Anekant Education Society's

TULJARAM CHATURCHAND COLLEGE

OF ARTS, COMMERCE AND SCIENCE, BARAMATI

DEPARTMENT OF PHYSICS

Subject-Quantum Mechanics [PHY4103]

Question Bank

M.Sc-I

1) Optimize the trial wave function exp(-αr) and evaluate the ground state of Hydrogen atom .

2) Estimate ground state energy of 1D harmonic oscillator of mass M and angular frequency ω using Gaussian trial wave function $\phi = A \exp(-\alpha x^2)$

3) Write the requirements of wave function.

4) Define operator and explain different operator in quantum mechanics.

5) Write down the equation of continuity and its physical significance.

6) Write a short note on eigen value and eigen function

7) Explain the term expectation value and probability density and normalization condition

8) Find wave function of particle in one dimensional box having length a.

9) Write a note on barrier penetration and tunneling effect also write its application.

10) Write down the application of quantum mechanics in real life

11) Using ground state function of a simple harmonic oscillator show that ground state energy is....

12) Using ground state wave function of simple harmonic oscillator find the $<x>$,$<x^2>$ and $<P_x>$.

13) What is the probability amplitude?

14) Write the postulate of quantum mechanics.

15) Prove that.

$[Lx, Ly] = i\hbar Lz$ and $[Lz, Lx] = 0$

16) By using Pauli's matrices prove that,

i)$[\sigma x, \sigma y] = 2i\hbar\sigma x$ and ii) $[\sigma x, \sigma y\sigma z] = i$

17) Write and explain the general uncertainty relation.

18) Write a note on Dirac's- Delta function.

19) Write a note on degeneracy and find the degeneracy of particle in 2D and 3D box

20) If X and P_X are co-ordinate and Momentum operator prove that,

$[x, p^n]$=ni$\hbar P^{n-1}$ Type equation here.

21) For angular momentum component Lx and Ly check whether LxLy+LyLx is Hermitian.

22) Write down de Broglie hypothesis and prove that $\lambda=h/p$

23) Write the relation between wave packet ,phase velocity and group velocity

24) Define wave packet ,phase velocity and group velocity

25) Write a note on a) Photoelectric effect

b) Black body radiation

c) Compton effect

26) prove that eigen value of Hermitian operator is unique.

27) Prove the following relations,

a) $[A, B]= -[B, A]$ b) $[A, B + C]= [A, B]+ [A, C]$ c) $[A, B]$=B $[B, A]$ B

28) If X and Px are the co-ordinate and momentum operator, prove that $[X, Px]=$ ni$\hbar P^{n-1}$

29) By using operator method find $\langle x\rangle$,$\langle x^2\rangle$ and $\langle P_x\rangle$.

30) Calculate the the C-G coefficient for ,

$j_1=1/2$ and $j_2=1/2$

31) For particle of mass M moving in the potential V

V(x)=kx where x>0 and V(x)=œ where x<0

Where K is a constant. optimize the trial wave function $\boldsymbol{\Phi}$=x exp(-αx) where a is the variable parameter and estimate the ground state energy of system .

32) A Quantum system is given by

find the probability and also find the average energy of system.

33) Given wave function $\Psi=1/\sqrt{7}\ (\sqrt{2}\ \Psi_1+\sqrt{3}\ \Psi_2+\Psi_3+\Psi_4)$ and $H\Psi_n=n^2\varepsilon_0\Psi_n$ Find the average energy E.

34) Show that by using WKB $\lambda dv/dx\ /4\pi(E-V) <1$

35) Using perturbation theory write a expression of Zeeman effect.

36) Consider a Quantum system of wave function $\Psi =$ $i/\sqrt{3}\ \Psi_1+\sqrt{2}/\sqrt{3}\ \Psi_2$

Where Ψ_1 and Ψ_2 are ground state wave function and first excited state of 1-D box find the average value of energy.

37) Consider particle of mass M moving in 1-D potential specified by

$V(x)=0$,$-2a<x<2a$ and $V(x)=\infty$ otherwise

find the energy eigen values and eigen functions .

38) The wave function of a particle confined in a box of length 'a' is $\Psi(x) = \sqrt{1/a}\sin(\pi x/a)$ $0 < x < a$

Calculate the probability of finding the particle in a region.

39) For n^{th} state of a linear harmonic oscillator calculate uncertainty product ($\Delta X \Delta P$)

40) Show that zero point energy of linear harmonic oscillator$1/2\ \hbar\omega$ is manifestation of the uncertainty principle.

41) Consider the Hamiltonian of a system is given by $H=P_x^{\ 2}/2m + V(x)$ the value of d^2/dx^2 $<x>$ is.

42) For the potential trapped in a potential well $V(x)=0$,$-a/2<x<a/2$ and $V(x)=\infty$ otherwise find the ground state energy and eigen functions are.

43) A simple harmonic oscillator mass M and angular frequency w is perturbed by an additional potential bx^3 evaluate the second order correction to the ground state of oscillator.

44) Find the first order energy correction of a simple harmonic oscillator at $H^I=bx$

45) Find the first order energy correction of a simple harmonic oscillator at $H^I=bx^2$

46) Find the first order energy correction of a simple harmonic oscillator at $H^I=bx^4$

47) What is perturbation? Explain time Dependent perturbation theory.

48) Explain Fermi-Golden rule.

49) What is mean by perturbation theory? Explain second order perturbation.

50) Write the expression for validity of WKB approximation.

51) Explain time independent perturbation theory for or non-degenerate case.

52) Explain time independent perturbation theory for degenerate case.

53) Write the expression for time dependent perturbation theory and explain first order

Transition amplitude.

54) Write the expression for time dependent perturbation theory and explain second order transition amplitude.

55) Explain Bohr's Sommerfield quantization condition.

56) Write the principle of WKB method and explain it.

57) Give the perturbation theory for degenerate case and discuss the normal Zeeman Effect

58) Give the stationary perturbation theory for degenerate case and use it to explain the first order stark effect in Hydrogen atom.

59) Describe WKB approximation method and give an any one application of this method .

60) Give the time dependent perturbation for harmonic perturbation.

61) Write note on a) Fermi golden rule.

b)WKB approximation .

62) Write a principle of variation method..

64) Find out the ground state of a simple harmonic oscillator by using variable method .

65) Find out the ground state of hydrogen atom by using variation method.

66) Find out the ground state of Helium atom by using variation method.

67) What is operator and give its types of operator.

68) Write note and probability interpretation of Ψ .wright orthonormality condition..

69) Define direct Delta function and represent it graphically.

70) State connection formula for WKB approximation .

71) Explain completeness property and prove through closer relation.

72) Write a note on degeneracy and find the degeneracy of particle in 1D, 2D and 3D harmonic oscillator.

73) Find the Eigen value and eigen function of L^2 and Lz operator .

74) Find Eigen value and Eigen function of momentum operator.

75) Write Postulate of quantum mechanics.

76) Define adjoint of an operator 'a' and Hermitian operator

77) Prove that $(AB)^+=A^+B^+$

78) Workout the Eigen values and Eigen functions of the matrix. $\begin{matrix} 1+\varepsilon & \varepsilon \\ \varepsilon & 1+\varepsilon \end{matrix}$

79) State and explain Fermi golden rule.

80) What is mean by degeneracy? Give one example.

81) Using variational method find the ground state energy of harmonic oscillator.

82) Write the principle and application of WKB approximation..

83) Find the value of constant B that makes $\exp(-ax^2)$ and eigen function of the operator $(d^2/dx^2 - Bx^2)$

What is the true corresponding Eigen value.

84) Prove that the eigen values of each Hermitian operator is real.

85) Show that the momentum operator $-i\hbar\ (d/dx)$ is Hermitian.

86) State and prove orthogonal condition through uncertainty relation for energy and time

87) State expansion theorem.

88) What do you mean by inner product?

89)What is Scmidths's orthogonalization method?

90)The raising operator and lowering operator of harmonic oscillator satisfy the relations,

$a|n\rangle=\sqrt{n}\,|\,n-1\rangle$, $a^{+}|n\rangle=\sqrt{n+1}\,|\,n+1\rangle$, n= 0,1,2…….obtain the matrices for a & a^{+}

91) The ground state wave function $\Psi_0(x)=A\exp\left(-\frac{m\omega x^2}{2\hbar}\right)$

Where A is constant. Using the raising and lowering operators, obtain the function of the first excited state of the harmonic oscillator.

92) State the matrices that represent the x,y,z components of the spin angular momentum vectore S and obtain their eigen values and eigen vectors .

93) For 1-D harmonic oscillator, using creation and annihilation operators, show that

$(\Delta X\Delta P) = (n+1/2)\,\hbar$

94) For 1-D harmonic oscillator, using creation and annihilation operators,

$[a, a+]=1$ and $[a, H]=\hbar\omega a$

95) For 1-D harmonic oscillator, using creation and annihilation operators

$aa^{+}=H/\hbar\omega - 1/2$

96) A simple pendulum of length l swings in a vertical plane under the influence of gravity. In the small angle approximation, find the energy levels of the system.

97) Calculate the de Broglie wavelength of an electron having a kinetic energy of 1000 eV. Compare the result with the wavelength of x-Ray having the same energy.

98)Determine the de Broglie wavelength of an electron that hs been accelerated trough a potential difference of a)100 V b)200 V

99) The operator J_+ and J_- are defined by $J_+ =J_x+iJ_y$ and $J_- =J_x+iJ_y$, where J_x and J_y are the x and y component of the general angular momentum J. Prove that

$J_+\,Ij,m\rangle= [j(j+1)-m(m+m)]^{1/2}\hbar\;\; Ij,m+1\rangle$

100) The operator J_+ and J_- are defined by $J_+ =J_x+iJ_y$ and $J_- =J_x+iJ_y$, where J_x and J_y are the x and y component of the general angular momentum J. Prove that

$J_-Ij,m\rangle= [j(j+1)-m(m-m)]^{1/2}\hbar\;\; Ij,m-1\rangle$