UNIT - V

9. Discuss time-independent perturbation theory and obtain expressions for the first order correction to energy and eigen function. 14

10. Describe briefly the variational method and use it to find the ground state energy of helium atom. 14

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PG ODD SEMESTER EXAMINATION, 2022

PHYSICS

1st Semester

Course No. : PHYCC - 503

(Quantum Mechanics)

Full Marks : 70

Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

(Answer any five questions, taking one from each unit)

UNIT - I

1. (a) Show that the de Broglie wave group associated with a moving particle travels with the same velocity as the particle itself. 6

   (b) State the postulates of quantum mechanics. 5

   (c) What do you mean by coordinate and momentum representations? Express the position and momentum operators in these representations. 3

2. (a) State and prove generalized uncertainty principle. 7

(b) Write a note on Hilbert space. Also, state the meaning of dual Hilbert space. 7

UNIT - II

3. A particle is moving in a one-dimensional potential given by

$V = 0$ for $x < 0$

$V = V_0$ for $x \geq 0$

(a) Write down the Schroedinger wave equation for the particle and solve it.

(b) Calculate the transmittance and reflectance for the case (i) $E > V_0$ and (ii) $0 < E < V_0$, where E is the total energy of the particle. 14

4. (a) Obtain Schroedinger's (i) time-dependent (ii) time-independent equations for matter waves. 10

(b) Write the expressions for energy and wavefunctions of a particle trapped in a one-dimensional box of side L. 4

UNIT - III

5. (a) Describe the meaning of different pictures in quantum mechanics. Obtain the euqation of motion in Schroedinger picture. 10

(b) State and prove Parseval's theorem. 4

6. (a) Discuss how the quantities such as kets, bras and operators are represented in a discrete basis. 7

(b) Dervie the expression for the energy eigenvalues of a linear hormonic oscillator by using operator method. 7

UNIT - IV

7. (a) Obtain the commutation relations satisfied by the orbital angular momentum operators $\hat{L}_x, \hat{L}_y \text{ and } \hat{L}_z$. 6

(b) If $\hat{L}\pm \text{ and } \hat{R}\pm$ are defined by 8

$\hat{L}\pm = \hat{L}_x \pm i\hat{L}_y \quad and$

$\hat{R}\pm = \hat{x} \pm i\hat{y}$

Prove the following commutators :

(a) $[\hat{L}\pm, \hat{R}\pm] = \pm 2\hbar\hat{z} \quad and$

(b) $[\hat{L}\pm, \hat{R}_{\mp}] = 0$

8. What are Clebsch-Gordan coefficients? Find the Clebsch-Gordan coefficients associated with the addition of two angulr momenta $j_1 = \frac{1}{2} \text{ and } j_2 = \frac{1}{2}$ 14