2021

B.A./B.Sc.

Fifth Semester

CORE – 11

PHYSICS

Course Code: PHC 5.11

(Quantum Mechanics & Applications)

Total Mark: 70 *Pass Mark: 28*

Time: 3 hours

Answer five *questions, taking* one *from each unit.*

UNIT–I

1. (a) State and prove the Cauchy-Schwarz inequality. 5
   (b) Are the vectors X_1=(1,0,0), X_2=(0,1,0), X_3=(0,0,1) linearly dependent? 2
   (c) Define eigenvectors and eigenvalues. Find the eigenvalues and eigenvectors of matrix $A=\begin{bmatrix}3 & 1 & 4\\ 0 & 2 & 6\\ 0 & 0 & 5\end{bmatrix}$ 7

2. (a) Prove that $C\langle X|Y\rangle = \langle CX|Y\rangle$ 2
   (b) Check whether the given set of vectors X_1=(1,2,1) and X_2=(2,1,4) are orthogonal. If they are not orthogonal, construct an orthogonal set of vectors. 5
   (c) What is diagonalisation of matrix? Explain the theorem on diagonalisation of a matrix. 7

UNIT–II

3. (a) Define operator. Show that the eigenvalues of Hermitian operator are real. 5
   (b) Prove that [A,[B,C]]+[B,[C,A]]+[C,[A,B]]=0. 4
   (c) Show that an operator representing any two components of the

orbital angular momentum do not commute. 5

4. (a) Prove that $[L_z, y] = -i\hbar x$ 4

(b) Show that the ladder operator L_+ increases the eigenvalue of operator L_z by $\hbar$. 3

(c) Explain the concept of parity. Show that eigenvalues of parity operators are +1 and –1. 7

UNIT–III

5. (a) Write a note on uncertainty principle. Give different forms of uncertainties. 5

(b) Calculate the maximum kinetic energy of a photoelectron (in eV) emitted, if incident light of wavelength 6.2×10^{-6} m falls on a metal surface. The work function of the metal is 0.1 eV. 3

(c) What is Compton effect? Illustrate how this phenomenon could be explained using the quantum theory of radiation. 6

6. (a) Discuss how classical approaches failed to account for the spectral distribution of energy density in the blackbody radiation. How did Planck's theory overcome this difficulty? 5

(b) Find the longest and the shortest wavelengths of the Lyman series. Given Rydberg constant $R = 1.097\times10^{7}\ m^{-1}$. 3

(c) Define specific heat capacity. Explain Einstein theory of specific heat of solids. 6

UNIT–IV

7. (a) Find the expectation value of position and momentum whose wave function is $\psi(x) = Ae^{\frac{x^2}{2S^2}} + ikx$ 5

(b) Obtain Schrodinger's time independent equation from time dependent equation. 5

(c) State and explain any four postulates of quantum mechanics. 4

8. (a) What are the continuity and boundary conditions that must be

satisfied for a wave function to be physically acceptable? 4

(b) State and prove Ehrenfest's theorem. 10

UNIT–V

9. (a) Calculate the three lowest energy levels (in eV) for an electron inside a one-dimensional infinite potential well of width 2Å. Given mass of electron $m = 9.1\times10^{-31}$ Kg, $\hbar = 1.05\times10^{-34}$ Js. 3

(b) The restoring force constant K for the vibrations of the inter-atomic spacing of the diatomic molecules is 10^3 J/m^2. If mass of the molecule is 4.9×10^{-26} kg, estimate the zero point energy of the oscillator. 3

(c) Obtain the energy eigenvalues and the normalized eigenfunctions for a particle in a one-dimensional infinite square well. 8

10. (a) What do you mean by tunneling through a barrier? A particle travelling with energy $E>0$, has a potential barrier defined as

$$V = \begin{cases} 0 & x \le 0 \\ V_0 & 0 < x < a \\ 0 & x \ge 0 \end{cases}$$

Obtain formulae for the transmission coefficient and reflection coefficient. 8

(b) Using ground state function of the simple harmonic oscillator, show that the ground state energy is $\frac{1}{2}\hbar\omega$. 6
