



K24P 0869

Reg. No. :

Name :

**Second Semester M.Sc. Degree (C.B.S.S. – Supple. (One Time Mercy
Chance)/Imp.) Examination, April 2024
(2014 to 2022 Admissions)**

PHYSICS

PHY 2C09 : Spectroscopy

Time : 3 Hours

Max. Marks : 60

SECTION – A

Answer both the questions (Either **a** or **b**).

- I. a) Distinguish between normal and anomalous Zeeman effects. Explain clearly the phenomenon of anomalous Zeeman effect and hence derive an expression for the magnetic interaction energy.

OR

- b) Discuss the quantum theory of Raman effect. With the help of a schematic diagram, explain the working of a Raman spectrometer.

- II. a) Discuss the rotational fine structure of electronic-vibrational transitions. Write a note on Fortrat diagram.

OR

- b) Discuss the rotational spectrum of a non-rigid heterogeneous diatomic molecule and compare the spectrum with that of a rigid heterogeneous diatomic molecule. Describe the effect of isotopic substitution on the rotational spectrum of a rigid rotator. **(2×12=24)**

SECTION – B

Answer **any four** questions (**1** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**).

- III. a) Give the expression for the wave number of H_{α} line in terms of Rydberg constant.
b) Write a note on Stark effect.
c) Calculate the possible orientations of the total angular momentum vector $\vec{J}$ corresponding to $j = \frac{3}{2}$ with respect to a magnetic field along the z-axis.

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- IV. a) What are hot bands ?
- b) Explain the effect of anharmonicity on the vibrational spectra of diatomic molecules.
- c) Calculate the energy in cm^{-1} of the photon absorbed when NO molecule goes from the state $v = 0, J'' = 0$ to $v = 1, J'' = 1$. Assume that the $v = 0$ and $v = 1$ states have the same B values. Given $\bar{\nu}_e = 1904 \text{ cm}^{-1}$, $x_e = 0.00733$ and $r_{\text{NO}} = 0.1151 \text{ nm}$. Here $\bar{\nu}_e$ is the equilibrium oscillation frequency expressed in wave number units and x_e is the anharmonic constant. Mass of $\text{N}^{14} = 23.25 \times 10^{-27} \text{ kg}$ and Mass of $\text{O}^{16} = 26.56 \times 10^{-27} \text{ kg}$.
- V. a) What are symmetric top molecules ?
- b) Explain any reason for the occurrence of pre-dissociation in the rotational fine structure of electronic spectra.
- c) In the vibrational Raman spectrum of HF, the Raman lines are observed at wavelengths $2670 \text{ \AA}$ and $3430 \text{ \AA}$. Find the fundamental vibrational frequency of the molecule.
- VI. a) Name the different relaxation process available in NMR.
- b) Write a note on Larmor precession and obtain an expression for Larmor frequency.
- c) Calculate the NMR frequency of F^{19} nucleus when it is placed in the magnetic field of 1.0 tesla. Given that $g_I = 5.256$ and $\mu_N = 5.0504 \times 10^{-27} \text{ JT}^{-1}$. Also calculate the relative population in the two spin states.
- VII. a) What is dipolar shift in ESR ?
- b) What do you mean by nuclear quadrupole resonance ?
- c) Obtain the recoil velocity of a free Mossbauer nucleus of mass $1.67 \times 10^{-25} \text{ kg}$ when emitting a γ -ray of wavelength 0.1 nm . What is the Doppler shift of the γ -ray frequency to an outside observer ?
- VIII. a) What do you mean by Fermi resonance ?
- b) Discuss the symmetry and fundamental modes of vibrations of CO_2 molecule.
- c) The $J = 0 \rightarrow J = 1$ rotational absorption line occurs at $1.153 \times 10^{11} \text{ cycles/s}$ in $^{12}\text{C}^{16}\text{O}$ and at $1.102 \times 10^{11} \text{ cycles/s}$ in $^n\text{C}^{16}\text{O}$. Calculate the mass number of the unknown carbon isotope ? (4×9=36)
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