Roll No. | | | | | | | | | | | | Total No. of Pages : 02

Total No. of Questions : 20

M.Sc. (Physics) (2018 Onwards Batch) (Sem.–1)

QUANTUM MECHANICS-I

Subject Code : MSPH-413-18

M.Code : 75124

Time : 3 Hrs. Max. Marks : 70

INSTRUCTIONS TO CANDIDATES :

1. SECTION-A is COMPULSORY consisting of TEN questions carrying TWO marks each.
2. SECTION-B contains SEVEN questions carrying FIVE marks each and students have to attempt any SIX questions.
3. SECTION-C contains THREE questions carrying TEN marks each and students have to attempt any TWO questions.

SECTION-A

1. Define Schwartz inequality. Give one example from quantum mechanics where you used this inequality.
2. Prove that the product of two commutating projection operators is also a projection operator.
3. Prove that the trace of an operator is base independent.
4. Show that the expectation values of anti-hermitian operator are always imaginary.
5. What is difference between inner product and outer product of two vectors? What should be the inner product of two orthogonal vectors?
6. Find the commutator of σ_1 and σ_2 Pauli matrices.
7. When you will prefer to use the perturbation theory as compared to variational method for solving quantum mechanics problem?
8. Define Fermi golden rule and give its expression (no derivation).
9. Show that $[L_x, X] = iY$.
10. Define optical theorem. What is its physical significance?

SECTION-B

11. Derive the Heisenberg uncertainly relation using operator algebra.

12. What is difference between Schrodinger, Heisenberg and interaction representation? Derive the equation of motion for wave function and operator in the interaction picture.

13. Explain infinitesimal and finite unitary transformations. Prove that the hermiticity of an operator is not destroyed under unitary transformations.

14. Using the angular momentum algebra, discuss the orbital angular momentum theory and derive the relations

$$L_{\pm}|l,m\rangle = \hbar\sqrt{l(l+1)-m(m\pm1)}\,|l,m\pm1\rangle$$

In above relation, L_+ and L_- are the raising and lowering operators, respectively and $|l,m>$ is the joint eigen state of L^2 and L_z operators.

15. Using the perturbation theory, explain the spin orbit interaction contribution to the energy of hydrogen atom.

16. Estimate the ground state energy of simple harmonic oscillator using the variational method. Consider $\psi(x) = Ae^{-cx^2}$ as trail function. Here A is the normalization constant and c is variational parameter.

17. Calculate the differential cross-section and total cross-section in the Born approximation for the Yukawa potential.

SECTION-C

18. Staring from the Schrodinger equation for a spherical symmetric potential, derive the expression for angular part of the wave function. Explain physical significance of all quantum numbers appearing in your derivation.

19. Derive the expression for transition probability for constant perturbation and harmonic perturbation in time dependent perturbation theory. How it explains the concept of stimulated absorption and emission processes?

20. Discuss in detail the partial wave analysis in scattering theory and derive the expression for total scattering cross-section.

NOTE: Disclosure of Identity by writing Mobile No. or Making of passing request on any page of Answer Sheet will lead to UMC against the Student.