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Reg. No. : .....

Code No. : 5032 **Sub. Code : ZPHM 31**

M.Sc. (CBCS) DEGREE EXAMINATION, APRIL 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. According to wave mechanics, the relation connecting wavelength (λ) and momentum (p) is

(a) $\lambda = \frac{1}{p}$ (b) $\lambda = \frac{h}{p}$

(c) $\lambda = hp$ (d) $\lambda = \frac{hc}{p}$

2. Which one of the following is true for a dispersive medium?

(a) $v_g < v_p$ (b) $v_g > v_p$

(c) $v_g = v_p$ (d) $v_g = 0$

3. The lowest possible energy of a linear harmonic oscillator is

(a) $E = h\upsilon$ (b) $E = \frac{1}{2}h\upsilon$

(c) $E = \frac{3}{2}h\upsilon$ (d) $E = 0$

4. A particle in a box having the lowest energy state is most likely to be

(a) anywhere in the box

(b) at the walls of the box

(c) outside the box

(d) in the middle of the box

5. An operator associated with a dynamical variable is _____ if its average value in any state is real.

(a) Hermitian (b) Hamiltonian

(c) Real (d) Imaginary

6. Which of the following statements is NOT TRUE in the case of unitary transformation?

(a) The normalization of an arbitrary wave function is left unchanged.

(b) The scalar product (f,g) remains invariant.

(c) The originally orthogonal wave-functions remain orthogonal

(d) A Hermitian operator does not remain Hermitian under a unitary transformation

7. The resultant of the commutation relation $[J^2, J_+]$ is

(a) $-\hbar J$ (b) $+-\hbar J$

(c) 0 (d) infinite

8. Which of the following is true?

(a) All 6j symbols may be real or complex

(b) All 6j symbols are imaginary

(c) 6j symbol is variant in a permutation of its columns

(d) 6j symbols differ from W-coefficients only through their sign

9. When the Hamiltonian of a system changes appreciably during a very short but finite interval of time is called

(a) Sudden approximation

(b) Adiabatic approximation

(c) Fermi's Golden Rule

(d) Stark effect

10. The splitting of energy levels of an atom caused by a uniform external electric field is called

(a) Normal Zeeman effect

(b) Anomalous Zeeman effect

(c) Stark effect

(d) Debye effect

PART B — ($5 \times 5 = 25$ marks)

Answer ALL questions, choosing either (a) or (b).
Each answer should not exceed 250 words.

11. (a) Obtain the relation between wave velocity and group velocity of a moving particle.

Or

(b) List out the basic postulates of wave mechanics.

12. (a) Solve the Schrödinger equation for a particle in a one dimensional square well potential.

Or

(b) Obtain Schrödinger' s equation for a particle moving under a central force.

13. (a) Prove that two commuting operators have simultaneous eigen functions.

Or

(b) Using matrix method, obtain the energy levels of a harmonic oscillator.

14. (a) If L_x, L_y and L_z are orbital angular momentum operators, show that $[L_x, L_y] = i\hbar L_z$.

Or

(b) What are Clebsch-Gordon coefficients? Mention their properties and selection rules.

15. (a) Explain why hydrogen atom in the ground state does not exhibit a first order Stark effect.

Or

(b) Write short notes on (i) Fermi-Golden rule and (ii) 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) State and explain Heisenberg's uncertainty principle.

Or

(b) State and prove Ehrenfest theorem.

17. (a) Solve the Schrödinger equation for the case of hydrogen atom and discuss the radial wave equation.

Or

(b) Obtain Schrödinger equation for spherically symmetric potential in spherical coordinates.

18. (a) Show that the eigen functions of Hermitian operator belonging to different eigen values are orthogonal.

Or

(b) Define Hubert space and illustrate its significance in the study of quantum mechanics.

19. (a) Derive the commutation relation for the components L_x, L_y and L_z of the orbital angular momentum and show that all the three components commute with $L^2 = L_x^2 + L_y^2 + L_z^2$.

Or

(b) Obtain the Clebsch-Gordon coefficient for a system having $J_1 = \frac{1}{2}$ and $J_2 = \frac{1}{2}$.

20. (a) Explain the time independent perturbation theory and obtain its general solution.

Or

(b) Describe adiabatic approximation and derive the expression for transitional probability.
