St. Joseph's college of arts and sciences (Autonomous)

Cuddalore - 1

Subject : Quantum mechanics - I

Subject code : PPH807S

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Section - A

1. Write the postulates of quantum mechanics.
2. What is a commutation relation?
3. Write down the final solution of hydrogen molecule.
4. Write a short note on angular momentum operator.
5. Explain expectation value.
6. What is difference between non-degenerate and degenerate case?
7. What is WKB approximation.
8. Write the principle of Dirac's equation.
9. Explain probability density.
10. What are eigen functions and eigen values?
11. What do you mean by operator?
12. Write the short note on Hydrogen atom.
13. Write the solution of Schrodinger equation for hydrogen atom.
14. What is commutation rules?
15. Write the principle of clebesh coefficient.
16. Write a short note on WKB approximation.
17. Write the principle of Zeeman and stark effect.
18. Write the principle of klein-Gorden equation?
19. Write down dirac's equation?
20. Define the expectation value of an observable and give the relation.
21. What is meant by Hermitian Operator? Give an example?
22. Distinguish finite square well and Infinite square well.
23. What do mean by Harmonic oscillator?
24. Derive the commutation relation between x and Px.
25. Distinguish Zeeman Effect and stark effect.
26. What is meant by degenerate and Non degenerate conditions?
27. State the meaning of Probability current density with equation.
28. Write the significance of positive and negative energy states in Dirac equations.
29. Give the equation of continuity.
30. What is normalization?

31. Explain zero point energy?
32. Give quantum numbers associated with hydrogen atom.

33. What is degeneracy?
34. Distinguish degenerate and non-degenerate states.
35. Define perturbation.
36. Define Dirac matrices.
37. What is expectation value?
38. Differentiate eigen value and eigen function.
39. Explain quantum mechanical tunneling.
40. What is zero point energy?
41. Show $[J_z, J_+] = \hbar J_+$
42. State Stark effect.
43. Write the Klein-Gorden equation for a free particle.
44. Prove that $\beta^2=1$.
45. Define expectation value of an operator.
46. Prove that momentum operator is Hermitian.
47. What is the value of momentum of a particle inside the box?
48. What is one dimensional potential barrier?
49. What is triangular rule?
50. Give the value of L2 operator in spherical polar co-ordinates.
51. Define degeneracy of a system.
52. What is Zeeman effect?
53. Give the draw backs of K.G.equation.
54. What is a hole?
55. Explain the term observable.
56. What is a harmonic oscillator? Give examples.
57. Are the rigid rotator energy levels degenerate?
58. Prove that $[x,p] = i\hbar$.
59. What are Pauli's spin matrices?
60. Define degeneracy of a system.
61. Give the validity condition of Born approximation.
62. What are the draw backs of K.G equation?

Section - B

1. Explain Ehrenfest's theorems.
2. Explain equation of continuity.
3. Explain rectangular barrier.
4. Explain one dimentional problem of hydrogen atom.

5. Explain ladder operators with suitable examples.
6. Explain momentum Eigen value and Eigen function.
7. Explain stark effects and its applications.
8. Explain the removal of degeneracy.
9. Explain the Dirac's matrices. If a spineless particle at rest (l=0) decays into a pair of spin-1/2 particles, show the final state must be a superposition of 1S and 3P.
10. Explain linear operator, self adjoint operator?
11. Explain Rigid rotator?
12. Explain infinite square well and finite square well.
13. Explain eigen value spectrum.
14. Construct the 3D1 angular momentum eigenfunction for a system of two spin ½ particles in its centre of mass frame, from the relevant orbital and spin wave functions.
15. Explain perturbation theory for non-degenerate and degenerate cases.
16. Write the application of ground state of anharmonic Oscillator.
17. Explain the plane wave solution of the Dirac's equation.
18. Explain Gamma matrices and their properties.
19. State and explain the Basic Postulates of Quantum Mechanics.
20. What are Linear and self adjoint operators, explain with examples?
21. Apply Schrödinger equation to a square well and discuss the results.
22. What is meant by Rigid rotator and obtain an expression for Rotational energy of a two body system?
23. Define the Ladder operators J+ and J- and find the commutation relation between Jz with J+ and J-.
24. Obtain the Eigen values of J+ and J- and Jx and Jy.
25. Explain the basic principle of WKB approximation.
26. Describe the principle and theory of Variation method.
27. Derive the Relativistic Schrödinger equation or Klein – Gordon equation.
28. Derive Dirac relativistic equation for free particle.
29. Discuss the physical significance of the wave function ψ.
30. Solve Schrodinger's equation for a Rigid rotator.
31. Discuss the commutation rules for angular momentum.
32. Calculate Clebsch-Gordon coefficients for j1=j2=(1/2).
33. Discuss the perturbation theory for the non degenerate stationary state.
34. Write a note on the Stark effect.
35. Discuss spin as an inherent property of an electron.
36. Write a note on the negative energy states.
37. Discuss the postulates of quantum mechanics.
38. Show that the momentum operator commutes with free particle Hamiltonian operator $[\hat{H}\ p]=0$.
39. Find the height of potential barrier for α particles emitted from Radon (222 Rn 86) taking nuclear radius $r = 1.5 \times 10^{-15} A^{1/3}$.
40. Solve Schrodinger's equation for a linear harmonic oscillator.

41. Discuss the commutation rules for angular momentum.
42. Discuss the perturbation theory for the non degenerate stationary state.
43. Write a note on the Zeeman effect.
44. Describe the plane wave solutions of the Diracs equation.
45. Write a note on the negative energy states.
46. Give the probability interpretation of the wave function and show that the probability density P and the current density j satisfy the continuity equation .$\partial P/\partial t+\nabla.j=0$.
47. What is a Hermitian operator? Give their properties.
48. The quantum numbers for the particle in a box are taken to be positive. Give arguments for neglecting n= 0, -1, -2, -3 etc.
49. A particle of mass 1mg is attached to a spring of spring constant 10-3 Nm-1. Calculate its zero point energy and classical value of amplitude of zero point vibration.
50. Prove that i) $[Jz, J+]=\hbar J+$ ii) $[J2, Jz\ ]=0$
51. What are Clebsch – Gordan coefficients? Explain their significance.
52. Deduce an expression for an anharmonic oscillator.
53. The WKB method is valid for systems in which the potential is slowly varying. Why?
54. What are Dirac's matrices? Give their properties.
55. Using Dirac's energy spectrum explain the concept of negative energy.
56. State the postulates of quantum mechanics and hence derive Schrödinger's time dependent wave equation.
57. i) What is an Eigen function and Eigen value? ii) The operator for Z component of angular momentum is $L_z= -i\hbar\partial/\partial\emptyset$, determine whether or not sin mØ is its Eigen function.
58. Show that linear momentum and energy of a particle in one dimensional box is quantized.
59. Derive the energy Eigen value of a one dimensional linear harmonic oscillator.
60. Find the values of angular momentum operators in Cartesian co- ordinates.
61. Prove that the square of the angular momentum operator commutes with one of its components but the components among themselves do not commute.
62. Explain the variation principle.

Section - C

1. i) Explain Hermitian operators for dynamical variable. ii) Explain Eigen value and Eigen functions.
2. Briefly explain rigid rotator.
3. Explain Clebesh Gorden co-efficients.
4. Explain application to ground state of anharmonic oscillator and explain variation methods.
5. Explain positive and negative energy state and Dirac's explanation.
6. Explain Hermitian Operator principle and Operator for dynamic variable.
7. Solve the harmonic oscillater problem by Schrodinger equation. Explain L2 Operators, Ladder operators with examples.
8. Briefly explain Hydrogen molecule?
9. Explain klein – Gorden equation and probability density.

10. Discuss the Problem of one dimensional Harmonic Oscillator by operator method and draw the diagram of wave function and energy atleast three levels.
11. Explain the addition of angular momenta and obtain the expression for Clebsch Gordon Coefficients.
12. Discuss the theory and principles of Non – Degenerate Perturbation theory. Briefly discuss the Dirac Free particle solutions or Plane wave solutions.
13. (a) Discuss the postulates of quantum mechanics (b) Show that the momentum operator commutes with free particle Hamiltonian operator $[\hat{H}\ p]=0$.
14. Obtain Schrodinger equation for spherically symmetric case of three dimensional harmonic oscillator.
15. a) Describe the operators. b) Explain the L2 operators eigen value and eigen function.
16. Discuss in detail the following: a) Zeeman effect b) WKB approximation.
17. Explain the Klein – Gordon equation in the presence of electromagnetic field.
18. State the Schrodinger's equation for a hydrogen atom and discuss the significance of various quantum numbers.
19. Derive the Clebsch-Gordon coefficients for addition of angular momentum.
20. Discuss in detail the W.K.B approximation and its validity.
21. (a) Discuss spin as an inherent property of an electron (b) Obtain Dirac's equation covariant form .
22. Arrive the energy Eigen value and Eigen function of a rigid rotator.
23. Starting from commutation relation, derive the Eigen values of operators J2 and Jz where J2 and Jz represent the square and the Z component of the angular momentum operator.
24. Give the theory of first order Stark effect on the basis of quantum mechanics and discuss the splitting of the energy level.
25. Use Dirac's equation to show that the electron is endowed with spin ½.
26. Solve radial part of Schrödinger's equation of hydrogen atom obtaining its energy levels and wave function.
27. Evaluate the C.G coefficients for a system having j1=1/2 and j2=1/2.
28. Give the perturbation theory for a degenerate case and discuss the normal Zeeman effect.
29. Give the energy spectrum of a free Dirac particle and explain pair production and pair annihilation.