

Time: 3 hrs.

M. M.: 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.

Constants: Boltzmann Constant $k=1.38 \times 10^{-23}$ J/K
 Planck's Constants $h= 6.26 \times 10^{-34}$ Js

Q1. Attempt any two

- (i) What is Bernoulli's trial? Explain the Binomial probability function and corresponding cumulative distribution function. 10
- (ii) Explain the terms with suitable example. 10
 - A) Chebyshev's inequality
 - B) Laws of Large Number
- (iii) Explain the Poisson distribution and derive the required relation. 10
- (iv) Explain in detail the methods of counting. 10

Q2 Attempt any two

- (i) Explain the trigonometric function of a complex number z . Using these 10
 - a) Prove that $\sin 2z = 2 \sin z \cos z$
 - b) Find the value of $\cos(\pi - 2i \ln 3)$
- (ii) Find the impedance of z_1 and z_2 in series and in parallel if 10

$$z_1 = 2\sqrt{3}e^{i\frac{\pi}{6}} \quad \text{and} \quad z_2 = 2e^{2i\frac{\pi}{3}}$$
- (iii) State the second order non-homogeneous differential equation with constant coefficients and obtain its solution. Hence solve 10

$$y'' + 3y' + 2y = e^{-x}$$
- (iv) The vertical motion of a particle of mass m on a spring with spring constant k is described by the following differential equation: 10

$$my'' = -ky + mg \quad (y(0) = y_0 \text{ and } y'(0) = 0)$$
 Solve this equation for the position of the particle as a function of time.

94BSc Sem 5 Nov 2023 Physics

- Q3 Attempt any two**
- (i) Derive the relation between internal energy and the canonical partition function. For an ensemble consisting of 1.00 moles of particles having two energy levels separated by $h\nu = 1.0 \times 10^{-20} \text{ J}$, at what temperature will the internal energy of this system equal 1.00 kJ? **10**
- (ii) What is degeneracy? State the equations for partition function and probability of occupying energy level for degenerate states. A system with single states has energy levels 0 and β^{-1} . Calculate its partition function and probability of occupying each energy level. How does its value change for another system having two states present at energy level β^{-1} ? **10**
- (iii) What is an entropy? Derive the relation $S = k \log(W)$. For a temperature of 273 K and a volume of $2.24 \times 10^{-2} \text{ m}^3$ determine the translational partition function for Argon gas (Given mass of Ar = $6.63 \times 10^{-26} \text{ kg}$). **10**
- (iv) What is partition function? Derive an expression for translational partition function. **10**
- Q4 Attempt any two**
- (i) Derive the Fermi-Dirac distribution law. **10**
- (ii) Obtain the expression for most probable distribution of N identical balls thrown in a random manner, in a large box of area A, divided into k cells of area a_1, a_2, \dots, a_k . **10**
- (iii) Derive the Planck's radiation formula for black body cavity having volume V. **10**
- (iv) Obtain the expression for Bose-Einstein distribution law. **10**
- Q5. Attempt any four**
- (i) If 1500 people each select a number at random, between 1 and 500, what is the probability that 2 people selected the number 44? **05**
- (ii) The number of particles emitted each minute by a radioactive source is recorded for a period of 10 hours; a total of 1800 counts are registered. During how many 1-minute intervals should we expect to observe no particles. **05**
- (iii) Find the value of i^{-2i} **05**
- (iv) Solve the equation **05**
- $$\frac{\partial u(x,y)}{\partial x} = 9 \frac{\partial u(x,y)}{\partial y}$$
- and find the solution subject to $u(x, 0) = 2e^{-3x}$
- (v) What is Dominant Configuration? **05**
- (vi) The vibrational frequency of I_2 is 208 cm^{-1} . What is the probability of I_2 populating the vibrational level $n=2$ if the molecular temperature is 298 K? **05**
- (vii) Obtain the Stefan-Boltzmann law using the Planck's radiation formula. **05**
- (viii) Consider an assembly of N molecules having energies u_1, u_2, \dots, u_k . If there are n_i molecules of energy u_i , then obtain the Maxwell-Boltzmann distribution law. **05**

Time: 3 hrs.

M. M.: 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.

Constants:Charge of an electron $e = 1.6021 \times 10^{-19}$ Coulomb, Mass of an electron $m_e = 9.11 \times 10^{-31}$ kgBoltzmann constant $k = 1.38054 \times 10^{-23}$ 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) Explain the following terms, (i) Crystal lattice (ii) Basis (iii) Coordination number (iv) Atoms per unit cell and (v) Atomic radius for a simple cubic crystal. 10
- (ii) Define packing fraction. Determine packing fraction for an hcp structure. 10
- (iii) Show that for a simple cubic lattice the interplaner spacing between two parallel planes with miller indices (h k l) is 10

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

- (iv) Derive an expression for the diffraction condition in terms of reciprocal lattice vector and explain it. 10

Q2 Attempt any two

- (i) Explain relaxation time, collision time and mean free path as applied to free electrons in a metal. 10
- (ii) Discuss the various drawback of classical free electron theory of metals and explain the assumptions made in the quantum theory to overcome them. 10
- (iii) Discuss the phenomenon of thermionic emission in metals. Obtain Richardson – Dushman equation for the thermionic emission current density at temperature T. 10
- (iv) Derive the expression of Fermi energy and average energy of electron gas at absolute zero. Assume the expression of density of states. 10

Q3 Attempt any two

- (i) Using Kronig-Penny model, obtain solution of Schrodinger's equation for an electron in a periodic potential. 10
- (ii) Explain the Brillouin zones in one dimension and two dimensions with neat diagram. How are they related to the energy levels of an electron in a metal? 10
- (iii) Apply the continuity equation to find the expression for injected minority carries concentration in a bar of semiconductor subjected to radiation at one end as a function of distance under the state of equilibrium. 10

- (iv) What is Hall effect? Derive the expression for the Hall voltage and Hall coefficient. Discuss significance of Hall coefficient. 10
- Q4** Attempt any **two**
- (i) Explain BCS theory of superconductors. 10
- (ii) What are superconductors? Explain the types of superconductors. 10
- (iii) State the 'law of junction' in p-n junction. Derive the same stating clearly the assumptions made. 10
- (iv) Show the complete volt ampere characteristic of p-n junction diode. Explain how they depend on temperature. 10
- Q5.** Attempt any **four**
- (i) Lattice constant of copper is 0.38 nm. Calculate the distance between (110) planes. 05
- (ii) Zinc has hcp structure. The height of unit cell is 0.494 nm, the nearest neighbor distance is 0.27 nm, the atomic weight of zinc is 65.37. Calculate the volume of the unit cell. 05
- (iii) Discuss electrical conductivity of metal on the basis of quantum theory of metals. 05
- (iv) At what temperature we expect a 10% probability the electrons in silver have an energy which is 1% above the Fermi energy ($E_F = 5.5$ eV for silver). 05
- (v) An electric field of 100V/m is applied to the sample of n-type semiconductor whose hall coefficient is found to be $-0.0125 \text{ m}^3/\text{C}$. Determine the current density in sample. Given: mobility of electron is $0.36 \text{ m}^2/\text{VS}$. 05
- (vi) Consider a germanium p-n junction at 300°K with doping concentration $N_V = 1.5 \times 10^{18} \text{ cm}^{-3}$ and $N_D = 2 \times 10^{15} \text{ cm}^{-3}$ in the p and n sides of the junction. Determine the contact potential across the junction. The intrinsic carrier concentration of Germanium $n_i = 2 \times 10^{13} \text{ cm}^{-3}$ at 300°K . 05
- (vii) Write a note on London equation in superconductors. 05
- (viii) A germanium p-n junction has reverse saturation current, $I_0 = 2 \mu\text{A}$ at 27°C . Find its dynamic resistance for an applied forward bias of 0.3 V at 27°C . 05

- Q4** Attempt any **two**:---
- (i) Define Raman shift and list the observations related to Raman effect. **10**
- (ii) Explain the Raman activity of water molecules by considering various modes of vibrations **10**
- (iii) Discuss pure vibrational Raman spectrum. Also explain stokes and antistokes lines that are observed **10**
- (iv) Explain the parts of an ESR spectrometer and discuss its working. **10**
- Q5** Attempt any **four**:---
- (i) Write L_z using spherical polar co-ordinates and obtain its eigen values. **05**
- (ii) A beam of electrons enters a uniform magnetic field, of magnitude 1.2 T, Find the energy difference between electrons whose spins are parallel and anti parallel to the applied field- **05**
 Given: $h = 6.63 \times 10^{-34}$ Js, $c = 3 \times 10^8$ m/s, $e = 1.6 \times 10^{-19}$ C, $m = 9.11 \times 10^{-31}$ Kg
- (iii) Spectral lines from 3P-3S transition in sodium atom splits up into two components of wavelength 5890AU and 5896AU due to spin orbit interaction. Estimate the magnetic field experienced by the spinning electron in 3P state due to its orbital motion. **05**
 Given: $h = 6.63 \times 10^{-34}$ Js, $c = 3 \times 10^8$ m/s, $e = 1.6 \times 10^{-19}$ C, $m = 9.11 \times 10^{-31}$ Kg
- (iv) Define Lande's 'g' factor and find its value for $^2P_{3/2}$. **05**
- (v) In a CO molecule, the bond length is 1.13 AU, and the masses of C and O atoms are 1.99×10^{-26} Kg and 2.66×10^{-26} Kg respectively. Calculate the moment of inertia of the CO molecule and the energy of the first rotational energy level. **05**
 Given: $h = 6.63 \times 10^{-34}$ Js
- (vi) State the principle involved in microwave spectroscopy. Also draw block diagram for Microwave Spectrometer. **05**
- (vii) A stokes line of wavelength 5540 AU was observed in a Raman spectrum when radiation of wavelength 5460AU was scattered by a medium. Calculate the Raman shift and wavelength of corresponding Anti-Stokes line. Given :- speed of light = 3×10^8 m/s **05**
- (viii) Calculate the resonance frequency in an NMR spectrometer experiment when a field of 2.3487 tesla is applied to a sample of hydrogen nuclei. Lande's g-factor for hydrogen is 5.585. **05**
 Given: - $h = 6.62 \times 10^{-34}$ Js, $\mu_N = 5.05 \times 10^{-27}$ JT⁻¹.

(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) Beginning with the time independent Schrodinger's equation for one electron atom, obtain three independent equations in spherical polar coordinates. 10
- (ii) Discuss quantization of orbital angular momentum with respect to magnitude and direction. 10
- (iii) Explain Radial probability density of an electron in hydrogen atom model using suitable graphs. Also discuss Azimuthal and Zenith probability densities. 10
- (iv) Describe the experimental setup of Stern Gerlach's experiment and explain how it was able to prove the existence of intrinsic spin of electron. 10
- Q2 Attempt any two:---
- (i) Show quantum mechanically that an electron undergoing transition from higher energy level E_m to a lower energy level E_n emits a radiation of frequency $\nu = \frac{E_m - E_n}{h}$. Also state selection rules for the allowed transition. 10
- (ii) Explain in detail, the experimental set up to observe Zeeman effect and comment on observed Zeeman components. 10
- (iii) Explain on the basis of vector atom model, simultaneous quantization of L, S and J vectors of one electron atom. 10
- (iv) Explain with classical theory Normal Zeeman effect. 10
- Q3 Attempt any two:---
- (i) Write the expression for vibration-rotation energy levels of a rigid diatomic molecule. Discuss features of P- branch and R-branch using suitable energy level diagram. 10
- (ii) Write an expression for rotational energy of a single diatomic molecule. Explain in detail how the energy levels get modified if the effect of bond elongation is taken into consideration. Draw appropriate energy level diagram. 10
- (iii) Draw a labelled schematic diagram of an absorption IR spectrometer and explain its parts. 10
- (iv) State Franck-Condon Principle. Using the principle, explain the electronic spectra of diatomic molecule. 10

(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) Beginning with the time independent Schrodinger's equation for one electron atom, obtain three independent equations in spherical polar coordinates. 10
- (ii) Discuss quantization of orbital angular momentum with respect to magnitude and direction. 10
- (iii) Explain Radial probability density of an electron in hydrogen atom model using suitable graphs. Also discuss Azimuthal and Zenith probability densities. 10
- (iv) Describe the experimental setup of Stern Gerlach's experiment and explain how it was able to prove the existence of intrinsic spin of electron. 10
- Q2** Attempt any two:---
- (i) Show quantum mechanically that an electron undergoing transition from higher energy level E_m to a lower energy level E_n emits a radiation of frequency $\nu = \frac{E_m - E_n}{h}$. Also state selection rules for the allowed transition. 10
- (ii) Explain in detail, the experimental set up to observe Zeeman effect and comment on observed Zeeman components. 10
- (iii) Explain on the basis of vector atom model, simultaneous quantization of L, S and J vectors of one electron atom. 10
- (iv) Explain with classical theory Normal Zeeman effect. 10
- Q3** Attempt any two:---
- (i) Write the expression for vibration-rotation energy levels of a rigid diatomic molecule. Discuss features of P- branch and R-branch using suitable energy level diagram. 10
- (ii) Write an expression for rotational energy of a single diatomic molecule. Explain in detail how the energy levels get modified if the effect of bond elongation is taken into consideration. Draw appropriate energy level diagram. 10
- (iii) Draw a labelled schematic diagram of an absorption IR spectrometer and explain its parts. 10
- (iv) State Franck-Condon Principle. Using the principle, explain the electronic spectra of diatomic molecule. 10

- Q4 Attempt any two:---
- (i) Define Raman shift and list the observations related to Raman effect. 10
- (ii) Explain the Raman activity of water molecules by considering various modes of vibrations 10
- (iii) Discuss pure vibrational Raman spectrum. Also explain stokes and antistokes lines that are observed 10
- (iv) Explain the parts of an ESR spectrometer and discuss its working. 10
- Q5 Attempt any four:---
- (i) Write L_z using spherical polar co-ordinates and obtain its eigen values. 05
- (ii) A beam of electrons enters a uniform magnetic field, of magnitude 1.2 T, Find the energy difference between electrons whose spins are parallel and anti parallel to the applied field. 05
Given: $h = 6.63 \times 10^{-34}$ Js, $c = 3 \times 10^8$ m/s, $e = 1.6 \times 10^{-19}$ C, $m = 9.11 \times 10^{-31}$ Kg
- (iii) Spectral lines from 3P-3S transition in sodium atom splits up into two components of wavelength 5890AU and 5896AU due to spin orbit interaction. Estimate the magnetic field experienced by the spinning electron in 3P state due to its orbital motion. 05
Given: $h = 6.63 \times 10^{-34}$ Js, $c = 3 \times 10^8$ m/s, $e = 1.6 \times 10^{-19}$ C, $m = 9.11 \times 10^{-31}$ Kg
- (iv) Define Lande's 'g' factor and find its value for $^2P_{3/2}$. 05
- (v) In a CO molecule, the bond length is 1.13 AU, and the masses of C and O atoms are 1.99×10^{-26} Kg and 2.66×10^{-26} Kg respectively. Calculate the moment of inertia of the CO molecule and the energy of the first rotational energy level. 05
Given: $h = 6.63 \times 10^{-34}$ Js
- (vi) State the principle involved in microwave spectroscopy. Also draw block diagram for Microwave Spectrometer. 05
- (vii) A stokes line of wavelength 5540 AU was observed in a Raman spectrum when radiation of wavelength 5460AU was scattered by a medium. Calculate the Raman shift and wavelength of corresponding Anti-Stokes line. Given :- speed of light = 3×10^8 m/s 05
- (viii) Calculate the resonance frequency in an NMR spectrometer experiment when a field of 2.3487 tesla is applied to a sample of hydrogen nuclei. Lande's g-factor for hydrogen is 5.585. 05
Given: $h = 6.62 \times 10^{-34}$ Js, $\mu_N = 5.05 \times 10^{-27}$ JT⁻¹.

231111

T352302

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

T.Y.B.Sc. (PHYSICS)
SEM - V

ELECTRONIC INSTRUMENTATION - I (USACE1501)
(03 Hours)

Time : 08:00 AM to 11:00 AM

Total Marks : 100
Date : 11 / 11 / 2023

- 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) Explain semi-conductor strain gauge.
(ii) State the principle and explain important characteristics of thermistor.
(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 dynamic type microphone? Explain its working with neat diagram.
(iii) With a neat circuit diagram, describe the working bust regulator.
- Q3 (A).** Attempt any TWO (Each question carry 10 Mark) (20M)
(i) Draw a neat circuit diagram of ladder resistor network of D/A converter and explain its construction. Also derive the formula for its output voltage.
(ii) Draw a neat circuit diagram of Voltage to time of dual slope in A/D converter and explain its working.
(iii) Explain single channel data acquisition system with their neat block diagram.
- Q4 (A).** Attempt any TWO (Each question carry 10 Mark) (20M)
(i) What is MRI ? Describe how does MRI machine work with different angles?
(ii) What is photolithography? Explain its use in printed circuit board (PCB).
(iii) Explain the working of CT scan.
- Q5 (A).** Attempt any FOUR (Each question carry 5 Mark) (20M)
(i) Write a note on Humidity sensor.
(ii) Discuss the different parameters for selection of transducer.
(iii) Write a note on $3\frac{1}{2}$ digits type DMM.
(iv) With the neat circuit diagram, explain the active peak detector.
(v) Write note on objectives of data acquisition system.
(vi) Write down the specifications for D/A converters.
(vii) Write down the advantages of PCB.
(viii) Explain Limb surface electrodes.

_____ × _____ THE END _____ × _____