5th semester Sessional Examination 2022 (CBCS)

Subject- Physics

Paper code : PHY-HC-5016 : Paper name: Quantum Mechanics and application

Marks: 30 Time: 1 hour

1) Answer any four 1×4=4
   a) Which of the following represents a localized wave function

   i) $\Psi(x,t) = \int_{-\infty}^{\infty} A(k)e^{i(kx-wt)}\, dk$ ii) $\Psi(x,t) = A\, e^{-i(kx-wt)}$ iV) $\Psi(x,t) = A \sin(kx - wt)$

   b) Only hermitian operators are associated with physical quantities. Why?

   c) The probability of finding a particle at a given point in space and at a given time is proportional to i) Ψ ii) $|\Psi|^2$ iii) $1/\Psi$ iv) $1/|\Psi|^2$ (Choose the correct)
   d) The Hamiltonian operator is the operator associated with i)linear momentum ii)position iii)energy iv)angular momentum (choose the correct)
   e) What is the value of angular momentum of an electron with orbital quantum number *l*
   f) What is Bohr Magneton ?

2) Answer any two 3×2=6

a) What is degenerate state? Show that n-th energy level of Hydrogen atom has degeneracy n^2

b) Normalize the wave function $\Psi(x) = Aexp(-\alpha^2x^2)$, $-\infty<x<\infty$ where A , α constants.

c) If Ψ_m and Ψ_n are two independent solutions of Schrödinger equation show that

$C_1\Psi_m + C_2\Psi_n$ is also a solution (C_1, C_2 are constants) . What property does it specify? 2+1=3

d) What is zero point energy? Give the physical significance of zero point energy. 1+2=3

3) Answer any two 5×2=10

a) From one dimensional time dependent Schrödinger equation obtain the time independent Schrödinger equation. Write this equation in operator form. 4+1=5

b) Prove i) $[L_x, L_y] = i\hbar L_z$ ii) $[L^2, L_x] = 0$ 3+2=5

c) What is Larmor theorem? Find the expression for Larmor frequency. 1+4=5

4) Answer any one 10×1=10

a) Define probability current density. Deduce the equation $\frac{\partial\rho}{\partial t} + \nabla.J = 0$ where $\boldsymbol{\rho}$ is position probability density , J is probability current density. Show that probability is conserved.

1+6+3=10

b) Show that for linear harmonic oscillator Schrödinger equation can be written as

$\frac{d^2\Psi}{dy^2} + (\lambda - y^2)\Psi = 0$ where $y = \sqrt{\frac{m\omega}{\hbar}}\,x$, $\lambda = \frac{2E}{\hbar\omega}$. Using Frobenius methods solve this equation to obtain energy Eigen values. What is its ground state energy? 3+6+1=10

c) Write Schrödinger equation for Hydrogen atom in spherical polar coordinates r,θ,ϕ. Separate this equation into radial, polar and azimuthal equations. Express the radial equation in equivalent one dimensional form with effective potential $V_{eff}(r) = V(r) + \frac{l(l+1)\hbar^2}{2mr^2}$. 1+6+3=10