Exam.Code:0905
Sub. Code: 33259

2125
B.E., First Semester
ASP-X02: Quantum Physics
(Common with CSE, IT)

Time allowed: 3 Hours **Max. Marks: 50**

NOTE: Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Section.

x-x-x

Question I Attempt any five parts (2 x 5=10)

(a) What was the drawback of Rayleigh Jeans treatment of black body radiation spectrum which led to ultraviolet catastrophe?

(b) What is Ehrenfest theorem and what is its significance?

(c) How do you understand barrier penetration through energy-time uncertainty principle?

(d) A particle is trapped in rigid cubical box and possesses energy of $9E_0$. Evaluate the fold of degeneracy associated with this energy.

(e) What are the essential requisites of quantum logic gates?

(f) What are Bell states and why are they significant?

(g) What are the distinct features of the harmonic motion of a quantum oscillator, compared with that of a classical oscillator?

SECTION A

Question II

(a) Show that the electron always recoils in the forward hemisphere in the Compton scattering process.

(b) Derive the expression for the average energy carried by each mode of oscillation in the black body radiation distribution.

(c) If radius of the hydrogen atom is $0.053nm$, then estimate its lowest energy.

(4,4,2)

Question III

(a) Arrive at the steady state Schrodinger's equation from first principles. Further write down the properties of a physically acceptable wave function.

(b) A moving particle is described by a wave function $\psi(x) = \sqrt{2}x \; for \; 0 < x < 1$ while it is zero elsewhere. Find the probability of finding the particle in the interval $\left(0, \frac{1}{3}\right)$. What is the average value of position of particle in given range?

(c) Why is the photoelectric effect not possible for a free electron? Justify.

(5,3,2)

P.T.O.

Question IV

(a) Show that the Heisenberg's uncertainty principle is a direct consequence of dual nature of moving material particles.

(b) X-rays of wavelength 0.1nm are scattered at such an angle that the recoil electron has maximum kinetic energy. What is wavelength of scattered X-ray and kinetic energy of recoiling electron?

(c) Prove that $[x^n, p_x] = i\hbar n x^{n-1}$. (4,3,3)

SECTION B

Question V

(a) An electron of kinetic energy E is incident on potential step of height V_0 such that $E > V_0$. Set up Schrodinger's equation for this system and show that the transmission of electron through the potential step is less than unity.

(b) A particle of mass 10^{-9} kg is moving with a speed 10^{-3} m/s in a one-dimensional potential well of infinite depth. If the width of the well is 10^{-2} m, calculate the number of possible quantum states of the particle in this well.

(c) If a proton (mass = 1 a.m.u.) and a deuteron (mass = 2 a.m.u.) have the same energy and are incident on a rectangular potential barrier, which of the two will penetrate more deeply into the barrier?

(4,3,3)

Question VI

(a) A particle of mass m and kinetic energy E is trapped in an infinitely deep one-dimensional potential well. Set up Schrodinger's equation for this system and obtain eigenvalues and eigenfunctions of permissible states. Further show that permissible eigenstates are mutually orthogonal.

(b) Write a note quantum bits clearly bringing out distinction from classical bits and emphasising EPR pairs.

(6,4)

Question VII

(a) Discuss various logic gates in classical computation and quantum computations. Further justify that all classical logical gates can't be inherited for quantum computation.

(b) Draw and discuss the working of a bit swapping quantum circuit.

(c) What are the major distinctions between classical and quantum computers.

(5,3,2)

x-x-x