

Roll No.

22022

**M. Sc. Physics 2nd Semester
Examination – May, 2019**

QUANTUM MECHANICS-II

Paper : PHY(H)-202

Time : Three hours] [Maximum Marks : 80

Before answering the questions, candidates should ensure that they have been supplied the correct and complete question paper. No complaint in this regard, will be entertained after examination.

Note : Attempt *five* questions in all, selecting *one* question from each Unit. Question No. 1 is *compulsory*. All questions carry equal marks.

1. (a) Estimate the ground state energy of Hydrogen atom using variational method. You may take $\psi(r, \theta, \phi) = e^{-\frac{r}{a}}$ as the trial wave function. 4

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- (b) Write the relationship between Einstein coefficients and explain why these are so important in selecting a material for laser fabrication. 4
- (c) Define differential scattering cross-section. Write the relation connecting scattering amplitude with differential scattering cross-section. 4
- (d) Wave function is either totally symmetric or totally anti-symmetric. Prove this statement for a system of three identical particles. 4

UNIT – I

- 2. Set-up the Hamiltonian for He-atom and separate it into unperturbed & perturbation part with proper justification for each term. Now using perturbation method estimate the ground state energy of He-atom and compare the result with experimental values. 16
- 3. What do you understand by a time dependent perturbation ? Develop the first order time dependent perturbation theory and hence obtain the expression of transition rates under constant and harmonic perturbation. 16

UNIT – II

4. What do you mean by semi-classical theory of radiation ? Obtain the probability for absorption and stimulated emission when EM radiation interacts with matter. Does semi-classical theory of radiation give any clue about the spontaneous emission of radiation ?
5. (a) Discuss electric dipole approximation and derive the selection rules for transitions.
(b) Briefly discuss higher order transitions.

UNIT – III

6. (a) Write and plot an attractive square well potential. Discuss the S-wave scattering of a particle of mass m from this potential and obtain an expression for phase shift.
- (b) Show that $\theta_1 = \theta/2$ and

$$\left(\frac{d\sigma}{d\Omega_1} \right)_{lab} = 4 \cos(\theta/2) \left(\frac{d\sigma}{d\Omega} \right)_{CM}$$

in case of scattering between two particles of same mass, where θ_1 and θ are the scattering angle in lab and centre of mass frame respectively.

7. (a) What do you mean by elastic and inelastic scattering ? Obtain an expression for total inelastic scattering cross-section. 9
- (b) State and prove optical theorem. 4
- (c) In a scattering experiment, the phase shifts are given as $\delta_0 = 60^\circ$ and $\delta_1 = 30^\circ$ and all other phase shifts are zero. Find the differential scattering cross-section for this experiment. 3

UNIT – IV

8. (a) Discuss how the principle of Indistinguishability of identical particles of a many body system leads to a classification of the physically acceptable wave functions into symmetric and anti-symmetric type. 10
- (b) What is Slater determinant ? How does it incorporate Pauli's Exclusion Principle ? 6
9. Write detailed notes on the following : 8 + 8 = 16
- (a) Helium Spectra
- (b) Collision of identical particles
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