May - 2016

(i) Printed Pages : 4 Roll No. .....

(ii) Questions : 7 Sub. Code : 6 6 6 8

Exam. Code : 0 9 0 6

B.Engg. 1st Year 2nd Semester

1046

(Mechanical) - QUANTUM AND STATISTICAL PHYSICS

(Common with ECE, IT and EEE)

Paper : APH - 203 (Common with ECE, IT & EEE)

Time Allowed : Three Hours] **[Maximum Marks : 50**

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

I. Answer the following briefly :

(a) Mention the postulates of Special theory of relativity.

(b) Explain the terms observable and operator. What is a Hermitian operator ?

(c) Define orbital angular momentum and orbital quantum number.

(d) Explain the relation between the zero-point energy and the uncertainty principle.

(e) How is Doppler effect different for sound and light waves ?

(f) Distinguish between Bose-Einstein and Fermi-Dirac Statistics.

(g) Why $\Phi = ax^2$ is not acceptable wavefunction in quantum mechanics ?

on VIII Solve the one-dimensional wave equation $\frac{\partial}{\partial x^2} = \frac{}{c^2}$

$t) = 0$ and initial conditions $y(x,0) = f(x)$, $\frac{\partial y}{\partial t}(x,0) =$

initial velocity. Here $y = y(x,t)$.

(h) Explain the importance of Fermi energy.

(i) Mention the significance of the Schwarzschild radius.

(j) Is it possible to observe the Compton effect with visible light ? Why ? $10\times1=10$

SECTION–A

II. (a) Discuss the Doppler effect in light. Derive an expression of change in wavelength when a source of light is receding away from the observer. Give one example to explain the relevance of this effect. 5

(b) Describe Michelson's Morely experiment. What is the aim and conclusion of the experiment ? 5

III. (a) Calculate the wavelength of incident X-ray photon which produces recoil electron of energy 4 keV in Compton effect. The electron recoils in the direction of incident photon and photon is scattered at an angle of 180°. 3

(b) State the postulates of quantum mechanics. 3

(c) Show that the expression for de-Broglie wavelength of a particle with rest mass m_0, and kinetic energy K in eV can be written as $\lambda = hc/\left[K\left(2m_0c^2 + K\right)\right]^{1/2}$ 4

IV. (a) Two rockets of rest length L_0 are approaching the earth from opposite directions at velocities c/2. How long does one of them appear to the other ? 3

(b) Assume that the uncertainty in the position of a particle is equal to its de-Broglie wavelength. Show that the uncertainty in its velocity is equal to or greater than $(1/4\pi)$ times its velocity. 3

(c) Derive Schrodinger time independent wave equation. What do you mean by stationary states ? 4

SECTION–B

V. (a) Describe Stern-Gerlach experiment with necessary theory. What was the aim of the experiment ? Discuss its significance. 4

(b) What are orthogonal wavefunctions ? For a particle in one dimensional box, show that the wavefunctions for two different states are orthogonal. 4

(c) Explain the physical significance of quantum numbers n, ℓ and m_l. How are they interrelated ? 2

VI. (a) Write a short account of the distribution of energy in the spectrum of a black body. Indicate graphically the energy distribution of black body radiation with wavelength at different temperatures. Discuss the important results with reference to Wien's and Rayleigh Jeans law. 5

(b) State and explain Pauli's exclusion principle. How does knowledge of symmetric and anti-symmetric wave functions lead to this principle ? 2

(c) Show that the average energy of a Planck's oscillator is given by $hv/(e^{hv/kt}-1)$. 3

find the general integrals of the ... $\frac{\partial^2}{\partial}$

... the one dimensional wave equation

VII. (a) Evaluate the transmission coefficient for an electron of total energy 2 eV incident upon a rectangular potential barrier of height 4 eV and thickness 10^{-10} m. 3

(b) What is spin-orbit interaction ? How does it lead to the observed fine-structure splitting of the spectral lines of the hydrogen atom ? 4

(c) Compare the probability for three bosons to be in a particular state with the three classical particles to be in the same state. 3

(i) Printed Pages : 3

(ii) Questions : 8

Roll No. .....

Sub. Code : 6 6 4 5

Exam. Code : 9 0 5

B.Engg. 1st Semester

1125

QUANTUM AND STATISTICAL PHYSICS

Paper–APH-103

Time Allowed : Three Hours] **[Maximum Marks : 50**

Note : (i) All questions carry equal marks.

(ii) Question **I** is compulsory.

(iii) Attempt **five** questions in all selecting **two** questions from each Part.

I. Attempt any **five** parts :

(a) What is ultraviolet catastrophe ?

(b) Why Doppler effect in light is termed as symmetric phenomenon ?

(c) Give two distinguishing features between three kinds of statistics obeyed by different physical systems.

(d) What are the postulates of special theory of relativity ?

(e) What are space like events ? Do they obey principle of causality ?

(f) What are the basic requisites for wave function to represent the state of a physical system ?

(g) Why a particle can't be at rest in the infinitely deep one dimensional potential well ? 2×5=10

PART–A

II. (a) Discuss Michelson-Morley experiment clearly giving its objective and results. 7

(b) Using Lorentz transformation, obtain the relation for length contraction. 3

III. (a) Derive the Lorentz transformations for different components of particles velocity. 5

(b) Show that $(E/c)^2 - p^2$ is invariant under Lorentz transformations. 5

IV. (a) Arrive at steady state form of Schrodinger's equation and show that the energy quantization is natural consequence of this equation. 6

(b) An X-ray photon is found to have its wavelength doubled on being scattered through 90°. Find the wavelength and energy of the incident photon. 4

PART–B

V. (a) A particle of mass m and kinetic energy E is incident on a one dimensional potential step of height V_0, such that $E < V_0$. Solve Schrodinger's equation for this particle and list the observations. How do these observations differ from the expectations of classical mechanics ? 7

(b) Prove the identity that $\lfloor x^2, p_x \rfloor = 2i\hbar x$. 3

(a) Discuss Stern Gerlach experiment emphasizing on its objective and outcome. 5

(b) Write a brief note on Zeeman effect. 5

VII. What is thermionic emission ? Using appropriate formalism of statistical physics, derive expression for Richardson Dushmann equation. 10

VIII. Giving basic elements of Maxwell-Boltzmann distribution, derive the distribution for molecular energies in a gas. 10

Discuss the mechanism of addition polymerizatio

Printed Pages : 3 Roll No. .....

Questions : 7 Sub. Code : 6 6 5 7

Exam. Code : 9 0 5

B.E. Computer Science & Engg. 1st Semester

1124

QUANTUM AND STATISTICAL PHYSICS

Paper :APH-103

Time Allowed : Three Hours] **[Maximum Marks : 50**

Note :– Attempt **five** questions in all including the compulsory question no. 1. All questions carry equal marks.

1. (a) State the two postulates of Special Theory of Relativity. 2

(b) What are the postulates of Quantum Mechanics ? 2

(c) Construct normalized, completely anti-symmetric two particle wavefunction. 2

(d) What is :

(i) Compton Effect

(ii) Photoelectric Effect ? 2

(e) What is Black Body Radiation ? Explain. 2

2. (a) Write a note on Lorentz transformations. 5

(b) In the reference frame of a star, the light emitted has frequency 5.55×10^{13} *Hz*, whereas an observer measured it as 6.66×10^{14} *Hz*. At what speed the star is moving towards / away from the observer ? 3

Q6. i) Explain the difference between structures and union

(c) How do two velocities add up in :

(i) Galilean frame

(ii) Lorentz frame ?

3. (a) A typical atomic nucleus radius is about 5×10^{-15} meters. Argue using uncertainty principle that it is not possible for it to contain electron. 4

(b) What is Bragg's Law ? How does it help in finding structure of a crystal ? 3

(c) What is de Broglie Hypothesis ? What is the typical value of de Broglie wave length of electron ? 3

4. (a) Use the ground state linear harmonic oscillator wavefunction to show by direct integration that expectation value of momentum operator P, $(< \Psi_0 \mid P \Psi_0 >)$ is zero. 4

(b) Explain qualitatively what happens when a quantum particle comes across a :

(i) Potential well

(ii) Potential barrier. 6

5. (a) Discuss qualitatively the Hydrogen Atom Spectrum. 5

(b) What happens when a Hydrogen atom is placed in magnetic field ? 3

(c) What does Stern-Gerlach experiment reveal ? 2

6. (a) Give a qualitative description of Kronig-Penney model. 5

(b) How does one distinguish conductors, semiconductors and insulators ? 5

2

(a) Briefly describe :

(i) Maxwell-Boltzman statistics

(ii) Bose-Einstein statistics and

(iii) Fermi-Dirac statistics. 6

(b) Why the electrons in a metal do not contribute to its specific heat except at very high and very low temperatures ? 4

to array and Pointe

Q6. i) Explain the difference between structures and unions w

ii) Explain different input and output functions in C.

Exam.Code:0905
Sub. Code: 6645

1127

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. I which is compulsory and selecting two questions from each Section.

x-x-x

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

(a) Draw and discuss the working of a Ferry's black body.

(b) What were the conclusions of Davison Germer experiment.

(c) Distinguish between macrostate and microstate of a statistical system.

(d) Show that Lorentz transformations of coordinates of a moving particle reduces to Galilean transformation when speed of particle is negligible as compared to the speed of light.

(e) Qualitatively argue that Heisenberg's uncertainty principle is natural consequence of wave nature of a particle.

(f) Why a particle of mass m trapped in an infinitely deep one dimensional potential well can never be at rest.

(g) How is the performance of PIN diode improves due to tunneling effect.

Section A

II (a) What was the objective of Michelson Morley experiment. Describe the working of interferometer used in this experiment. Giving observations, discuss the inferences drawn from this experiment. (7)

(b) Derive the energy-momentum relation $E^2 = p^2c^2 + m^2c^4$. (3)

III (a) How was meson decay problem explained through the concept of special theory of relativity. (5)

(b) Show that $(x^2 + y^2 + z^2 - c^2t^2)$ is invariant under Lorentz transformations. (5)

IV (a) What is photoelectric effect. How does quantum theory explains this phenomenon. (6)

(b) An x-ray photon is found to have its wavelength doubled on being scattered through 90°. Fi the wavelength and energy of the incident photon. (4)

Section B

V (a) A particle of mass m and kinetic energy E is trapped in one dimensional potential well of infinite depth, Solve Schrodinger's equation for this particle to obtain permissible states of trapped particle. Further show that energy quantization is a natural consequence. (7)

(b) Prove the identity that $\left[x^2, p_x\right] = 2i\hbar x$ (3)

VI.(a) Derive the expression for radiative transitions in the hydrogen atom. What are its guiding selection rules. (5)

(b) Discuss objective, working and inferences of Stern-Gerlach experiment. (5)

VII What is black body radiation? Using appropriate formalism of statistical physics, derive expression for Planck's radiation formula. (10)

Exam. Code: 0905
Sub. Code: 6645

1128

B.E. (Bio-Technology) 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. I which is compulsory and selecting two questions from each Part.

x-x-x

I. Attempt any five of the following:-

a) What is paradoxical about twin paradox?

b) Why pair production cannot occur in free space?

c) Why gravitational red shift is not apparent for most of the stars?

d) What are the angles between L and the z axis for l = 1? For I=2?

e) Why is it not possible for Stern-Gerlach-experiment to be performed in a uniform magnetic field?

f) Distinguish between macrostate and microstate of a statistical system.

g) Under what condition do B-E and F-D statistics yield Classical statistics? (5x2)

UNIT – I

II. a) What was the aim and conclusion of Michelsen-Morely experiment?

b) According to the postulates of Einstein theory, laws of physics are same in all inertial frame. What about non-inertial frames? Why they can't be same in non-inertial frame?

c) What were the limitations of Galilean transformations? Obtain Lorentz transformation laws for position and time coordinates. Why we consider y=y' and z=z'? (2,3,5)

III. a) How are continuous and characteristic X-rays produced? How can you control the intensity and penetrating power of the X-rays?

b) Work function of nickel is 5.01 eV. Will violet light of wavelength 400nm cause the photoelectric effect in nickel?

c) Cite an experiment which proved de Broglie's hypothesis. (3,3,4)

P.T.O.

IV. a) What is the Bern's interpretation of quantum mechanical wave function? What are the essential requirements for an acceptable (well-behaved) wave function?

b) Using operator mechanics find cummutator $[\hat{x}, \hat{p}_x^2]$.

c) Qualitatively show that Heisenberg's Uncertainty principle is natural consequence of wave nature of particle. (4,4,2)

UNIT – II

V. a) A particle having energy E faces a step potential barrier of height V_o at X=0. Show that even if $E<V_o$. the particle has finite probability to tunnel into the region X>0.

b) Prove that average value of for a Is electron in hydrogen atom is $\frac{1}{a_0}$. a_0 is Bohr radius and wave function for 1s electron is $\psi = \frac{e^{\frac{-r}{a_0}}}{\sqrt{\pi} a_0^{\frac{3}{2}}}$

VI. a) How is the Pauli exclusion principle a consequence of antisymmetric wave function?

b) Show that Rayleigh-Jeans law failed but Plank's radiation law successfully explained the observed radiation spectrum of a blackbody. (5,5)

VII. a) Discuss the phenomenon of thermionic emission in metals. Obtain Richardson - Dushman equation.

b) Show that the most probable speed of an ideal gas molecule is $\sqrt{\frac{2kt}{m}}$. (6,4)

Exam. Code: 0906
Sub. Code: 6668

1018

B. Engg. (Mechanical)

1st Year (2nd Semester)

APH-203: Quantum and Statistical Physics

(Common with ECE, IT & EEE)

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 Part.*

x-x-x

Q1. Attempt any five parts:

(a) For most of the stars gravitational red shift is not apparent. Why?

(b) What bearing would you think the uncertainty principle has on the zero point energy of a harmonic oscillator?

(c) Why is it impossible for a $2^2D_{3/2}$ state to exist?

(d) Find the value of $[\hat{x}, \hat{p}_x^2]$.

(e) What is the significance of Fermi energy in a fermion system at 0K? At T>0K?

(f) Calculate the number of different arrangements of 6 bosons among 4 cells of equal a priori probability.

(g) Under what circumstances, if any, is Lz equal to L?

5 X 2=10

Part A

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

(b) Show that the mass of an object depends on its velocity. Cite an experiment to support this fact. (4)

(c) An electron (m= 0.511 MeV/c^2) and a photon (m=0) both have momenta of 2.00 MeV/c. Find the total energy of each. (2)

Q3. (a) What is Compton Effect? Find the maximum energy of the recoil electron. (6)

(b) Find the Schwarzschild radius of the earth, whose mass is 5.98×10^{24} Kg. (2)

(c) A positron collides head on with an electron and both are annihilated. Each particle had a kinetic energy of 1 MeV. Find the wavelength of the resulting photons. (2)

Q4. (a) Is it correct to say that the maximum photoelectron energy KE_{max} is proportional to the frequency of incident light? If not, what would a correct statement of the relationship between KE_{max} and frequency 'f' be? (3)

(b) The wave function of a particle is $\psi = A\cos^2 x$ for $\frac{-\pi}{2} < x < \frac{\pi}{2}$. (i) Find the value of A. (ii) Find the probability that the particle be found between x=0 and x= $\frac{\pi}{4}$. (4)

(c) What is Heisenberg's uncertainty principle? Apply it to prove the non-existence of the electron in the nucleus. (3)

P.T.O

Part B

Q5. (a) Show that the evenly spaced energy levels of quantum harmonic oscillator are given by equation: $E_n = \left(n + \frac{1}{2}\right)\hbar\omega$ where n is quantum number. What is zero point energy of the harmonic oscillator. (6)

(b) An electron is bound by a potential which closely approaches an infinite potential square well of width 2.5×10^{-10}m. Calculate the lowest three permissible quantum energies the electron can have. (4)

Q6. (a) Write the wave function for hydrogen atom. Discuss the significance of the quantum numbers. (5)

(b) What was the basic objective of Stern Gerlach experiment? With suitable schematic, discuss the observations and results of the experiment. (5)

Q7 (a) Show that the average kinetic energy of a three dimensional gas of N free electrons at 0^{o}K is $\overline{E_0} = \frac{3}{5}E_F$. (5)

(b) State Plank's radiation law and derive it from Bose-Einstein statistics. How does this law solve ultraviolet catastrophe? (5)

x-x-x

Exam.Code:0905
Sub. Code: 6645

1127

B.E. (Biotechnology)

First Semester

APH-103: Quantum and Statistical Physics

(Common with IT and CSE)

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Section A

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x-x-x