Exam.Code:0905
Sub. Code: 6645

1078
B.E. (Biotechnology), First Semester
APH-103: Quantum and Statistical Physics
(Common with IT and CSE)

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.*

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Q1. Attempt any five parts of the following:

(a) Find the Schwarzschild radius of the earth, whose mass is 5.98×10^{24}kg? (2)

(b) An electron in an electron gun is accelerated by a potential of 100KV. Calculate its velocity and mass using classical and relativistic considerations? (2)

(c) Calculate the percentage contraction in length of a rod moving with velocity 0.8c in the direction of its own length? (2)

(d) Under what circumstances is an atomic electron's probability density distribution spherically symmetric? (2)

(e) Why spin quantum number was introduced? (2)

(f) Why inhomogeneous magnetic field is used in Stern-Gerlach experiment? (2)

(g) In classical statistics, what is the basis for treating identical gas molecules as distinguishable? (2)

Part A

Q2. (a) Deduce the relativistic velocity addition theorem. Show that it is in agreement with second postulate of relativity. (4)

(b) What was the theoretical background of the Michelson –Morley Experiment? How are the negative results of the experiment interpreted? (3)

(c) Verify that $\gamma^2 = 1 + \frac{p^2}{m^2c^2}$ (3)

Q3. (a) Show that two simultaneous events at different positions in a frame of reference are not in general simultaneous in another inertial frame moving relative to this frame with velocity v. (3)

(b) What are black holes? How can we detect them? (3)

(c) X- rays of wavelength 10 pm are scattered from a target. (i) Find the wavelength of the x-rays scattered through 45°. (ii) Find the maximum wavelength present in the scattered x-rays. (c) Find the maximum kinetic energy of the recoil electrons. (4)

Q4. (a) Deduce time independent one dimensional Schrödinger equation for a non-relativistic free particle. (6)

(b) What is Max Born's interpretation of a wave function? (2)

(c) What effect on the scattering angle in the Davisson-Germer experiment does increasing the electron energy have? (2)

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Part B

Q5. (a) Derive an expression for energy of a particle of mass m confined to infinite potential well of width L. Why such a particle cannot have zero energy? (6)

(b) Find the expectation value of the position of a particle trapped in a box L wide. (4)

Q6. (a) Write the wave function of Hydrogen atom and explain the significance of each quantum number. (4)

(c) A sample of a certain element is placed in a 0.3 T magnetic field and suitably excited. How far apart are the Zeeman components of the 450nm spectral line of this element? (4)

(c) Under what condition/conditions do B-E and F-D statistics yield classical statistics? (2)

Q7 (a) What is Plank's quantum hypothesis to explain the observed spectrum of a black body? Give shortcomings of the old theory. (5)

(b) Show that the average kinetic energy of a three dimensional gas of N free electrons at 0°K is $\overline{E_0} = \frac{3}{5} N E_F$ (5)

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