrogen atom.

10. Distinguish between symmetric and antisymmetric wave functions

11. What is slater determinant?

12. Explain the optical theorem. Why the theorem is called so?

(12 x 1 = 12 Weightage)

Section B

Answer any *two* questions. Each question carries 6 weightage.

13. What are the fundamental postulates of quantum mechanics? Explain their significance.

14. What are different pictures in quantum mechanics? Apply the Schrodinger picture to find the eigen values and eigen state of a linear harmonic oscillator.

15. Show that the wave function of a system of indistinguishable particles will be either totally symmetric or totally antisymmetric. Calculate the ground state energy of a helium atom considering it as a system of indistinguishable particles

16. Define scattering amplitude and scattering cross section. How they are related? Using partial wave analyses derive an expression for scattering cross section.

(2 x 6 = 12 Weightage)

Section C

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

17. If a particle is represented by the normalized wave function.

$$\psi(x) = \left\{ \left(\frac{\sqrt{15}(a^2 - x^2)}{4a^{\frac{5}{2}}} \right) \text{ for } -a < x < a \text{ and zero otherwise.} \right.$$

then find the uncertainty Δp in its momentum

18. If the operators A and B satisfy the commutation relation $[A, B] = I$ where I is the identity operator then find the commutator $[e^A, B]$

19. What are Chebsch-Gordon coefficients? Calculate the Chebsch-Gordon coefficients for $J_1 = \frac{1}{2}$ and $J_2 = \frac{1}{2}$.

20. The Hamiltonian for spin $\frac{1}{2}$ particle at rest is given by $H = E_0(\sigma_z + \alpha\sigma_x)$ where σ_x and σ_z are Pauli spin matrices and E_0 and α are constants. Then find the eigen values of this Hamiltonian.

21. Show that conservation of energy is a consequence of symmetry under time translation.

22. Find the scattering amplitude $f(\theta)$ for the potential $V(r) = \beta e^{-\mu r}$ where β and μ are positive constants

(4 x 3 = 12 Weightage)

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