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Reg. No. : .....

Name : .....

Third Semester M.Sc. Degree Examination, February 2024

Physics

PH 231 : ADVANCED QUANTUM MECHANICS

(2018-2019 Admission)

Time : 3 Hours Max. Marks : 75

PART – A

I. Answer any **five** questions. Each question carries **3** marks.

(a) Explain variational principle.

(b) Explain the mechanism of spontaneous emission.

(c) Write down connection formula and explain its significance.

(d) Derive the relationship between scattering amplitude and cross section.

(e) Explain in brief the Thomas-Fermi model of an atom.

(f) Establish the relation between time translation and the conservation of energy.

(g) Write down Klein-Gordon equation. What are its shortcomings?

(h) Show that $\left[\hat{L}^2, \hat{L}\right] = 0$.

($5 \times 3 = 15$ Marks)

P.T.O.

PART – B

Answer **all** questions. Each question carries **15** marks.

II. (a) (i) Determine the ground state of He atom using variational method.

(ii) Explain stark effect.

OR

(b) (i) Discuss the effect of an electric field on $n = 2$ state of a hydrogen atom.

(ii) Explain absorption and emission of radiation.

III. (a) (i) Briefly explain the method of Born approximation, its validity

(ii) Illustrate with the example of scattering by a Coulomb potential.

OR

(b) (i) Explain briefly Hartree and Hartree-Fock methods and compare their applications.

(ii) Explain Thomas Fermi model of an atom.

IV. (a) (i) Discuss the problem of addition of angular momenta.

(ii) Explain Clebsch-Gordon coefficients and derive selection rules.

OR

(b) (i) Discuss free particle solution of Dirac equation.

(ii) Explain negative energy states.

($3 \times 15 = 45$ Marks)

PART – C

V. Answer any **three** questions. Each question carries **5** marks.

(a) Determine the ground state energy of a harmonic oscillator in one dimension using trial wave function $\psi(x) = A \exp\left(-bx^2\right)$.

(b) Consider the Hamiltonian of a system given by

$$E_0 \begin{pmatrix} 15 & 0 & 0 & 0 \\ 0 & 3 & \lambda & 0 \\ 0 & \lambda & 3 & 0 \\ 0 & 0 & 0 & 3 \end{pmatrix}$$ where $\lambda = E_0 / 100$. Find the eigen energies to first order perturbation.

(c) Write down the expression for transition probability of first-order and apply this to the case of a constant perturbation.

(d) Discuss the S-wave scattering by a hard sphere.

(e) Show that Dirac's equation can be written in covariant form. Derive the properties of Dirac matrices.

(f) Consider the case where $j = 1$. Find the matrix representation of operators: $\hat{J}^2, \hat{J}_z, \hat{J}_{\pm}, \hat{J}_x$ and $\hat{J}_y$

($3 \times 5 = 15$ Marks)
