2023

Time - 3 hours

Full Marks - 60

*Answer **all groups** as per instructions.*
Figures in the right hand margin indicate marks.

GROUP – A

1. Fill in the blanks. (all) [1 × 8

(a) The velocity operator is given by _____.

(b) The condition of orthogonalisation is _____.

(c) The potential function of a harmonic oscillator is _____.

(d) The value of the commutator $[x^n, p_x]$ is _____.

(e) The probability of finding the particle in the normal state of the oscillator within classical limit is _____.

(f) Hermitian operators have _____ eigen values.

(g) The expression for transmittance is _____.

(h) The operator 'x' in the momentum representation is _____.

GROUP – B

2. Answer any eight of the following questions within two to three sentences each. [1½ × 8

(a) What is Gaussian wave packet ?

(b) Define wave function.

(c) Explain unit operator is a constant operator.

(d) Explain why spin of particle are not considered for Schrodinger's equation ?

(e) What are boundary conditions ?

(f) Explain Paaschen back effect.

(g) Explain Anomalous Zeeman effect.

(h) Write the significance of Stern-Gerlach experimental result.

(i) What is the nature of energy levels of an linear harmonic oscillator ?

(j) Determine the parity of the ground states of atoms of the Nitrogen (N).

GROUP – C

3. Answer any eight of the following questions within 75 words each. [2 × 8

(a) Find the eigen functions of the operator $\frac{d^2}{dx^2}$.

(b) If a 5000 Å line exhibits normal Zeeman splitting of 1.1×10^{-3} Å, find the field strength.

(c) Calculate the Lande's g-factor for the $^2P_{\frac{3}{2}}$ state.

(d) Explain space quantisation.

(e) Explain quantum dot.

(f) Justify that 'tunneling' is a quantum mechanical phenomenon.

(g) What are eigen values and eigen functions ?

(h) Determine whether $\psi(x) = e^x$ is an acceptable wave function or not.

(i) Heisenberg's uncertainty principle is valid for all kinds of particles. Explain.

(j) Find whether the operator $\hat{A} = 3x^2$ and $\hat{B} = \frac{d}{dx}$ commute or not.

GROUP – D

*Answer **all** questions within 500 words each.*

4. Derive an expression for time dependent Schrodinger's equation for a non-relativistic particle. [6

OR

Derive an expression for position and momentum uncertainty relation.

5. Define expectation value of a dynamical variable. Give expression for expectation value of position and momentum. [6

OR

Explain eigenvalues and eigenfunctions of Hermitian operator. Also explain that momentum operator is Hermitian.

6. Derive an expression for quantum mechanical tunneling across a rectangular potential barrier. [6

OR

Derive an expression for boundary conditions using Schrodinger's equation to one dimensional square well potential.

7. State and explain Larmor's theorem. Then derive and expression for Larmor's frequency. [6

OR

Explain the normal Zeeman effect using classical theory and also obtain an expression for Zeeman shift.