2023

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) Explain spin-orbit coupling. Obtain the expression for energy shift in the fine structure of hydrogen atom due to spin-orbit interaction. 3+7=10

   (b) Calculate the first order correction to ground state energy of harmonic oscillator with perturbation $H' = \lambda x^4$. 4

2. (a) What is Zeeman effect? Obtain the expression for weak-Zeeman splitting of the ground state of hydrogen atom. 7

   (b) Derive the fundamental result of two fold degenerate perturbation theory. 7

UNIT–II

3. (a) Explain the principle of variation method. Show that the variation method gives an upper bound to the ground state energy. 7

   (b) Using appropriate trial wave function, obtain the ground state energy of harmonic oscillator using variational method. 7

4. (a) Obtain the ground state energy of an infinite square well using variational principle. 7

   (b) Derive an expression for the direct integral and exchange integral for hydrogen molecule ion. 7

UNIT–III

5. (a) Explain WKB approximation. Obtain the solution of classically allowed region ($E > V$) for a motion of particle in a time-dependent potential $V(x)$. 7
   (b) Using WKB approximation, obtain an expression for transmission coefficient. 7

6. (a) Derive the connection formula for WKB approximation. 7
   (b) Explain the concept of field emission of electron using WKB approximation. 7

UNIT–IV

7. (a) Discuss time dependent perturbation theory. Obtain expression for first order transition amplitude. 2+5=7
   (b) State and prove Fermi's golden rule. 7

8. (a) What is harmonic perturbation? Obtain expression for transition probability. 1+6=7
   (b) Discuss Einstein coefficients for spontaneous emission. 4
   (c) Write a short note on selection rule and lifetime of an excited state. 3

UNIT–V

9. (a) Using the method of partial wave, obtain cross-section for scattering by a perfectly rigid sphere. 8
   (b) Derive an expression for total scattering cross section in terms of phase shift. 6

10. (a) Explain quantum scattering theory. Show that $\sigma(\theta, \Phi) = \left| f(\theta, \Phi) \right|^2$. 2+5=7
   (b) Show that for a classical hard sphere scattering, the cross-sectional area of the sphere is πr^2. 7