Registration Number:

Date & Session:

ST JOSEPH'S UNIVERSITY, BENGALURU -27
M.Sc. Physics – III SEMESTER
SEMESTER EXAMINATION: OCTOBER 2023
(Examination conducted in November /December 2023)
PH 9222: Atomic and Molecular Physics
(For current batch students only)

Time: 2 Hours **Max Marks: 50**

This paper contains Two printed pages and Two parts

PART-A

Answer any FIVE questions. Each question carries SEVEN Marks.

[5 x 7 = 35]

1. With a neat sketch, describe the process of Zeeman splitting pattern for low, high, and intermediate magnetic fields?
2. (a). With a neat sketch, describe the different modes of vibration of **CO_2** molecules.
   (b). Explain, why the diatomic molecules such as CO, HF will show a rotational spectrum whereas N_2, O_2, H_2 will not?
   (c). why, the intensity of $J = 0 \rightarrow J = 1$ is often not the most intense rotational line?

   [3+2+2]
3. With a neat diagram, describe the elastic (Rayleigh) and inelastic (Raman) scattering in Raman spectroscopy. Obtain an expression for polarization using classical Raman theory.
4. Explain the physical principle and resonance condition of Nuclear magnetic resonance with a suitable diagram. How does the NMR Frequency relate to the external magnetic field?
5. (a). With a neat sketch, describe the Beer lambert's law.
   (b). Outline the basic requirements, working principle of UV-Visible spectrometer.

   [3+4]
6. Describe the processes of absorption, fluorescence, phosphorescence, internal conversion, intersystem crossing, and vibrational relaxation using a Jablonski diagram?
7. Explain the spin arrangements and hyperfine slitting components for unpaired electron coupling with two equivalent nuclei of spin I = ½ in electron spin resonance spectrum. The ESR spectrum shows three lines with intensities 1:2:1 for the above condition. Why?

PART-B

Answer any THREE questions. Each question carries FIVE Marks.

[3 x 5 = 15]

8. The Raman line associated with a vibrational mode which is both Raman and infrared active is found at 4600 Å when excited by light of wavelength 4358 Å. Calculate the wavelength of the corresponding infrared band.
9. Find the Zeeman structure of a spectral line which results from the transition and also find Lande g factor values for each energy levels.

$$^4F_{\frac{3}{2}} \rightarrow \ ^4\mathrm{D}_{\frac{5}{2}}$$

10. Calculate the frequencies for the quadrupolar transitions, assuming an axial filed gradient. The spin of ^{35} Cl is I=3/2.
11. A particular NMR instrument operates at 30.256 MHz. What magnetic fields are required to bring a proton nucleus and a ^{13}C molecules to the resonance frequency? [magnetic moment of proton = 2.7927μ_N and magnetic moment of ^{13}c = 0.7022μ_N.

List of Physics Constants

Speed of light in vacuum (c)	2.997925×10^8 ms^{-1}
Charge of electron (e)	1.6021×10^{-19} C
Rest mass of electron (m)	9.109×10^{-31} kg
Atomic mass unit (m_u)	1.6604×10^{-27} kg
Electron radius (r_e)	2.828×10^{-15} m
1 Angstrom unit (Å)	10^{-10} m
Avogadro's number (N_A)	6.02252×10^{26} kmol^{-1}
Boltzmann constant (k_B)	1.38054×10^{-23} jK^{-1}
Thermal energy at 300K (k_BT)	0.0258 J
Planck's constant (h)	6.626×10^{-34} Js
Permeability of free space (μ_o)	$4\pi \times 10^{-7}$ Hm^{-1}
Permittivity of free space (ε_o)	8.854×10^{-12} Fm^{-1}
Rydberg constant for Hydrogen (R_H)	1.0967758×10^7 m^{-1}
Universal gas constant ($Ru = N_Ak_B$)	8.3143×10^3 Jkmol^{-1}K