2022

M.Sc.

Second Semester

CORE - 6

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) What is perturbation theory? Obtain the first order correction to energy and the wave function for a stationary state perturbation theory. 8

   (b) If the perturbation $H' = ax + bx^2$ is added to the infinite square well potential $V(x) = \begin{cases} 0 & \text{for } 0 \le x \le \pi \\ \infty & \text{otherwise} \end{cases}$

   obtain the first order correction to the ground state energy. 6

2. (a) Explain briefly the concept of fine structure of hydrogen. Obtain the equation for the energy shift due to spin-orbit interaction. 10

   (b) Explain in brief the hyperfine splitting with an example. 4

UNIT–II

3. (a) What is a variational principle? Show that the expectation of Hamiltonian using an appropriate trial wave function is always greater or equal to the ground state energy of the system. 4

   (b) Show theoretically that a stable electron is shared between the two protons of the Hydrogen molecule ion. 10

4. (a) Show that the variational principle gives a more realistic theoretical value to the ground state energy of helium atom. 10

(b) Obtain the ground state energy of delta-function potential using variational principle. 4

UNIT–III

5. (a) Explain the condition for the validity of WKB approximation. Obtain the WKB solution for classically allowed region, classically forbidden region and show that WKB method blows up at the classically turning point. 10
   (b) Show that WKB method gives an exact solution to linear harmonic oscillator. 4

6. (a) Obtain the tunneling transmission probability using WKB method. 5
   (b) Explain in detail, the application of tunneling to α-decay. 9

UNIT–IV

7. (a) Obtain the transition probability for sinusoidal perturbation. 5
   (b) Explain the time-dependent perturbation theory. Outline the theory of sudden approximation. 9

8. (a) Establish the relations between Einstein coefficients. 5
   (b) Show that the lifetime of an excited state depends on the transition rate coefficient. 5
   (c) Explain in brief about magnetic resonance. 4

UNIT–V

9. (a) Discuss the scattering of particles by a spherically symmetric potential. What do you mean by 'partial wave' and 'phase shifts'? 7
   (b) Obtain an expression for differential scattering cross section from the asymptotic form of wave function. 7

10. (a) Obtain an expression for scattering cross section for Yukawa potential using Born approximation. 6
    (b) Deduce the Rayleigh's formula for quantum scattering. 8
