4533/MPA **MAY 2010**

Paper V — QUANTUM THEORY

(For those who joined in July 2003 and after)

Time : Three hours Maximum : 100 marks

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

All questions carry equal marks.

1. (a) Obtain the Schroedinger equation for a free particle in one dimension. and represent the wave function as a linear combination of superposition of harmonic wave. Explain how this can be generalized to three dimensions. Explain how Schroedinger equation can be modified to include forces. Explain box normalization.

Or

(b) State and prove Ehrenfest's theorem.

2. (a) Explain how the Schroedinger equation can be solved for a spherically symmetric potential in three dimensions. Solve the radial wave equation for a three dimensional square well potential and obtain the energy eigenvalues for the bound state.

Or

(b) Discuss the asymptotic behaviour of partial waves and explain phase shift. Obtain expressions for the scattering amplitude and total scattering cross section in terms of phase shifts. Explain optical theorem.

3. (a) Define Hermitian and unitary matrices. Show that the eigenvalues of a Hermitian matrix are all real. Outline the transformation theory. Explain what is meant by projection operators.

Or

(b) Explain the difference between schroedinger and Heisenberg pictures. Obtain the equations of motion in both these pictures.

4. (a) Discuss the theory of WKB approximation and obtain the solution near a turning point. Using asymptotic connection formula obtain the Bohr-Sommerfeld quantum condition.

Or

(b) Define Einstein coefficients A and B and obtain the relation between them. Discuss photoelectric effect and obtain the transition probability per unit time from the bound to the ionized state.

5. (a) Set up the Klein-Gordon equation for a free particle and for a force field. Solve the Klein – Gordon equation for a hydrogen atom.

Or

(b) Write down the Dirac Hamiltonian and set up the relativistic wave equation for a free particle. Obtain the plane wave solutions for the Dirac particle. Discuss the significance of negative energy states.

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