STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086.
(For candidates admitted during the academic year 2004-05 & thereafter)

SUBJECT CODE : **PH/MC/QM64**

B.Sc. DEGREE EXAMINATION APRIL 2009
BRANCH III - PHYSICS
SIXTH SEMESTER

REG. No._____

COURSE : **MAJOR – CORE**
PAPER : **QUANTUM MECHANICS**
TIME : **30 MINS.** MAX. MARKS : 30

SECTION – A

TO BE ANSWERED IN THE QUESTION PAPER ITSELF

ANSWER ALL QUESTIONS: (30 x 1 = 30)

I CHOOSE THE CORRECT ANSWER:

1. Any _____ particle has wave nature associated with it.
   a) charged b) moving c) tiny

2. If the momentum of two particles are in the ratio 1: 0.5, their de Broglie wavelengths will be in the ratio
   a) 2:1 b) 1:2 c) 4:1

3. The product of uncertainties of energy and _____ is equal to or greater than $\hbar/2$
   a) position b) angle c) time

4. A wave function is said to be normalized if
   a) $\int \psi^* \psi d\tau = 0$ b) $\int \psi^* \psi d\tau = 1$ c) $\int \psi^* \psi d\tau = \infty$

5. Which of the following is an admissible wave function?
   a) y^2 b) $e^{|x|}$ c) A $\sin \alpha x$

6. The product of two _____ Hermitian operators is Hermitian
   a) singular b) non commuting c) commuting

7. Unitary operator is the one for which its adjoint is equal to
   a) itself b) its inverse c) its complex conjugate

8. The probability of a particle tunneling through a potential barrier
   a) decreases with mass b) increases with mass c) independent of its mass

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9. The binding energy of an electron must be
   a) positive b) negative c) zero

10. The spacing between the energy levels of a linear harmonic oscillator is
    a) $h\nu$ b) $\frac{1}{2} h\nu$ c) zero

11. The zero point energy in eV of an oscillator with a period of 1 second is
    a) 2.07×10^{-15} b) 3.2×10^{-34} c) 2.07×10^{-15}

12. A _____ is an example of a spherically symmetric system.
    a) particle in a box b) LHO c) rigid rotator

13. The n^{th} energy level of Hydrogen atom is _____ fold degenerate.
    a) n b) n^2 c) 2n + 1

14. Eigen functions of Hermitian operators belonging to different eigen values are _____
    a) normalized b) orthogonal c) orthonormal

15. $[L_x, L_y] =$ _____
    a) $i\hbar$ b) 0 c) $i\hbar L_z$

II STATE WHETHER TRUE OR FALSE:

16. Hamiltonian operator is a Hermitian operator.

17. Planck's constant is a number without dimension.

18. The expectation value of momentum is given by $-i\hbar\partial\psi/\partial x$

19. There is no reflection of a particle approaching a potential step with E>Vo.

20. $[x, p_x]=[p_x, x]$

III FILL IN THE BLANKS:

21. A free particle moves in a region of constant _____.

22. A wave has phase velocity but a wave packet has _____ velocity.

23. The average result of a number of measurements made on a system is known as _____.

24. Quantum states with the same energy are said to be _____.

25. The eigen values of the parity operator are _____.

IV ANSWER THE FOLLOWING:

26. What are canonically conjugate variables?

27. Give the conditions for a set of functions to be orthogonal.

28. Comment on the zero point energy of a linear harmonic oscillator.

29. Write down Schrödinger equation for a linear harmonic oscillator.

30. What are ladder operators?

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SECTION – B

ANSWER ANY FIVE QUESTIONS: (5 x 5 = 25)

1. The average kinetic energy of a thermal neutron is (3/2)kT. Determine the deBroglie wavelength associated with the neutron in thermal equilibrium at 350K. (Boltzmann constant = 1.38×10^{-23} J/Kelvin).

2. An oil drop of mass 2×10^{-12}g is floating on the surface of a liquid. Its position at any instant can be determined with a probable error of 10^{-6}m. Calculate the uncertainty in the value of its velocity.

3. Normalize the wave function e^{-x}, for $0 < x < 1$.

4. Calculate the first three permitted energy levels in eV, for an electron in a cubical box of side 3Å.

5. An electron with energy 10 eV moves towards a potential step of height 4 eV. Find the coefficients of transmission and reflection of the electron when it strikes the potential step.

6. The energy of a linear harmonic oscillator in its second excited state is 1.5 eV. Determine its frequency of vibration.

7. Show that the momentum operator $\left(\hbar/i\right)\partial/\partial x$ is Hermitian.

SECTION – C

ANSWER ANY THREE QUESTIONS: (3 x 15 = 45)

8. Obtain an expression for de Broglie wavelength. Describe Davisson and Germer experiment and discuss its results.

9. State and explain the uncertainty principle. Discuss any two consequences of the uncertainty principle.

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10. A particle in a 1-D box is restrained by reflecting walls at x = 0 and x = L. Solve the Schrödinger's equation for this system and obtain the energy eigen value and eigen function. Indicate graphically the first three wave functions.

11. Arrive at the expression for the tunneling probability for a particle through a finite potential barrier. Give any one example of barrier penetration by particles.

12. Obtain the commutation relations between the following pairs of operators.
(i) momentum and free particle Hamiltonian operator (ii) L^2 and L_x
(iii) L_+ and L_- .

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