Question Paper Code : 5667

M.Sc. (Semester-IV) Examination, 2018

(Regular/Back Paper/Exempted)

PHYSICS

(Module-PHYC-401)

(Quantum Mechanics-2)

Time : Three Hours] **[Maximum Marks : 70**

Note : Answer **five** questions in **all**. **Question No. 1** is **compulsory** and carries **30** marks. In addition attempt **one** question (carrying **10** marks) from each unit.

1. Answer briefly the following : [3x10=30]

   (a) What do you understand by "Born Oppenheimer Approximation" and how does it help in simplifying the electronic Hamiltonian ?

   (b) Why is there a bond formation at equilibrium distance R_e ?

   (c) Assuming that the ionic character in H-Br bond is 11%, calculate the fraction of contribution of ionic character to the valence bond wave function.

UNIT-IV

8. Derive the transition probabilities for absorption and emission of radiation by relativistic cahrged particle using Quantum Field Theory.

9. Using the Lagrangian density

   $L = \frac{\partial \psi^*}{\partial t}\frac{\partial \psi}{\partial t} - (\nabla \psi^* \nabla \psi) - m^2 \psi^* \psi$, where ψ and ψ^* are independent fields, derive the energy and total charge of the field in occupation number representation. Describe briefly how this field can be used to describe mutual mesons as field quanta.

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(d) What deficiency of the Klein Gordon equation caused it to be discarded initially ?

(e) What happens when a charge conjugation operation is carried out on the wave function of an electron ?

(f) What are the properties satisfied by Dirac matrices ?

(g) What is natural system of units used in Quantum Field Theory ?

(h) What do you understand by Lorentz Gauge Transformation ? Highlight its importance in electromagnetic field.

(i) What is a conjugate field ? Write the commutation relations obeyed by the field amplitudes and conjugate field.

(j) Write any one triumph of Quantum Field Theory over Classical Field Theory.

UNIT-I

2. What do you understand by Central Field Approximation ? Using the Thomas Fermi Model calculate the field for a many electron atom.

3. Using Heitler-London theory, derive the energy for the ground state of hydrogen molecule. Illustrate graphically the variation of energy with inter-nuclear distance for symmetric and anti-symmetric states.

UNIT-II

4. Obtain the Dirac equation in covariant form. Why is this required ? Also derive the expression for probability density.

5. Find out the energy of a charged particle obeying Klein Gordon equation in a Coulomb potential. Explain the significance of the different terms.

UNIT-III

6. Explain what are number, creation and annihilation operators. In what way can these operators be used to represent the fermionic and bosonic fields.

7. Using appropriate Lagrangian density functional, derive the classical field equation in Lagrangian form. How is this field quantized ?