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

Code No. : 5399 **Sub. Code : ZPHM 41**

M.Sc. (CBCS) DEGREE EXAMINATION, APRIL 2023.

Fourth Semester

Physics – Core

QUANTUM MECHANICS – II

(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 variation method is applied to_____ state of the system.
   (a) Lowest and Highest
   (b) Highest
   (c) Lowest
   (d) None of the above

2. The ground state energy of helium atom is _____
   (a) $-2.85\ e^2/a_0$ (b) $2.85\ e^2/a_0$
   (c) $\hbar^2/m_0 e^2$ (d) $-\hbar^2/m_0 e^2$

3. Born approximation is applicable, when V(r) is
   (a) Fairly Small (b) Small
   (c) High (d) Very High

4. If the molecule is considered as a point charge and orbital electrons are absent then the potential energy of an electron is _____
   (a) Coulomb (b) Screened coulomb
   (c) Yukawa (d) None of the above

5. A wave function is anti-symmetric if the interchange of any pair of particles among the arguments changes the
   (a) Sign of wave function
   (b) Wave function
   (c) Symmetric wave function
   (d) None of the above

6. The spin function for two electrons have the eigen values of S^2 is _____
   (a) $\hbar$ (b) 0
   (c) $2\hbar^2$ (d) $2\hbar^2$ and 0

7. Electrons wave functions can be represented by
   (a) Row vectors
   (b) Column vectors
   (c) Square matrices
   (d) Rectangular matrices

8. The value of $[x,P_x]$ is
   (a) $i\hbar$ (b) $-i\hbar$
   (c) 0 (d) 1

9. A free particle has
   (a) Potential energy
   (b) Kinetic energy
   (c) Potential and Kinetic energy
   (d) None of the above

10. The energy spectrum of free particle has
   (a) Two branches (b) Three branches
   (c) Four branches (d) Five branches

PART B — (5 × 5 = 25 marks)

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

11. (a) Write the connection formula from the WKB approximation.

Or

(b) Write short notes on Vander Waal's interaction.

12. (a) Establish the relation between the scattering cross section and scattering amplitude.

Or

(b) Obtain the scattering cross section for a charge particle interaction with a screened coulomb potential under Born approximation.

13. (a) Distinguish symmetric and anti-symmetric wave function. How are they Constructed for a system of N identical particles?

Or

(b) Show that $\begin{bmatrix} 1 \\ 0 \end{bmatrix}$ and $\begin{bmatrix} 0 \\ 1 \end{bmatrix}$ are the eigen functions of S^2 and S_z operators for an electron.

14. (a) Explain Schrodinger representation.

Or

(b) Explain the relation connecting Poisson bracket and commutation bracket.

15. (a) Write the theory of positive or negative energy states.

Or

(b) Derive Klein-Gordon equation and also find the precision of charge and current density.

PART C — (5 × 8 = 40 marks)

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

16. (a) Give the WKB approximation of finding the wave function obtain Bohr-Summerfield quantization rule.

Or

(b) Apply variation method to calculate the ground state energy of helium atom.

17. (a) Give the partial wave analysis and find an expression for scattering cross Section in terms of phase shift.

Or

(b) Find the expression for scattering amplitude in terms of Green's function.

18. (a) Describe the spin function for two electrons. Find the Eigen value of S^2 and S_z for this state.

Or

(b) Explain the effect of spin on the energy state of an atom (helium).

19. (a) Describe Heisenberg and interaction pictures.

Or

(b) Explain the conservation laws and degeneracy associated with Symmetries.

20. (a) Describe the energy levels of a charged particle in a coulomb field using Schrodinger Relativistic equation.

Or

(b) Discuss the method to find the free particle solutions of Dirac's equation.

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