UNIVERSITY OF GUJRAT
A WORLD CLASS UNIVERSITY

(Physics)

(M.A/M.Sc Part-I)

Quantum Mechanics

Roll No: _____

Time Allowed : 3 hrs
Max. Marks : 100

Attempt any **FIVE** Questions, selecting at least one from each section.
All questions carry equal marks

SECTION I

1- a) What is the difference between Phase Velocity and Group Velocity? In case of a free particle, show that its phase velocity is one half of its classical velocity and discuss the result. 10

b) Show that $\Delta A \Delta B \geq \frac{1}{2} \left| \left\langle \left[\hat{A}, \hat{B} \right] \right\rangle \right|$, where $\hat{A}$ and $\hat{B}$ are two operators and ΔA and ΔB are uncertainties in these operators. Using $\hat{X}$ and $\hat{P}$ as position and momentum operators in above general relation instead of $\hat{A}$ and $\hat{B}$, prove the exact Heisenberg's uncertainty principle. 10

2- a) Define operator and Hermitian operator. Show that momentum operator is Hermitian operator. 10

b) Show that commutator of two Hermitian operators is anti-Hermitian. 5

c) Evaluate the commutator $[\hat{A}, [\hat{B}, \hat{C}]\hat{D}]$. 5

3- For a linear harmonic oscillator of mass m,

a) Find the Quantized Energy Value and Quantized Eigen States. 15

b) What is its zero point energy? If zero point energy is assumed to be equal to zero, explain how it violates the Uncertainty Principle. 5

SECTION II

4- What are Bound and Scattering States? Consider a particle of mass m trapped in an infinite square potential well. Applying Schrodinger wave equation, calculate the energy of the particle and explain that it is quantized. Also calculate its energy eigen states for first three energy values and plot the results. 20

5- a) Differentiate Distinguishable and Indistinguishable Particles. 4,4,4,4,4

b) What is Symmetrization Postulate.

c) Write Wave function of two particle system.

d) What is Boson condensation?

e) Determine the ground state of carbon atom, C^6

6- a) Show that in spherical coordinates $L_+ = \pm \hbar e^{\pm i\phi} \left(\frac{\partial}{\partial\theta} \pm \cot\theta \frac{\partial}{\partial\phi}\right)$ 15

b) Show that $[L^2 L_z] = 0$ 5

SECTION III

7- a) Using non-degenerate perturbation theory, calculate the first- and second-order corrections in energy for a system perturbed by small perturbation H'. 15

b) Suppose we put a delta function bump in the center of the infinite square well: $H' = \alpha\delta(x - a|2)$, where α is constant. Find the first-order correction to the allowed energies. Explain why the energies are not perturbed for even n. 5

8- Discuss the condition of applicability of WKB approximation. Obtain the expression of WKB approximation. 20

9- Write note on the following: 10, 10

a) Pauli Exclusion Principle

b) Variational Method