TDC (CBCS) Odd Semester Exam., 2020
held in March, 2021

PHYSICS

(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

1. Answer any *ten* of the following questions : 2×10=20

(a) Write two properties of wave function.

(b) Write the operators associated with—

(i) energy;

(ii) momentum.

(c) What do you mean by the expectation values of dynamical quantities?

(d) Write the values of the following commutators :

(i) $[L_x, L_y]$

(ii) $[L^2, L_z]$

(e) What do you mean by normalized and orthogonal wave functions?

(f) State and explain Heisenberg's uncertainty principle.

(g) Name an experiment which supports electron spin hypothesis. What is its principle?

(h) Mention two applications of Schrödinger equation.

(i) Explain the quantum picture of a material particle.

(j) What is the difference between phase velocity and group velocity?

(k) What do you understand by free particle? Write the time-independent Schrödinger equation for free particle.

(l) Explain Stark effect.

(m) Explain what you understand by the term 'potential barrier'.

(n) Briefly explain about Larmor's theorem.

(o) Explain Pauli's exclusion principle.

(p) Explain the coupling of orbital and spin angular momenta in vector atom model.

(q) State the principle of superposition of eigenstates.

(r) What is Zeeman effect?

(s) Discuss the origin of quantum mechanics.

(t) Define density of energy states.

SECTION—B

Answer *any* **five** questions

2. Give the Max Born idea of probability of finding a particle associated with a wave. Also derive the equation of continuity

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

where,

$\rho = \psi^* \psi$ is the probability density

J = current density 1+5=6

3. Derive Schrödinger time-dependent form of wave equation for a particle characterized by the PE function $V(r, t)$. 6

4. Explain anomalous Zeeman effect. 6

5. Deduce the expression of Hamiltonian in quantum mechanics. Hence use it to find Schrödinger time-independent equation. 6

6. Establish Schrödinger equation for a linear harmonic oscillator. Write down the expression for eigenvalues of the energy levels of the oscillator. 4+2=6

7. A particle, moving in a one-dimensional potential, is given by $V = 0$ for $x < 0$ and $V = V_0$ for $x \geq 0$. Write down the Schrödinger wave equation for the particle and solve it. 6

8. Write the Schrödinger equation for hydrogen atom in spherical polar coordinates and split it into the radial, polar and azimuthal parts. 6

9. Define angular momentum operator and show that $[L_x, L_y] = i\hbar L_z$. 1+5=6

10. Describe Stern-Gerlach experiment. 6

11. What are symmetric and anti-symmetric wave functions? Show how they lead to the Pauli's exclusion principle. 2+4=6

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