LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

M.Sc. DEGREE EXAMINATION – **MATHEMATICS**

THIRD SEMESTER – APRIL 2010

PH 3900 - QUANTUM MECHANICS

Date & Time: 29/04/2010 / 9:00 - 12:00   Dept. No.   Max. : 100 Marks

Part – A (10 x 2 = 20 marks)

(Answer all questions)

1. What is superposition theorem in Quantum Mechanics?
2. What is meant by box normalization?
3. What are linear operators? Why are they important in quantum mechanics?
4. Show that commuting operators have simultaneous eigen functions.
5. Give any two properties of Dirac's δ-function.
6. Define degeneracy? What is meant by degree of degeneracy?
7. What happens to the transmission coefficient when the height of the potential barrier is infinity?
8. Why is the energy of a particle in a square potential well quantized?
9. Plot the potential energy curve of a linear harmonic oscillator.
10. What is the degeneracy of the state represented by the wave function
$$\Psi(\theta,\phi) = P_3^m(\cos \theta)\, e^{im\phi}$$

Part – B (4 x 7.5 = 30 marks)

(Answer any four questions)

11. a. Define probability density and probability current density. (4)
    b. Obtain the equation of continuity in Quantum Mechanics (3.5)

12. If A and B are two vectors given by $|A> = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix}$ and $|B> = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix}$, evaluate

    $<A|B>$ and $|A><B|$ and elaborate their difference.

13. a. Evaluate $\int_{-2}^{2} x^3 \frac{d^2\delta(x-1)}{dx^2}\, dx$ (4)

    b. Prove the commutation relation $[A, [B, C]] + [B, [C, A]] + [C, [A, B]] = 0$ (3.5)

14. a. Find the energy eigen values of a particle of mass 'm' confined to a box of side 'L' (4)
    b. Three electrons are confined to a box of side 0.5Au. Find the lowest possible energy of the system if electron mass is 9.1 x 10^{-31}kg and Planck's constant h= 6.63x10^{-34}Js (3.5)

15. Obtain the expression for the angular momentum operator $\hat{L}^2$ in terms of the position operator $\hat{r}$ and momentum operator $\hat{p}$

Part – C (4 x 12.5 = 50 marks)

(Answer any four questions)

16. Give a detailed account of the fundamental postulates of Quantum Mechanics.
17. Using commutator algebra, obtain Heisenberg's uncertainty relation.
18. What is quantum mechanical tunneling? Obtain an expression for the transmission coefficient for a stream of particles incident on a potential barrier of width 'a' and height V_0, such that the energy of the particles $E<V_0$
19. Define operators a and a†. Obtain an expression for the Hamiltonian of a linear harmonic oscillator using them. Also obtain the ground state eigen function of the system.
20. Solve the radial part of Schrodinger wave equation. Obtain the energy eigen values and eigen functions for Hydrogen atom.

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