(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

(2125)

QUANTUM MECHANICS–I

Paper : PHY-8013

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

Note :— Answer **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) Write a note on Eigen Kets, Eigen Bras and Dirac operator approach to quantum mechanics. 8

2. (a) Using Dirac operator method, solve one dimensional simple harmonic oscillator for its eigenvalues. 10

   (b) State the properties of :

   (i) Inner product

   (ii) Projection operator 6

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) $[L_x L_z, L_y]$

(ii) $[L_z, y]$

(iii) $[p_x, L_y]$

(iv) $[L_z, L_-]$ 8

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

4. (a) Obtain the matrix representation of J^2 and J_z for spin $\frac{3}{2}$. 8

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

UNIT—III

5. (a) Derive Schrodinger equation using variational method. 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) Explain degenerate perturbation theory. 8

(b) A one-dimensional quantum harmonic oscillator is subjected to a perturbation αx^3. 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) Write a note on Einstein coefficients. 6

8. (a) A one-dimensional Harmonic oscillator in ground state is subject to a perturbation,

$$H' = X^2 V(t), \quad \text{where } V(t) = \begin{cases} 0 & t < 0 \\ V_0 & t \geq 0 \end{cases}$$

Find the probability of finding the system in :

(i) First excited state

(ii) Second excited state 8

(b) State and explain Fermi Golden Rule. 8

UNIT—V

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

(b) State two postulates of quantum mechanics. 2

(c) What are the properties of linear vector space? 2

(d) What is Zeeman effect? 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 complete :

(i) Symmetric,

(ii) Anti-symmetric two identical particle quantum mechanical wave functions. 3