(6 pages) Reg. No. : .....

Code No. : 7032 **Sub. Code : ZPHM 31**

M.Sc. (CBCS) DEGREE EXAMINATION, NOVEMBER 2025.

Third Semester

Physics — Core

QUANTUM MECHANICS – I

(For those who joined in July 2021-2022 only)

Time : Three hours Maximum : 75 marks

PART A — (10 × 1 = 10 marks)

Answer ALL questions.

Choose the correct answer :

1. Wave-particle duality was explained by
   (a) Schrodinger
   (b) De-Broglie
   (c) Max Planck
   (d) Heisenberg

2. For N-particles in a d-dimensional space the dimension of the wave function is
   (a) $(\text{length})^{-Nd/3}$ (b) $(\text{length})^{-Nd/2}$
   (c) $(\text{length})^{-d/2}$ (d) $(\text{length})^{-N/2}$

3. The energy spectrum of a quantum mechanical system is
   (a) Discrete
   (b) Continuous
   (c) Both discrete and continuous
   (d) Depends on the system

4. Spherically symmetric potential depends on
   (a) radius (b) angular part
   (c) time (d) space

5. For any system with time-independent Hamiltonian operator, energy is
   (a) conserved
   (b) time-dependent
   (c) continuous
   (d) conventional

6. The trace of the any operator is under unitary transformations

(a) variant (b) invariant

(c) orthogonal (d) orthonormal

7. What is the result of L × L?

(a) 0 (b) $i\hbar Z$

(c) $i\hbar L$ (d) $-i\hbar Z$

8. The eigen values of J^2 is

(a) $(2l+1)$ (b) $2(2l+1)$

(c) $l(l+1)$ (d) $j(j+1)\hbar^2$

9. The first-order correction to energy eigen value of a perturbed linear harmonic oscillator is

(a) 0 (b) unity

(c) $e^2E^2/2m\omega^2$ (d) $-e^2E^2/2m\omega^2$

10. When the perturbation is sufficiently slow in an adiabatic process, then the state of the system

(a) infinite (b) zero

(c) finite (d) same

PART B — (5 × 5 = 25 marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 250 words.

11. (a) Analyze the inadequacies of classical and old quantum theories.

Or

(b) Discuss the basic postulates of quantum mechanics.

12. (a) Explain the abstract operator method to linear harmonic oscillator.

Or

(b) Discuss the case of rigid rotator.

13. (a) Relate Dirac's Bra and Ket notations and explain their properties.

Or

(b) Manipulate the Hilbert Space from ordinary N-dimensional vector space.

14. (a) Determine the expression for $[L_x, L_y]$.

Or

(b) Describe the eigen functions of L^2 and Lz.

15. (a) Develop the perturbation theory for non-degenerate levels and derive the first order corrections.

Or

(b) Write a note on sudden approximation.

PART C — (5 × 8 = 40 marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 600 words.

16. (a) Define Heisenberg uncertainty principle and derive the same.

Or

(b) State and Prove Ehrenfest's theorem.

17. (a) Obtain the eigen values of one-dimensional harmonic oscillator.

Or

(b) Derive the radial equations of central potential and its solutions.

18. (a) What are Hermitian operators and state their properties?

Or

(b) Transform a Hamiltonian by using an unitary matrix.

19. (a) Evaluate the commutation relation of Lx and Ly.

Or

(b) Find out the Clebsch-Gordan coefficients for j=1/2 or 1.

20. (a) Describe briefly the first order stark effect in hydrogen atom.

Or

(b) List out the various features of first-order transition probability employed from constant perturbation.

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