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

Code No. : 6391 **Sub. Code : ZPHM 31**

M.Sc. (CBCS) DEGREE EXAMINATION, NOVEMBER 2022.

Third Semester

Physics — Core

QUANTUM MECHANICS — I

(For those who joined in July 2021 onwards)

Time : Three hours Maximum : 75 marks

PART A — (10 × 1 = 10 marks)

Answer ALL questions.

Choose the correct answer :

1. The value of probability density will be

(a) $\frac{1}{\sqrt{2}}$ (b) $\frac{1}{2}$

(c) $\frac{1}{2^2}$ (d) $(1/2)^2$

2. To solve schrodinger equation we need potential and

(a) physical requirements of system

(b) boundary condition

(c) none of these

(d) both (a) and (b)

3. The energy Spectra of bound state are

(a) Continuous (b) Discrete

(c) Degenerate (d) Non Degenerate

4. Bound State Occur when particle can not move to

(a) Infinity (b) Maximum

(c) Zero (d) Minimum

5. The eigen function of a degenerate spectrum is an even potential do not have

(a) odd parity (b) even parity

(c) definite parity (d) none

6. If the PE is even the Hamilton will be

(a) odd

(b) even

(c) neither even nor odd

(d) none

7. If L is angular momentum operator then

(a) $L \times L = 0$ (b) $L\_L = L_z$

(c) $L \times L = iLh/2\pi$ (d) $L\_(L \times L) = 0$

8. If L is angular momentum operator and L_z is its z-component, then

(a) $[L, L_z] = 0$ (b) $[L^2, Lz] = 0$

(c) $[L^2, L_z] = h$ (d) $[L^2, Lz] = 1$

9. In the Stark effect if first excited state of hydrogen atom, the degeneracy is

(a) Completely removes

(b) Not remove at all

(c) Partially removes

(d) Four folds

10. The Process which is not allowed is

(a) Spontaneous emission

(b) Spontaneous absorption

(c) Induced absorption

(d) Induced emission

PART B — (5 × 5 = 25 marks)

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

11. (a) An electron has a speed of 5.00 m/s with an accuracy of 0.004 % calculate the certainty with which we can locate the position of the electron.

Or

(b) How classical physics failed to account for the spectral distribution of energy density in a black body?

12. (a) Formulate schroedingers for a rigid rotator. Find its eigen values and eigen functions.

Or

(b) Determine the energy levels of a linear harmonic oscillator on the basis of the schroedinger's equation.

13. (a) If A and B are constants of motion and H is the Hamiltonian, then show that [A,B] is also a constant of motion.

Or

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

14. (a) If the angular momentum operators obey the rule $[J_x, J_y] = i\hbar\, j_z$ and similar commutation relations for the other components, evaluate the commutators $[J^2, J_x]$ and $[J^2, J_+]$. What would be the roles of J_+ and J_- in the new situation?

Or

(b) Derive the eigen value of operator J^2 and J_z where J^2 and J_z represent the square and the Z-component of the angular momentum operator.

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

Or

(b) Which of the following transitions are electric dipole allowed?

(i) $1s \rightarrow 2s$

(ii) $1s \rightarrow 2p$

(iii) $2p \rightarrow 3d$

PART C — (5 × 8 = 40 marks)

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

16. (a) Anucileus is confined to nucleus of radius 5×10^{-15} meters. Calculate the minimum uncertainty in the momentum of the nucleon. Also calculate the minimum kinetic energy of the nucleon.

Or

(b) Derive time dependent and independent schrodinger wave equations.

17. (a) Write down radial wave function for hydrogen atom and solve it to obtain the expression for bound state.

Or

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

18. (a) Does taking the complex conjugate correspond to
(i) a linear operator
(ii) a Hermitian operator
(iii) an operator which is its own complex conjugate?

Or

(b) Give the matrix theory of the linear harmonic oscillator.

19. (a) Calculate C-G coefficient for $j_1 = 1$ and $j_2 = 1/2$.

Or

(b) Find the angular momentum matrices for j = 1 for the operator $< J'm' | J^2 | Jm >$ and $< J'm' | J_Z | J_m >$.

20. (a) What do you mean by perturbation theory? Discuss the perturbation theory for non-degerate levels in first and second orders.

Or

(b) Derive Fermi-Golden rule for constant perturbation that acts for a short interval of time.
