STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086
(For candidates admitted during the academic year 2019-2020 & thereafter)
SUBJECT CODE :19PH/MC/QR64
B.Sc. DEGREE EXAMINATION APRIL 2023
BRANCH III - PHYSICS
SIXTH SEMESTER

COURSE : MAJOR – CORE
PAPER : QUANTUM MECHANICS AND RELATIVITY
TIME : 3 HOURS
MAX. MARKS :100

SECTION – A

ANSWER ALL QUESTIONS: 25 MARKS
I CHOOSE THE CORRECT ANSWER: (10 X 1 = 10)

1.The velocity of matter waves is
a) greater than electromagnetic wave b) not constant
c) lesser than electromagnetic wave d) constant

2. Of the following particles moving with the same momentum, the particle with the largest wavelength is _____
a) proton b) α-particle
c) electron d) all have the same de Broglie wavelength.

3. Schrodinger equation is a _____ form of equation.
a) Linear b) Partial differential
c) Non linear d) Both a and b

4.Which of the following statement is correct for a particle in a 3-dimensional box
a) The energy levels are evenly spaced b) Ground state energy is zero.
c)The second excited state is 3-fold degenerate d) The third excited state is non-degenerate

5. The quantum mechanical operator for the momentum of a particle moving in one dimension is given by
a) $i\hbar\frac{d}{dx}$ b) $-i\hbar\frac{d}{dx}$
c) $i\hbar\frac{\partial}{\partial t}$ d) $-\frac{h^2}{2m}\frac{d^2}{dx^2}$

6. Which of the following commutation relations is NOT CORRECT
a) $[L^2, L_z] = 0$ b) $[L_x, L_y] = i\hbar L_z$
c) $[L_x, L_+] = \hbar L_+$ d) $[L_z, L_-] = \hbar L_-$

7. According to the special theory of relativity, physical laws are the same in frames of reference which
a) move at uniform velocity b) accelerate
c) move in circles. d) none of the above.

8. The term "relativistic" refers to effects that are
a) observed when speeds are near the speed of light. b) noticed about a moving object.
c) observed when objects move backward in time. d) measured by stationary observers only

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9. A clock in a moving reference frame, compared to an identical clock in a stationary reference frame, appear to run
   a) slower b) at the same rate
   c) faster d) backward in time

10. As the speed of a particle approaches the speed of light, the momentum of the particle.
   a) Increases b) Decreases
   c) Remains the same d) Approaches zero

II. FILL IN THE BLANKS (5 x 1 = 5)

11. The superposition principle is the idea that a system _____
12. For a particle inside a box, the energy of the particle is directly proportional to the _____ of the quantum state in which the particle currently is.
13. Eigen functions of a Hermitian operator are _____if they have different eigenvalues.
14. The purpose of the Michelson-Morley experiment was to detect possible motion of the _____ relative to _____.
15. The mass of a 2MeV electron is _____kg.

III. SHORT ANSWER: (5 x 2 =10)

16. State Heisenberg uncertainity principle.
17. What is the difference between a wave function and a probability density function in Schrödinger's equation?
18. What is the difference between Hermitian and Hamiltonian operator?
19. State the postulates of Special Theory of Relativity.
20. Obtain the relation between momentum and energy

SECTION - B

ANSWER ANY FIVE QUESTIONS: (5 x 6 = 30)

21. Compute the de Broglie wavelength of a proton whose kinetic energy is equal to the rest energy of an electron. Mass of proton is 1836 times that of electron.

22. Calculate the zero-point energy for a particle in an infinite potential well for an electron confined to a 1nm atom.

23. Evaluate the following commutation relations.
   (a) $[L_+, L_-]$
   (b) $[L^2, L_+]$

24. Give a brief account on Galilean Transformations.

25. Derive Einstein's mass energy relation.

26. Find the probability that a particle in a one-dimensional box of length *L* can be found between 0.49 L to 0.51 *L* for the ground state.

27. How fast would a rocket have to go relative to an observer for its length to be contracted to 99 percent of its length at rest.

SECTION - C

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

28. (a) Describe Davisson-Germer experiment and interpret its results.
    (b) By applying Heisenberg's uncertainty principle explain the existence of protons inside the nucleus.

29. (a) Derive Schrodinger's time independent wave equation.
    (b) Explain degenerate and non-degenerate states with example.

30. (a) Define a parity operator and establish the commutation relation between the Hamiltonian and parity operator.
    (b) Prove that Hermitian operator has real Eigen value. Show that the momentum operator is Hermitian.

31. (a) What are inertial and non-inertial frames.
    (b) Explain the Michelson – Morley experiment.

32. (a) Derive Lorentz space-time transformation equations.
    (b) Discuss the experimental verification of length contraction and time dilation.

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