Roll No. ....

Total Pages : 3

752103

January 2023

M.Sc. (Phy.) - Ist SEMESTER

Quantum Mechanics - 1 (MPH-103)

Time : 3 Hours] [Max. Marks : 75

Instructions :

1. *It is compulsory to answer all the questions (1.5 marks each) of Part-A in short.*
2. *Answer any four questions from Part-B in detail.*
3. *Different sub-parts of a question are to be attempted adjacent to each other.*

PART–A

1. (a) Under what conditions, A wave function may be regarded as physically accepted. (1.5)

(b) What do you mean by probability density, append your answer with Max Born's statistical interpretation about probability density. (1.5)

(c) What is a simple harmonic oscillator? Write it's differential equation. (1.5)

(d) Describe the representations $|\,\rangle$, $\langle\,|$, $\langle\,|\,\rangle$ and $|\,\rangle\langle\,|$. (1.5)

(e) Prove that eigen values of a Hermitian operator are real. (1.5)

(f) Briefly describe - What a linear vector space is all about. (1.5)

(g) Evaluate the commutation relation between L_z and L_+. (1.5)

(h) Write down Pauli's matrices and verify any two properties associated with these. (1.5)

(i) Explain the general concept of perturbation theory and it's limitation in brief. (1.5)

(j) Express the formula for Fermi Golden Rule. Also, write it's two applications. (1.5)

PART–B

2. (a) Calculate the eigen values of $\Psi(x, t) = \exp\{i(kx - \omega t)\}$ with application of Energy operator and Linear momentum operator. (4)

(b) A particle is represented (at time t = 0) by the wave function (4)

$$\Psi(x,0) - \begin{cases} A(a^2 - x^2), & \text{if } -a \le x \le +a \\ 0 & \text{otherwise} \end{cases}$$

Find the expectation value of $\hat{p}^2$.

(c) Derive the expression for energy eigen values in case of a one-dimensional harmonic oscillator. (7)

3. (a) Derive recursion formula for solution of Hydrogen atom radial wave function. (8)

(b) Write down the matrix representation of $\langle a|b\rangle$, $|a\rangle\langle b|$ and $\langle a|H|b\rangle$ (7)

4. Explain Schrödinger, Heisenberg and Interaction Pictures of quantum mechanics. (15)

5. (a) Derive an expression to determine the eigen values of general angular momentum operators L^2 and L_z. (10)

(b) Demonstrate Stern-Gerlach experiment for evidence of electronic spin and analyse empirical outcomes of it. (5)

6. (a) Write down matrices of any four spin angular momentum operators in case particles with spin 1. (8)

(b) Explain first order correction for energy eigen values in Zeeman effect by perturbation theory. (7)

7. Describe First order Stark effect in Hydrogen atom using perturbation method. (15)