STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086.
(For candidates admitted during the academic year 2011-12 & thereafter)

SUBJECT CODE : 11PH/MC/QR64

B.Sc. DEGREE EXAMINATION APRIL 2015
BRANCH III - PHYSICS
SIXTH SEMESTER

REG. No._____

COURSE : MAJOR – CORE
PAPER : QUANTUM MECHANICS AND RELATIVITY
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. The de Broglie wavelength of a molecule of thermal energy KT is given by
   (a) h/√2mKT (b) h/2mKT (c) h√2mKT (d) 1/h√2mKT

2. In Davisson and Germer experiment the angle between incident beam and diffracted beam is called _____.
   (a) angle of diffraction (b) angle of incidence (c) co-latitude (d) glancing angle.

3. The group velocity v_g with which a wave packet moves is
   (a) $v_g = d\omega/dk$ (b) $v_g = c$ (c) $v_g = c/2$ (d) $v_g = c/8$

4. If two operators A and B are hermitian, then their product (AB) is also hermitian, if and only if A and B
   (a) commute (b) do not commute (c) are non-zero (d) associate

5. Which one is not an example of potential barrier penetration:
   (a) emission of α -particle in the decay of radio-active nuclei.
   (b) periodic inversion of ammonia molecule.
   (c) tunnel diode as a switch.
   (d) free particle motion.

6. The general solution for a particle in a one dimensional box is
   (a) ψ = A sin kx+ B cos kx (b) ψ = A sin kx / B cos kx
   (c) ψ = A cos kx / B sin kx (d) ψ = A cos kx

7. Which one is correct?
   (a) $[L^2,L]=0$ (b) $[[L^2,L]=1$ (c) $[L^2,L_z]=1$ (d) $[L^2,L_x]=1$

8. The potential energy (V) of the electron having charge e in the hydrogen atom of r is
   (a) $V= e^2/r$ (b) $V= - e^2/r$ (c) $V= 4 e^2/r$ (d) $V= - 4e^2/r$

9. -The wave function Ψ_m and Ψ_n $(m \neq n)$ will be orthogonal if
   (a) $\int \psi_m^* \psi_n \, dt = 1$ (b) $\int \psi_m^* \psi_n \, dt = 0$
   (c) $\int \psi_m^* \psi_n \, dt = \infty$ (d) $\int \psi_m^* \psi_n \, dt =$ some finite value

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10. The relativistic mass of a particle is twice its rest mass, what is the ratio of its speed to that of light.
    (a) $\sqrt{3}/2$ (b) $1/\sqrt{2}$ (c) 1/2 (d) 1/4

11. Which is invariant under Lorentz transformation?
    (a) line element (b) area element
    (c) 3-D volume element dxdydz (d) time element

12. An inertial frame is
    (a) accelerated (b) decelerated
    (c) un accelerated (d) may be accelerated or unaccelerated

13. A young lady of 25 years starts running at relativistic speed v ,then she would appear to her stationary friend as
    (a) thin and younger (b) fat and older (c) fat and younger (d) thin and older

14. How will a square object moving with relativistic speed 0.6c appear to a stationary observer?
    (a) square (b) rectangle (c) triangle (d) circular

15. Which of the quantities is invariant under special theory of relativity
    (a) mass (b) momentum (c) time (d) acceleration.

II Fill in the blanks:

16. In Davisson and Germer experiment the angle at which the incident beam makes with the normal to the nickel crystal is ----------.
17. The ground state energy of a linear harmonic oscillator is----------.
18. An operator is said to be Hermitian operator if it satisfies the condition----------.
19. An elevator falling freely under the action of gravity is a ---------- frame of reference.
20. In momentum-four vector, the fourth component is ----------.

III State whether true or false:

21. Electrons are particles that do not show wave-like behaviour.
22. Operator form of time dependent Schroedinger's equation is $H\Psi = E\Psi$
23. The fundamental commutation relation in quantum mechanics is $[x,p_x] = 0$
24. The stationary ether hypothesis cannot explain the results of Michelson-Morley experiment.
25. In pair annihilation energy is converted to mass.

IV Answer briefly:

26. What do you mean by wave – particle duality Explain?

27. Give the physical significance of wave function.

28. What are eigen values and eigen functions?

29. Had Michelson Morley experiment given a positive result ,what would it have implied?

30. Give the equivalence between mass and energy. What is its importance?

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TIME : 2 ½ HOURS MAX. MARKS : 70

SECTION – B

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

1. Derive an expression for the relationship between particle velocity and group velocity.
2. Find the lowest energy of an electron confined to move in 1-D potential box of length1°A.
3. Write down the eigen values of operators L^2 and L_Z.
4. The lifetime of a μ-meson is $2.2x10^{-6}$sec when measured at rest. How far will it travel before decaying if its speed is 0.99c when it is created?
5. The speed of light in water is 3c/4 .Does this result violate the postulate of relativity? Why?
6. Discuss variation of mass with velocity. What are its consequences?
7. Obtain Schrodinger's time independent wave equation for matter waves and give its physical significance.

SECTION – C

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

8. What are matter waves? Describe an experiment in support of the existence of matter waves. Discus the results of the experiment.
9. Solve the linear harmonic oscillator problem quantum mechanically.
10. Using the ideas of separation of variables, explain how one arrives at the radial part of the Schrödinger's equation for a hydrogen.
11. Describe the Michelson –Morley experiment and explain the significance of the negative result.
12. Derive Lorentz transformation equations and show that when v<< c ,it tends to Galilean transformation. Discus the concept of relativity of simultaneity.

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