7506/MPA

OCTOBER 2008

Paper V — QUANTUM THEORY

(For those who joined in July 2003 and after)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

All questions carry equal marks.

1. (a) What is wave packet? How it is represented analytically and diagrammatically. Prove that the velocity of a particle and the velocity of the corresponding wave packet are the same. Outline the probability interpretation of the wave function. (20)

Or

(b) (i) Explain momentum eigen functions - with examples. (6)

(ii) Consider a particle with energy $E<0$ is kept in a potential well defined as

$$V(x) = -V_0 \text{ for } |x| < a$$
$$= 0 \quad \text{for } |x| > a$$

where '$2a$' is the width of the well. Solve the equation to get the energy eigen value and energy eigen function. (14)

2. (a) Write the radial part of Schroedinger equation for hydrogen atom. Solve it to find the energy eigen values and energy eigen functions. Explain bound states. (20)

Or

(b) Outline the method of partial waves and obtain an expression for the total cross section in terms of phase shifts. Discuss the theory of Born approximation in the case of electron and atom scattering and explain its validity. (20)

3. (a) Obtain the equations of motion in Schroedinger picture. Give the matrix theory of linear harmonic oscillator and hence determine the energy value of it. (20)

Or

(b) (i) Distinguish the symmetric and antisymmetric wave functions of a system of identical particles. Construct these functions for n particles system. (12)

(ii) Prove that

(1) $[J_z, J_+] = \hbar J_+$ and

(2) $[J_+, J_-] = 2\hbar J_z$. (8)

4. (a) Explain the variation method. How it can be used to estimate the ground state energy of Helium atom. (20)

Or

(b) Show that the transition probability for spontaneous emission is equal to the transition probability for induced emission that would result from an isotropic field of such intensity that there is one quantum per state of the field in the neighborhood of the transition frequency. (20)

5. (a) Derive Schroedinger relativistic equation for a free particle. Show that Dirac's equation leads automatically to the spin-orbit interaction in the presence of central potential $V(r)$. (20)

Or

(b) Explain quantization of electro magnetic field. Show that

$$H = \sum_{K\lambda} \hbar CK \left(N_{K\lambda} + \frac{1}{2} \right)$$

based on field quantization.
