Sem 5 T.Y.B.Sc. Physics Nov 2022

(3 Hours) [Total Marks: 100]

N.B. : (1) **All** questions are **compulsory**.
(2) **Figures** to the **right** indicate **full** marks.
(3) Draw **neat** diagrams wherever **necessary**.
(4) Symbols have usual meaning unless otherwise stated.
(5) Use of **non-programmable** calculator is allowed.

Q1. Attempt any **two:---**

(i) Starting with the three dimensional Schrodinger's equation in spherical polar coordinates for Hydrogen atom, obtain three ordinary differential equations that describe the hydrogen atom. **10**

(ii) Explain space & magnitude quantization in hydrogen atom in Schrodinger's hydrogen model. **10**

(iii) What are symmetric and anti-symmetric wave functions? Show that system of electrons is described by antisymmetric wave functions. **10**

(iv) a) State the rule of maximum multiplicity and explain it with one example. **10**
b) Find set of all four quantum numbers for all the electrons in n = 2 (L – shell) using Pauli's exclusion principle.

Q2 Attempt any **two:---**

(i) Explain Vector atom model with *LS* coupling and *JJ* coupling schemes. **10**

(ii) Explain quantum theory of radiative transition. Also show that when the electron jumps from higher energy level E_m to a lower energy level E_n the frequency of photon emitted is $\nu = \frac{E_m - E_n}{h}$ **10**

(iii) Discuss the quantum theory of normal Zeeman effect and obtain an expression for Zeeman shift. **10**

(iv) Derive the expression for Lande g-factor. **10**

Q3 Attempt any **two:---**

(i) Considering the diatomic molecule as a rigid rotator, derive an expression for rotational energy E_J and show that the rotational energy levels are not equally spaced. **10**

(ii) Write the expression for vibration-rotation energy levels of a rigid diatomic molecule (neglect anharmonicity). Discuss features of P- branch and R-branch using suitable energy level diagram. **10**

(iii) What is Born Oppenheimer approximation? What is meant by coarse structure of an electronic spectrum of a diatomic molecule? Discuss it by drawing a suitable energy level diagram. **10**

(iv) State the principle of microwave spectrometer. Draw its labeled schematic diagram and explain the functions of its various parts. **10**

Q4 Attempt any **two:---**

(i) Give classification of molecules based on rotational behavior. **10**

(ii) Explain the Raman activity of vibrations of Carbon Dioxide molecules by considering different modes of vibration. **10**

(iii) Discuss pure rotational Raman spectra of linear molecules. **10**

(iv) Explain the Electron Spin Resonance (ESR) in materials. Why paramagnetic materials exhibit ESR? **10**

Q5. Attempt any **four:---** **20**

(i) Solve the Φ – equation and normalize the wave function. Name the quantum number introduced. **05**

(ii) Using $R = \frac{2}{a^{3/2}} e^{-r/a}$ calculate the radial probability density of electron beyond Bohr radius 'a'. **05**

(iii) Calculate the angle between $\bar{J}$ and $\bar{L}$ in $^2P_{3/2}$ state. **05**

(iv) Explain Anomalous Zeeman Effect **05**

(v) Calculate the moment of inertia and energy of rotational J = 2 level in HCl molecules. Given: M (H) = 1.66 x 10^{-27} Kg, M (Cl) = 5.81 x 10^{-26} Kg, bond length = 2.1 AU , h = 6.63 X 10^{-34} joule-sec. **05**

(vi) State the principle involved in IR spectroscopy. Also draw block diagram for Absorption IR Spectrometer. **05**

(vii) In pure rotational Raman spectrum of CO gas, the Raman shift for the first stokes line is observed to be 0.35 X 10^{12} Hz. Use this information to calculate the bond length of CO molecule. **05**
Given : Reduced mass of CO molecule is 1.14 x 10^{-26} kg, h = 6.63 X 10^{-34} joule-sec.

(viii) A particular NMR instrument operates at 30.256MHz; what magnetic field is required to bring ^{13}C nuclei to resonance? g-factor for ^{13}C nucleus = 1.404 **05**
Given : $\mu_N = 5.05 \times 10^{-27}$ J/T

Sem 5 T.Y.B.Sc Physics Nov 2022

[Time: 3 Hours] [Marks:100]

N.B. : (1) **All** questions are **compulsory**.
(2) **Figures** to the **right** indicate **full** marks.
(3) Draw **neat** diagrams wherever **necessary**.
(4) Symbols have usual meaning unless otherwise stated.
(5) Use of **non-programmable** calculator is allowed.

List of Constants:

Charge of an electron $e = 1.6021 \times 10^{-19}$ Coulomb, Mass of an electron $m_e = 9.109 \times 10^{-31}$ kg
Boltzmann constant $k_B = 1.38054 \times 10^{-23}$ Joule/Kelvin,
Planck's constant $h = 6.626 \times 10^{-34}$ joule sec
Permeability of free space $\mu_0 = 4 \times 10^{-7}$ Henry/m,
Avogadro's number $N_A = 6.023 \times 10^{26}$ /kg mole.

Q1. Attempt any **two:—**

(i) With the help of a neat diagram, explain the seven systems of the crystal. How will you differentiate them on the basis of the relation to length of axis and the angle between the axis of a unit cell in each case. **10**

(ii) Explain what you understand by miller indices of a lattice plane. Deduce the relation for interplanar spacing of a set of miller Planes in a simple cubic crystal in terms of lattice parameter. **10**

(iii) Define packing fraction. Determine packing fraction for a hcp-structure. **10**

(iv) What is crystal symmetry? Explain X-ray diffraction process through a crystal on the basis of Ewald's sphere of reflection and reciprocal lattice vector. **10**

Q2 Attempt any **two:—**

(i) Discuss classical free electron theory of metals and obtain the expression for electrical conductivity. **10**

(ii) a) Explain and derive expression for collision time. **10**
b) Explain the drawback of the classical free electron theory in terms of the heat capacity of metal.

(iii) Derive the expression of Fermi energy and average energy of electron gas at absolute zero. Assume the expression of density of states. **10**

(iv) Discuss the phenomenon of thermionic emission in metals. Obtain Richardson- Dushman equation for the thermionic emission current density at temperature T. **10**

Q3 Attempt any **two:—**

(i) Using Kronig Penney model, obtain solution of Schrodinger's equation for an electron in a periodic potential. **10**

(ii) Discuss the motion of an electron in one dimensional periodic potential under the influence of external electric field. Hence bring out the concept of effective mass of an electron. **10**

(iii) What is Hall effect? Derive the expression for the Hall voltage and Hall coefficient. Discuss significance of Hall coefficient. **10**

(iv) Derive the expression for the concentration of the holes in the valence band. **10**

Q4 Attempt any **two:—**

(i) Explain the band structure of an open circuited p-n junction with the help of a neat diagram. Derive expression for contact potential E_0 at the junction. **10**

(ii) Derive the law of junction for a low level injection for a p-n junction diode. **10**

(iii) a) Explain in brief the Meissner effect in superconductors. **10**
b) Explain Type I and Type II superconductors.

(iv) Discuss in brief BCS theory of superconductivity. **10**

Q5. Attempt any **four:—** **20**

(i) The Atomic radius of silver having fcc-structure is 0.152nm. Find the interplanar spacing of (2 3 1) and (1 1 0) planes. **05**

(ii) For a simple cubic lattice show that, the ratio of density of points in (1 1 1) and (1 1 0) planes is 0.82. **05**

(iii) The Fermi energy of silver is 5.51 eV. **05**
a) What is the average energy of the free electrons in silver at 0 K?
b) What is the speed of the electrons with this energy?

(iv) Calculate the probability that an allowed state occupied by an electron lies above the Fermi level by 6 k_BT. **05**

(v) Consider a two dimensional square lattice of side 0.3 nm. At what electron momentum values do the sides of the first Brillouin zone come? What is the energy of the free electron with this momentum? **05**

(vi) The energy band gap of an intrinsic semiconductor is 0.7 eV. Determine the position of the Fermi level at 300 K, if the effective mass of electron is 1/6 times the effective mass of hole. (given kT = 0.026 eV) **05**

(vii) The conductivities of n-region and p-region of the germanium p-n junction are 200/Wm and 500/Wm respectively. The cross sectional area of crystal is 0.004cm^2. Dielectric constant for Germanium is 16. Calculate width of depletion region when p-n junction is unbiased. **05**
[$\epsilon_0 = 8.85 \times 10^{-12}$ S.I. units and $\epsilon_r = 16$ S.I. unit]
[$\mu_p = 0.18$ SI unit , $\mu_n = 0.39$ SI unit, $n_i = 2.20 \times 10^{19}$ /m^3]

(viii) Calculate the London penetration depth from the following data. **05**
[Given : Atomic weight = 118.7 , Density = 7.3×10^3 Kg/m^3,
critical temperature =3.7K, Effective mass (m*) = 1.9m,
mass of electron(m) = 9.1×10^{-31} Kg].

****

Sem 5 T.Y.BSc Physics Nov 2022

(2 ½ Hours) **Marks : 75**

N.B. : (1) **All** questions are **compulsory**.
(2) **Figures** to the **right** indicate **full** marks.
(3) Draw **neat** diagrams wherever **necessary**.
(5) Symbols have usual meaning unless otherwise stated.
(5) Use of **non-programmable** calculator is allowed.

1. A) Attempt any **one:---**
   (i) Explain in brief about Poisson distribution. Derive the equation for Poisson distribution. **10**
   (ii) Explain the terms **10**
   i) Binomial probability function.
   ii) Chebyshev's inequality
   iii) Laws of large numbers

   B) Attempt any **one:---**
   (i) Explain the Mean value, Variation and Standard deviation of a random variables. **5**
   (ii) A coin is tossed three times. A uniform Sample space for this problem contains eight points. What is the probability of at least two tails in succession? What is the Probability that two consecutive coins fall the same? **5**

2. A) Attempt any **one:---**
   (i) Solve the following **10**
   a) $y'' + y' - 6y = 12$
   b) $y'' + 3y' = 10 \sin x$
   (ii) a) Find the Fourier transform of the function **10**
   $f(x) = 3$ for $-a \leq x \leq a$
   $f(x) = 0$ for $|x| > a$
   b) Find Laplace transform of the function $f(t) = e^{-at}$ for $t > 0$
   Hence find Laplace transform of the function
   $$\frac{e^{-at} - e^{-bt}}{b - a}$$

   B) Attempt any **one:---**
   (i) Laplace transform of the function y(t) is written as $Y = L[y(t)]$. Obtain expressions for Laplace transform of derivatives $y'(t)$ **5**
   (ii) Find the Fourier cosine transform of the function e^{-4x} **5**

3. A) Attempt any **one:---**
   (i) For an infinitely small interaction, Derive first law of thermodynamics. **10**
   (ii) Consider the system A is in contact with a heat reservoir at temperature T. Find the probability that the system A has energy U_r in r^{th} quantum state. Define the partition function 'Z' and show that; $\overline{U} = \frac{\sum U_r e^{-\beta U_r}}{Z}$. **10**

B) Attempt any **one:---**

(i) Write a short note on Helmboltz free energy (F) and Enthalpy (H). **5**

(ii) Energy state of a particle is given by; $\varepsilon = 66\frac{h^2}{8mL^2}$ Determine the degeneracy of the state. **5**

4. A) Attempt any **one:---**

(i) Using Maxwell-Boltzmann distribution law of velocities, derive the expression for root mean square velocity, average velocity and most probable velocity. **10**

(ii) Which particles are called Boson's? Derive Bose-Einstein's distribution law. **10**

B) Attempt any **one:---**

(i) Show that the Plank's law and the Rayleigh-Jeans's law become identical if the temperature becomes very high. **5**

(ii) Find out the number of possible arrangements of seven particles in ten cells, assuming they obey: **5**

(a) B.E. Statistics (b) F.D. Statistics.

5. (a) Attempt any **one:---**

(i) A club consists of 20 members. In how many ways can a president, Vice-president, secretary and treasurer be chosen? In how many ways can a committee of four members be chosen? **4**

(ii) Find the probability of exactly 52 heads in 100 tosses of a coin using the binomial distribution and using the normal approximation. **4**

(b) Attempt any **one:---**

(i) Using the method of undetermined coefficients , find the particular solution of the differential equation $y'' - y' - 2y = 4\,e^{3x}$ **4**

(ii) If Fourier transform of a function f (x) is F(k), find Fourier transform of its derivative $f'(x)$ **4**

(c) Attempt any **one:---**

(i) Consider the system of two indistinguishable particles in a cubical box. Find the number of distributions giving rise to 12 units of energy. Find the number of microstates accessible to each distribution and hence the most probable distribution. **4**

(ii) Vapour pressure of solid ammonia is given by; $\ln p = 23.03 - \frac{3754}{T}$ while that of liquid ammonia is, $\ln p = 19.49 - \frac{3063}{T}$. Calculate the triple point of ammonia. **4**

(d) Attempt any **one:**---

(i) If the r.m.s. velocity of the molecules of hydrogen at N.T.P. is 1.5 km/s, calculate the r.m.s. velocity of oxygen molecules at N.T.P. Molecular weight of hydrogen and oxygen are 2 and 32 respectively. **3**

(ii) Calculate the number of modes of vibration between wavelengths $6550A^0$ and $6552A^0$ in black body cavity of volume 1000cc. **3**

C460CB4B35C9E0A88A4A3F70FBDD9C41

Sem 5 T.Y.B.Sc Physics Nov 2022

(3 Hours) [Total Marks: 100]

N.B. : (1) **All** questions are **compulsory**.
(2) **Figures** to the **right** indicate **full** marks.
(3) Draw **neat** diagrams wherever **necessary**.
(5) Symbols have usual meaning unless otherwise stated.
(5) Use of **non-programmable** calculator is allowed.

Q1. Attempt any **two:---**

(i) Explain the fundamental principle of counting with a suitable example. **10**

(ii) What is Bernoulli's trial? Explain Binomial Probability function and corresponding cumulative distribution function. **10**

(iii) Consider an experiment of tossing two dices and write uniform sample space. What is a random variable? Consider x = sum of the numbers on the dice and explain the probability function $f(x_i)$ for the random variable. **10**

(iv) Explain Poisson's distribution. Derive expression for it considering number of particles emitted by a radioactive substance. **10**
Consider an experiment in which number particles emitted each minute by a radioactive source is recorded for a period of 15 hrs. A total of 2700 counts are registered. During how many 1-minute intervals should we expect to observe no particles?

Q2 Attempt any **two:---**

(i) Define sin z and cos z in terms of exponential functions of z. Using these definitions **10**
(a) Find the value of $sin(\pi/2 + i \ln 2)$
(b) Prove that $sin^2 z + cos^2 z = 1$
(c) Prove that $d/dz\ (sin\ z) = cos\ z$

(ii) Find impedance of the circuit in which R and L and C are in series. Also find ω in terms of R, L and C at resonance. **10**

(iii) The vertical motion of a particle of mass m on a spring with spring constant k is described by the following differential equation: **10**

$$my'' = -ky + mg \quad where\ (y(0) = y_0\ and\ y'(0) = 0)$$

Solve this equation for the position of the particle as a function of time.

(iv) Solve the equation $\frac{\partial^2 z(x,y)}{\partial x\, \partial y} = x^2 y$ **10**

subject to the conditions

$$z(x,0) = x^2$$
$$and\ z(1,y) = cos\ y$$

Q3 Attempt any **two:—**

(i) What is Boltzmann distribution? Derive its expression. **10**

(ii) What is a Canonical Ensemble? Express canonical partition function Q. Hence obtain its relation with q for an ideal gas? How does this relationship differ for distinguishable and indistinguishable particles? **10**

(iii) What is entropy? Derive the Boltzmann formula $dS = k\, d(lnW)$. **10**

(iv) Obtain the relation between β and temperature T. What are the units of kT where k is Boltzmann constant? **10**

Q4 Attempt any **two:---**

(i) Consider a large box of area A divided into k cells of area $a_1, a_2, \ldots a_k$. N identical balls are thrown in a completely random manner. Obtain the most probable distribution of N balls in the k cells. **10**

(ii) Derive Rayleigh Jeans formula to explain black body radiation. **10**

(iii) Using Maxwell's distribution of velocity, derive an expression for the average velocity and most probable velocity. **10**

(iv) Derive Fermi-Dirac distribution law. **10**

Q5. Attempt any **four:---** **20**

(i) Explain the terms mean value, standard deviation and variance of an experimental data. **05**

(ii) Consider tossing of a coin 5 times. Find the probability of getting a particular event, say, thhth where 't' and 'h' indicate tail and head on the top face of the coin. Also give the probability of getting 3 heads and 2 tails. **05**

(iii) If $z = \cos^{-1}2$, find all values of z. **05**

(iv) Solve $y'' - 2y' + y = 2 \cos x$ by finding the complementary and particular solution. **05**

(v) Determine the total energy of a canonical ensemble consisting of N particles that have only two energy levels separated by $h\nu$. **05**

(vi) Write a short note on translational partition function. **05**

(vii) Calculate the number of modes of vibration per unit volume in a black body cavity for the wavelengths between 6000 AU and 6010 AU. **05**

(viii) When the temperature of black body is 60°C, it emits maximum energy at wavelength 8.71×10^{-6} m. If its temperature increased to 100°C, at what wavelength will the maximum energy be emitted? **05**

Date:- 24/11/2022

Sem 5 T.Y.B.Sc Physics Nov 2022

RIZVI COLLEGE OF ARTS, SCIENCE AND COMMERCE
(University of Mumbai)

T.Y.B.Sc. (PHYSICS) ELECTRONIC INSTRUMENTATION - I (USACE1501)
SEM - V (03 Hours) Total Marks : 100
Time : 08·00 AM to 11·00 AM Date : 24 / 11 /2022

N.B. : (1) All questions are compulsory.
(2) Draw neat diagrams whenever necessary.
(3) Figures to the right indicate full marks.
(4) Use of log table or non-programmable calculator is permitted.

Q1 (A). Attempt any TWO (Each question carry 10 Mark) (20M)
(i) What is thermocouple? State the factors used for the selection of a thermocouple.
(ii) What is LVDT? Explain its construction and uses.
(iii) Explain the working of LED and give its applications.

Q2 (A). Attempt any TWO (Each question carry 10 Mark) (20M)
(i) Discuss the different front panel controls of CRO like Intensity, Focus, Astigmatism and X-Y position.
(ii) What is carbon microphone? Describe its working with neat diagram.
(iii) Explain the working of bust regulator.

Q3 (A). Attempt any TWO (Each question carry 10 Mark) (20M)
(i) Draw a neat circuit diagram of weightage network of D/A converter and explain its construction. Also derive the formula for its output voltage.
(ii) Explain the successive approximation A/D converter with neat circuit diagram.
(iii) Explain multi channel data acquisition system with their neat block diagram.

Q4 (A). Attempt any TWO (Each question carry 10 Mark) (20M)
(i) What is ECG? Explain its working with different probes along with their V-T graph.their
(i) What is MRI ? Describe how does MRI machine work with different angles?
(ii) Explain the operating principle of microwave oven with their neat diagram.

Q5 (A). Attempt any FOUR (Each question carry 5 Mark) (20M)
(i) Discuss the classification of different types of transducers.
(ii) Discuss PH sensor.
(iii) Write a note on $3\frac{1}{2}$ digits type DMM.
(iv) What is a 10:1 probe in CRO? How it works?
(v) With the neat circuit diagram, explain active positive clamper.
(vi) Explain signal conditioning inputs of data acquisition system.
(vii) Write a note on EMG.
(viii) Explain internal and micro electrodes.

_____ × _____ THE END _____ × _____

Date: 24/11/2022

RIZVI COLLEGE OF ARTS, SCIENCE AND COMMERCE
(University of Mumbai)

AGICT

T.Y.B.Sc. (PHYSICS) **ELECTRONIC INSTRUMENTATION - I (USACE1501)**
SEM - V **($2\frac{1}{2}$ Hours)** **Total Marks : 75**
Time : 08·00 AM to 10·30 AM **Date : 24 / 11 /2022**

N.B. : (1) All questions are compusory.
(2) Draw neat diagrams whenever necessary.
(3) Figures to the right indicate full marks.
(4) Use of log table or non-programmable calculator is permitted.

Q1 (A). Attempt any ONE (8M)

(i) What is thermocouple? State the factors used for the selection of a thermocouple.

(ii) What is LVDT ? Explain its construction and uses.

Q1 (B). Attempt any ONE (7M)

(i) Describe the construction of CMOS LCD decoder with suitable example.

(ii) Explain the construction and working of LED and give its applications.

Q2 (A). Attempt any ONE (8M)

(i) With the help of labeled neat diagram, explain the operations of internal structure of the cathode ray tube (CRT).

(ii) Draw a neat circuit diagram of weighted resistor D/A converter and explain its construction. Also derive the formula for its output voltage.

Q2 (B). Attempt any ONE (7M)

(i) With the help of neat circuit diagram, discuss the working of transistor voltmeter.

(ii) With a neat circuit diagram, explain the delay line in a CRO.

Q3 (A). Attempt any ONE (8M)

(i) Draw a neat circuit diagram of a saw-tooth wave generator using OP – AMPs and explain its working with output waveform.

(ii) Explain the operation of an active wide band stop filter using OP – AMP. Draw the circuit diagram and frequency response. The wide band pass filter has the cut-off frequency $F_L = 300\ H_Z$ and $F_H = 3 \cdot 5\ K\ H_Z$. Calculate its center frequency and Q-factor.

Q3 (B). Attempt any ONE (7M)

(i) Describe the operation of second order high pass filter. Draw the circuit diagram and the frequency response. Second order high pass filter has given $R_1 = R_F = 10\ K\ \Omega$ and $R_2 = R_3 = 47\ K\ \Omega$ and $C_2 = C_3 = 0.1\mu\ F$, calculate its pass band gain and cut-off frequency.

P.T.O.

(ii) In Triangular wave generator, $R_1 = 10K\,\Omega$, $R_2 = R_3 = 100\,\Omega$ and $C = 0{\cdot}1\,\mu F$; then find frequency (f_0), time period (T) and also find out $V_{O(P-P)}$ when $V_{SAT} = 10$ V.

Q4 (A). Attempt any ONE (8M)

(i) Draw the circuit diagram of an adjustable bipolar voltage regulator using LM 317 and LM 337. Write its operation and derive an expression for the output voltage.

(ii) With a neat circuit diagram, describe the working Boost regulator.

Q4 (B). Attempt any ONE (7M)

(iii) Explain the construction and working of constant high current source using OP-AMP and transistor with neat labeled circuit diagram.

(iv) Discuss the working of an adjustable positive voltage regulator using LM 317. Find V_{IN} and R_2 in LM 317, if V_0=8 V, V_{REF}=1.25 V and R_1= 240 Ω are given.

Q5 (A). Attempt any THREE (15M)

(i) Discuss the working of uncompensated attenuator in CRO.

(ii) With the neat labeled diagram, discuss the horizontal amplifier in a CRO.

(iii) A resistance strain gauge factor (K) of 3 is cemented to a steel member which is subjected to a strain of 0.75×10^{-6}. If the original resistance (R) value of the gauge is 150 Ω, Calculate the change in the resistance (dR).

(iv) Write note on $3\frac{1}{2}$ digits type DVM.

(v) Write note on Instrumentation amplifier as temperature indicator.

(vi) Write down the characteristics of LM 317.

×_____END_____×