1592/MPA **MAY 2008**

Paper V — QUANTUM THEORY

Time : Three hours Maximum : 100 marks

Answer ALL the questions chcosing either (a) or (b) from each.

All the questions carry equal marks.

1. (a) Explain the concept of probability density and probability current density using schroedinger equation. Define expectation value of a particle in a volume d^3x and in a whole volume. Also state and explain the fundamental postulates of quantum mechanics.

Or

(b) If A and B are canonical conjugate pair of operators, prove that the product of their uncertainties is $(\Delta A)(\Delta B) \geq \hbar/2$. For states with minimum value of uncertainty product, if A and B are canonically conjugate pair of position and momentum obtain the normalized wave function.

2. (a) Write down the schroedinger equation in spherical polar coordinate system and separate the equation into radial and angular parts for a spherically symmetric potential. Solve the angular and radial parts by assuming a square well potential.

Or

(b) Starting from the wave function for the scattering problem in terms of Green's function, obtain the first Born scattering amplitude. Also obtain the scattering cross section for a screened Coulomb potential.

3. (a) Give the matrix theory of harmonic oscillator. Define raising, lowering and number operators. Obtain the energy eigenvalues for the harmonic oscillator.

Or

(b) Obtain the eigenvalue spectrum for the angular momentum vectors J^2 and J_z. Find a matrix representation for J^2 and J_z when the angular momentum is $\frac{1}{2}\hbar$.

4. (a) Discuss the variation method and its application to the hydrogen molecule.

Or

(b) Discuss the semiclassical treatment of radiation and apply it to find the transition probability per unit time for absorption and induced emission in the dipole approximation.

5. (a) Starting from the Dirac Hamiltonian, set up the Dirac's relativistic equation for a free particle. Obtain suitable forms for Dirac matrices $\vec{\alpha}$ and β. Show that the total angular momentum is conserved in a central field for relativistic electron.

Or

(b) Explain second quantization. Discuss the quantisation of non-relativistic schroedinger equation.

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