Reg. No .................... Name .............................. **21P2019**

# M. Sc DEGREE END SEMESTER EXAMINATION - JULY 2021

## SEMESTER 2 : PHYSICS

COURSE : **16P2PHYT06 : QUANTUM MECHANICS -1**

*(For Regular - 2020 Admission and Supplementary 2019/2018/2017/2016 Admissions)*

Time : Three Hours Max. Marks: 75

## PART A
### Answer All (1 mark each)

1. The matrix representation of S₋ is
   a $\hbar\begin{pmatrix}0 & 1\\ 0 & 0\end{pmatrix}$ b) $\hbar\begin{pmatrix}0 & 0\\ 1 & 0\end{pmatrix}$ c) $\hbar\begin{pmatrix}0 & 1\\ 0 & 0\end{pmatrix}$ d) $\hbar\begin{pmatrix}1 & 0\\ 0 & 0\end{pmatrix}$
2. If $a$ is an annihilation operator then $a|0\rangle =$
   a) $|0\rangle$ b) 0 c) $|1\rangle$ d) a
3. The canonical commutation relation, [H,N], between the Hamiltonian (H) and the number operator (N) of a quantum mechanical simple harmonic oscillator is
   a) 1 b) $a^{+}$ c) a d) 0
4. If $\sigma_x$, $\sigma_y$ and $\sigma_z$ are the Pauli matrices
   a) $\{\sigma_i, \sigma_j\} = 2\delta_{ij}$ b) $\{\sigma_i, \sigma_j\} = \delta_{ij}$ c) $\{\sigma_i, \sigma_j\} = 2$ d) $\{\sigma_i, \sigma_j\} = 0$
5. In WKB approximation the first power of $\hbar$ gives
   a) The classical result b) quantum result c) the connection formulae d) e/m ratio

**(1 x 5 = 5)**

## PART B
### Answer any 7 (2 marks each)

6. Give the significance of momentum representation.
7. What are Abelian and non - Abelian groups give examples
8. Prove that the expectation value of an anti-Hermitian operator is purely imaginary.
9. Write down the properties of the time evolution operator.
10. Sketch graphs of $\psi(x)$ and $|\psi(x)|^2$ for the first excited state of the one-dimensional simple harmonic oscillator.
11. Write and explain the transition amplitude in Schrödinger picture and the Heisenberg picture.
12. Write down the Pauli spin matrices
13. Write down the commutation relation between $L^2, L_x, L_y$ and $L_z$.
14. Explain the principle of variational method.
15. Explain briefly the principle of time independent perturbation theory.

**(2 x 7 = 14)**

## PART C
### Answer any 4 (5 marks each)

16. What are unitary equivalent observables. Show that these observables have the same eigen values.
17. The normalized wavefunction of a particle is $\Psi(x) = Ae^{iax-ibt}$, where A, a and b are constants. Evaluate the uncertainity in its momentum.
18. Obtain the expression for the time evolution operator in Schrodinger picture.
19. Show that even if a particle is well localized in space at time t=0, its position becomes more and more uncertain with time.
20. What are ladder operators? Why are they called so?

21. Estimate the ground state energy of a Harmonic oscillator of mass m and angular frequency $\omega$ using a Gaussian trial wave function $\phi(x) = Ae^{-\alpha x^2}$ where A and $\alpha$ are constants.

**(5 x 4 = 20)**

## PART D

**Answer any 3 (12 marks each)**

22.1. What are the properties of the infinitesimal translation operator? Show that $1 - iK \cdot dx'$ can be used to represent the infinitesimal translation operator and hence derive the commutation relation between momentum and position operators.

**OR**

2. Obtain the eigen kets and eigenvalues of a simple harmonic oscillator.

23.1. Obtain the fundamental commutation relations of angular momentum operators.

**OR**

2. Obtain the eigen values and eigen kets of the angular momentum operators $J^2$ and $J_z$.

24.1. Discuss the first order time independent perturbation theory for non degenerate stationary case. Obtain the corrected eigenvalues and Eigen vectors.

**OR**

2. Discuss the WKB approximation method and explain the validity criterion.

**(12 x 3 = 36)**