Exam.Code:0905
Sub. Code: 6204

2023
B.E., First Semester
ASP-X02: Quantum Physics (CSE, IT)

Time allowed: 3 Hours | Max. Marks: 50

NOTE: *Attempt five questions in all, including Question No. 1 which is compulsory and selecting two questions from each Part.*

x-x-x

Q1. ***Attempt the following questions.*** **(2 x 5=10)**

(a) Show that the velocity of a relativistic particle, with momentum p, is given by

$$v = \frac{pc}{\sqrt{(p^2 + m_0^2 c^2)}}$$

(b) Show that pair production cannot occur in free space.

(c) The wave function of a certain particle is $\Psi = Ax\, e^{ix}$ for $0 < x < L$. Find the value of normalization constant, A.

(d) Find the width of the box if an electron in a one-dimensional infinite potential well, defined by V(x) = 0 for -a<x<a) and V(x) = ∞ otherwise, goes from the n = 4 to the n = 2 level. The frequency of the emitted photon is 3.43×10^{14} Hz.

(e) Calculate the Fermi energy (in eV) and Fermi temperature if Fermi velocity of electron in Cs metal is 0.73×10^6 m/s.

Part-A

Q2.

(a) What was the objective of conducting the Michelson-Morley experiment? Describe the experiment. How is the negative result of the experiment interpreted? **(5)**

(b) A π-meson has a mean life of 2×10^{-8} sec when measured at rest. How far does it go before decaying if moving at a speed of 0.99 c? **(2)**

(c) Show that under certain conditions, Lorentz transformation equations become identical to Galilean transformation. **(3)**

Q3.

(a) Compare the uncertainities in the velocities of an electron and a proton confined in a 1 nm box. **(2)**

(b) What was the objective of Davisson Germer experiment? Discuss the results of this experiment. **(4)**

(c) Derive an expression for Compton shift in the wavelength of a photon after scattering from an electron. **(4)**

Q4.

(a) What are operators? Obtain the operator form of time independent Schrodinger equation. **(4)**

(b) Find out whether $Nx\, exp\ (-x^2/2)$ is an eigenfunction of Hamiltonian operator and if yes, determine its eigenvalue. **(2)**

(c) Derive an expression for the gravitational red shift. Find the approximate red shift in 500 nm light emitted by a white dwarf star whose mass is 2×10^{30} kg and radius is 6.4×10^6 m. **(4)**

Part-B

Q5.

(a) A proton and a deuteron attempt to penetrate a rectangular potential barrier of height 10 MeV and thickness 10^{-14} m. Both particles have total energies of 3 MeV. Use qualitative arguments to predict which particle has the highest probability of succeeding. Evaluate quantitatively the probability of success for both particles. **(3)**

(b) Assuming the time independent Schrodinger equation, discuss the solution for a particle in one dimensional potential well of infinite height. Also obtain the normalized wave function. **(4)**

(c) Compare the probability densities of a particle in quantum mechanical oscillator with that of a classical oscillator. Also show how this harmonic oscillator problem is in accordance with correspondence principle. **(3)**

Q6.

(a) Explain the formation of allowed and forbidden bands in solids using Kronig-Penney model. **(5)**

(b) Consider an electron moving in a crystal lattice. Derive the expression for its effective mass. Show the variation of the effective mass in a band. **(5)**

P.T.O.

Q7.

(a) State and explain Dulong-Petit's law and show how the departure from this law has been explained by Einstein's theory. (3)

(b) Explain the free electron model proposed by Drude & Lorentz. What modifications were proposed by Sommerfield? Find the drift velocity of electrons in copper conductor with a cross sectional area of 10^{-6} m2 carrying a current of 4A. The atomic weight of Cu is 63.6 and the density is 8.9 g/cm3 (4)

(c) Discuss the variation of Fermi Dirac distribution function with temperature. (3)

x-x-x