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 2008
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. For a non-relativistic free particle, the phase velocity is _____ the group velocity.
   a) equal to b) half c) twice

2. The wavelength of an electron accelerated by a potential of 10^2 volts is
   a) 12.28 Å b) 122.8 Å c) 1.228 Å

3. The average time of an electron remaining in an excited state in an atom is 10^{-8}sec. If this the uncertainty in the measurement of time, the uncertainty in energy is
   a) 5.6eV b) 6.59×10^{-8} eV c) 1.05 eV

4. The wave function describing a physical system
   a) should be continuous b) can have many values c) should be real

5. In Quantum Mechanics, the operator for p_x^2 is
   a) $\hbar^2 \partial^2/\partial x^2$ b) $-\hbar^2 \partial^2/\partial x^2$ c) $-i\hbar \partial/\partial t$

6. The energy of a particle in a bound system are
   a) continuous b) discrete c) positive

7. For a particle encountering a potential barrier, the sum of reflection and transmission coefficients is always
   a) zero b) less than 1 c) 1

8. The eigen functions of a Hermitian operator belonging to _____ eigen value(s) are orthogonal
   a) same b) distinct c) continuous

..2

9. A beam of particles with energy $E>V_0$, impinges on a potential step of height V_0. The particles will be
   a) transmitted only
   b) reflected only
   c) reflected or transmitted

10. The tunneling of a particle through a potential barrier can be explained only on the basis of
    a) the uncertainty principle
    b) dual nature of matter
    c) dual nature of waves

11. If the ground state energy of a cubical box is 2eV, the energy of the particle in the first excited is _____ eV.
    a) 4 b) 6 c) 8

12. The commutator of position and momentum operators is
    a) 0 b) $-i\hbar$ c) $-\hbar$ /I

13. The zero point energy of a linear harmonic oscillator is
    a) zero b) ½ hv c) hv

14. The wave function for a rigid rotator consists of
    a) Legendre polynomial
    b) Hermite polynomial
    c) Laguerre polynomial

15. Unitary operator is the one whose adjoint is equal to
    a) the identity operator b) the operator itself c) its inverse

II STATE WHETHER TRUE OR FALSE:

16. The group velocity of a wave packet associated with a moving particle is greater than the particle velocity.

17. Canonically conjugate pairs of variables can not be measured to the same level of accuracy simultaneously.

18. The operator for linear momentum need not be Hermitian.

19. The function $\psi = e^{|x|}$ is an acceptable wave function in Quantum mechanics.

20. In quantum mechanical tunneling process, the energy remains conserved.

III FILL IN THE BLANKS:

21. Stationary state is the one in which _____ is independent of time.

22. The Hamiltonian for a free particle is _____.

23. If Ψ is an normalized wave function, the expectation value of velocity is given as _____.

24. The potential of a linear harmonic oscillator is _____.

25. _____ is an example of a rigid rotator.

IV ANSWER THE FOLLOWING:

26. State Heisenberg's uncertainty principle.

27. Why should the wave function be finite everywhere?

28. Give the condition for a set of functions to be mutually orthogonal.

29. What is a linear operator?

30. What is 'quantum tunneling'?

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SECTION – B

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

1. Electrons of energy 60eV fall on the lattice planes of a crystal and give Bragg reflection in the first order. If the lattice spacing of the crystal is 0.91 Å, calculate the glancing angle at which the electrons must be incident.

2. The uncertainty in velocity is given to be 10 m/sec. Calculate the uncertainty in the position of a) an electron b) a 20 gm bullet. Comment on you result.

3. The width of a spectral line of wavelength 6000 Å is measured as 0.012 Å. Find the average time for which the system remains in the corresponding energy state.

4. Determine the degree of degeneracy of the energy level $38\pi^2 \hbar^2/2mL^2$ of a particle of mass 'm' in a cubical box of side 'L'.

5. Calculate the probability of transmission for a 3MeV proton through a 6 MeV high and 2 x 10^{-14}m thick rectangular potential barrier.

6. Calculate the zero point energy of a system consisting of a mass of 1 gm connected to a fixed point by a spring which is stretched to 1 cm by a force of 10^5 Newtons. The particle is restricted to move in one direction only.

7. Obtain the commutation relation between any two components of angular momentum.

SECTION – C

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

8. State de Broglie's postulates. Describe Davission and Germer's experiment and explain its results.

9. Establish Schrodinger's time independent equation. Comment on 'probabilistic interpretation' and 'normalization' of the wave function.

10. Solve Schrödinger's equation for a particle in a 1-D box with impenetrable walls at x = 0 and x = a and obtain its energy eigen functions. Show that the energy levels of this system are discrete.

11. Write down the radial part of the time independent Schrödinger equation for the hydrogen atom and find the relation between the energy levels E_n and the principal quantum number, n.

12. Discuss the properties of Hermitian operators. Evaluate a) $[x^n, p_x]$ and b) $[L_z, L_{\pm}]$.