2024
M.Sc.
Second Semester
CORE – 06
PHYSICS
Course Code: MPHC 2.21
(Quantum Mechanics - II)

Total Mark: 70 *Pass Mark: 28*
Time: 3 hours

Answer five questions, taking one from each unit.

UNIT–I

1. (a) Show that a single energy level split into two energy levels according to degenerate perturbation theory. 8
   (b) Suppose we put a delta function bump in the centre of the infinite square well $H' = \alpha\delta\left(x - \frac{a}{2}\right)$.
   (i) Find the first order correction to the allowed energies Ψ_1^1.
   (ii) Find the first three non-zero terms of the correction to the ground state .
   (iii) Find the second order correction to energy E_n^2. 6

2. (a) What is Zeeman effect? Obtain the solution for intermediate Zeeman field effect of hydrogen atom. 6
   (b) The unperturbed wave functions for the infinite square well are $\Psi_n^0(x) = \sqrt{\frac{2}{a}} \sin\frac{n\pi x}{a}$, calculate the first order correction to energy if the floor of the well is raised by a constant potential V_0. 4
   (c) Explain spin-orbit interaction in brief. 4

UNIT–II

3. (a) Describe time dependent perturbation theory. Deduce the solution of two level systems for time dependent perturbation theory. 8
   (b) Obtain the transition probability for sinusoidal perturbations. 6

4. (a) Explain adiabatic process and prove the adiabatic theorem. 7
   (b) State and prove Fermi golden rule. 7

UNIT–III

5. (a) Explain the principle of variational method. Obtain the ground state energy of delta function potential using variational principle. 8
   (b) Obtain the ground state energy of an infinite square well using variational principle. 6

6. (a) Use the variational method to estimate the ground state energy of helium atom. 9
   (b) Derive the expression for the overlap integral for hydrogen molecule ion. 5

UNIT–IV

7. (a) Explain WKB approximation. Obtain the energy eigen value for potential well with two vertical walls using WKB method. 7
   (b) Show that the WKB method gives an exact solution to liner harmonic oscillator. 7

8. (a) Obtain the transmission probability of tunnelling using WKB method and give a detail account on the application of tunnelling to α-decay. 10
   (b) Briefly explain the concept of field emission of electron using WKB approximation. 4

UNIT–V

9. (a) Show that for quantum hard sphere scattering, the total cross-section for low energy scattering is twice the total cross-section of high energy scattering. 8
   (b) Deduce the Rayleigh's formula for quantum scattering. 6

10. (a) What is soft sphere scattering? Obtain the expression for total cross-section for low energy soft sphere scattering. 6

(b) Derive an expression for scattering cross-section for Yukawa potential using Born approximation. 8
