(7 pages) Reg. No. : .....

Code No. : 7395 **Sub. Code : ZPHM 31**

M.Sc. (CBCS) DEGREE EXAMINATION, NOVEMBER 2024.

Third Semester

Physics – Core

QUANTUM MECHANICS – I

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

Time : Three hours Maximum : 75 marks

PART A — (10 × 1 = 10 marks)

Answer ALL questions.

Choose the correct answer :

1. The application of the Schrodinger's equation enable us to compare the predictions of

   (a) quantum mechanics

   (b) classical mechanics

   (c) none of these

   (d) both (a) and (b)

2. The state function $\psi(x)$ has physical dimensions of

   (a) $\left(1/\sqrt{2}\right)^2$ (b) $1/\sqrt{2}$

   (c) 1/2 (d) $1/2^2$

3. Boundary Condition are used to Find out

   (a) One dimensional motion

   (b) Energy

   (c) Wave function

   (d) (b) and (c)

4. In bound state have energies and potential is

   (a) $E < V$ (b) $E > V$

   (c) $E = V$ (d) None of These

5. There must be one to one corresponding between wave function and energy is called

   (a) degenerate state

   (b) non degenerate state

   (c) symmetric potential

   (d) none

6. The wave function of box of particle is given by

(a) $A \sin kx$

(b) $B \cos k x$

(c) $A \sin(kx) + B \cos(kx)$

(d) $A \sin(kx) - B \cos(kx)$

7. Which of the following has the value of $h/2x$?

(a) $-i[z, P_z]$ (b) $[x, P_x]$

(c) $[y, P_y]$ (d) $[y, P_z]$

8. The commutator $[x^2, d/dx]$ is

(a) $-2x$ (b) d^2/dx^2

(c) $x - 2$ (d) $2x$

9. Fermi's Golden rule obtained using time dependent perturbation theory

(a) is time-dependent

(b) is time-independent

(c) depends on time harmonically

(d) is partially time dependent

10. With stark effect in the first excited state of hydrogen atom the degeneracy is

(a) one-fold (b) two-fold

(c) three-fold (d) four-fold

PART B — (5 × 5 = 25 marks)

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

Each answer should not exceed 250 words.

11. (a) The average time that an atom retains excitation energy before remitting in its in the form electromagnetic radiation is 10^{-8} sec calculate the limits of accuracy with which the excitation energy of the emitted radiation can be determined.

Or

(b) Explain the normalization and probability interpretation of wave function.

12. (a) Evaluate the most probable distance of the electron of the hydrogen atom in its 2P is the radial probability at that distance.

Or

(b) Solve Schroedinger's equation for a rigid rotator with a free axis.

13. (a) Show that $(xP_x + P_x X)$ is a self adjiont operator, Where as xP_x is not.

Or

(b) Outline Divac's bra and ket notation.

14. (a) Show that $[L^2, L] = 0$.

Or

(b) Prove that following identity $\left[J_x^2, J_y^2\right] = \left[J_x^2, J_y^2\right] = \left[J_z^2, J_x^2\right]$.

15. (a) Give an account of adiabatic approximation.

Or

(b) Give an account of selection rules for dipole transition.

PART C — (5 × 8 = 40 marks)

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

Each answer should not exceed 600 words.

16. (a) An electron has a speed 1.05×10^4 m/s with in accuracy of 0.01%. Calculate the uncertainty in the position of the electron.

Or

(b) Explain the postulates of quantum mechanics.

17. (a) Solve Schroedinger's equation for the hydrogen atom and discuss the radial wave function.

Or

(b) Calculated the discrete energy levels of a particle in one dimensional square well potential with perfectly rigid Walls.

18. (a) The Hamiltonian of a particle is given by $H = p^2/2m + \frac{1}{2}m\omega^2 x^2 + \alpha x^3$ where p and x are the momentum and the position operators for the particle. Find p and x.

Or

(b) Explain Poisson brackets and equation of motion.

19. (a) Find angular momentum matrices for = $\frac{1}{2}$ for the operator

$< j'm' |J_+| jm >$ and $< j'm' |J_- |jm >$

Or

(b) Explain the Rachah's coefficients of $6j$ and $9j$ symbols.

20. (a) Give the theory of first order stark effect on the basis of quantum mechanics and discuss the splitting of the energy levels.

Or

(b) Explain the Einstein's A and B coefficients.
