TDC (CBCS) Odd Semester Exam., 2023

PHYSICS

(Honours)

(5th Semester)

Course No. : PHSHCC-501T

(Quantum Mechanics and Applications)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

Answer *ten* questions, selecting any *two* from each Unit : 2×10=20

UNIT—I

1. What are Hermitian operators in quantum mechanics? Give one example.

2. Explain the term 'stationary state' in quantum mechanics.

3. Write the equation of continuity and state its significance.

UNIT—II

4. Prove that

$$[x, P_x] = i\hbar$$

5. What do you mean by ladder operator?

6. Give expressions for operators associated with three components of angular momentum.

UNIT—III

7. Explain the terms 'degenerate' and 'non-degenerate' states.

8. Explain the significance of zero-point energy.

9. Write down an expression for Hamiltonian of simple harmonic oscillator.

UNIT—IV

10. What is Bohr magneton?

11. Write a note on 'spin in quantum mechanics'.

12. Why are spherical polar coordinates used to solve the Schrödinger's equation for hydrogen atom?

UNIT—V

13. What is anomalous Zeeman effect?

14. State and explain Hund's rule.

15. What is the significance of the Stern-Gerlach experiment?

SECTION—B

Answer *five* questions, selecting *one* from each Unit : 6×5=30

UNIT—I

16. Starting with Born's interpretation of wave functions, prove that

$$\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{J} = 0$$

where symbols have their usual meanings.

17. Obtain time dependent Schrödinger's equation by considering a plane monochromatic matter wave.

UNIT—II

18. State and prove Ehrenfest theorem.

19. A particle is in a state

$$\Psi(x) = \left(\frac{1}{\pi}\right)^{\frac{1}{4}} \exp\left(-\frac{x^2}{2}\right)$$

Find $\langle x \rangle$, $\langle p_x \rangle$, $\langle x^2 \rangle$ and $\langle p_x^2 \rangle$.

UNIT—III

20. Obtain the eigenfunctions of a linear harmonic oscillator in terms of Hermite's polynomials.

21. Write down Schrödinger's equation for the potential

$$V(x) = \begin{cases} 0\ , & \text{for } x < 0 \\ -V_0\ , & \text{for } 0 < x < a \\ 0\ , & \text{for } x > a \end{cases}$$

and solve it.

UNIT—IV

22. Starting from the Schrödinger's equation for hydrogen atom, obtain differential equation for the radial wave function.

23. Solve the polar wave equation for the hydrogen atom.

UNIT—V

24. Explain fine structure sodium D-line.

25. Give classical theory of normal Zeeman effect.

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