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