(i) Printed Pages : 4 Roll No. .....

(ii) Questions : 9 Sub. Code : 2 6 1 0 3

Exam. Code : 0 4 7 2

M.Sc. Physics 1st Semester

(2124)

QUANTUM MECHANICS–I

Paper : PHY–8013

Time Allowed : Three Hours] **[Maximum Marks : 80**

Note :— Attempt **FIVE** questions in all, selecting **ONE** question each from Units I-IV and the compulsory question from Unit-V.

UNIT—I

1. (a) Explain Gram-Schmidt procedure of orthonormalization in detail. 8

   (b) Show that for operators A, B, C satisfying [A, B] = iC, the following relation holds :

   $\Delta A\, \Delta B \geq \frac{1}{2} < C >$, where symbols have their usual meaning. 8

2. (a) Using Dirac operator method, solve one dimensional simple harmonic oscillator for its eigenvalues. 8

   (b) State and prove Schwarz Inequality. 8

UNIT—II

3. (a) Using basic commutator $[x_i, p_j] = i\hbar\delta_{ij}$, i,j = x,y,z, $\vec{L} = \vec{r} \times \vec{p}$, find the commutators :

   (i) $[x, p^2_x]$

   (ii) [Ly, Lx]

   (iii) [px, Ly]

   (iv) $[Lz, L_+]$ 8

   (b) For $\vec{J}_1 = \frac{1}{2}$ and $\vec{J}_2 = \frac{1}{2}$, obtain the Clebsch-Gordan coefficients. 8

4. (a) Obtain the matrix representation of J_x and J_y for spin 1. 8

   (b) Find the eigenvalues of L^2 and L_z. 8

UNIT—III

5. (a) Obtain expression for first order correction to energy and first order correction to wave function for non-degenerate case in time-independent perturbation theory. 8

   (b) A particle of mass 'm' is moving in a one-dimensional box defined by the potential

$$V = \begin{cases} 0, & 0 \le x \le a \\ \infty, & \text{otherwise} \end{cases}$$

   Estimate the ground state energy using trial function

$$\psi(x) = Ax(a - x), \quad 0 \le x \le a$$

   8

6. (a) Write a note on Variational method. 8

(b) A one-dimensional quantum harmonic oscillator is subjected to a perturbation αx^4. Find the first order correction to the energy of the ground state and first excited state. 8

UNIT—IV

7. (a) Discuss briefly the time dependent perturbation theory and obtain the general expression for probability of transition from one state to another under harmonic time dependent perturbation. 10

(b) Discuss the concept of absorption, spontaneous emission and induced emission of radiation using Einstein's coefficients. 6

8. (a) A one-dimensional Harmonic oscillator in the first excited state is subject to a perturbation :

$$H' = axF(t), \text{ where } F(t) = \begin{cases} 0 & t < 0, t > T \\ 1 & 0 < t < T \end{cases}$$

What is the probability that the oscillator will be found in the ground state for $t > T$? Use first order perturbation theory. 10

(b) State and explain Fermi Golden Rule. 6

UNIT—V

9. (a) Write down the properties of projection operator. 2

(b) State two postulates of quantum mechanics. 2

(c) Show that momentum operator is Hermitian. 2

(d) Explain the concept of degeneracy. 2

(e) Define Hilbert Space. 2

(f) Second order correction to ground state energy is always negative, in non-degenerate perturbation theory. Explain why. 3

(g) Write down the properties of inner product. 3