C 22578 **(Pages : 2)** **Name.....**

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4C 12—ATOMIC AND MOLECULAR SPECTROSCOPY

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 *Short questions answerable within* 7.5 *minutes.*
Answer **all** *questions, each question carries weightage* 1.

1. Explain clearly the phenomenon of normal and anomalous Zeeman effect.
2. Mention the concepts underlaying vector atom model of the atom and the different quantum numbers associated with it.
3. Explain the principle of Fourier transformation I R Spectroscopy.
4. With the help of a diagram, explain fortrat parabola.
5. Obtain a simple relation for the relative intensity of Stokes lines and anti-Stokes lines. How does the intensity vary with temperature ?
6. Briefly explain recoilless emission and absorption of γ-rays.
7. Distinguish between spin lattice and spin-spin relaxation.
8. Explain the basic principle of Stimulated Raman Scattering.

(8 × 1 = 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes.
Answer any **two** *questions, each question carries weightage 5.*

9. Discuss the theory of the rotational spectrum of symmetric top molecule, what is the information derived from Rotational Spectrum ?

10. Describe the rotational Raman spectrum of symmetric top molecules. Bring out the salient features.

11. Discuss the rotational fine structure of the electronic vibrational transitions. Explain band head formation.

12. Explain the Bloch equations and the steady state solutions in the case of NMR.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions, each question carries weightage 3.*

13. Consider a hydrogen atom in the $^{D}_{3/2}$ state, (i) Find the possible values of I_Z. (ii) What are the different orientations of the J-vector in space.

14. Rotational and centrifugal distortion constants of HCl molecule are 10.593 cm^{-1} and 5.3×10^{-4} cm^{-1} respectively. Estimate the vibrational frequency and force constant of the molecule.

15. If the bond length of H_2 is 0.07417nm, what would be the positions of the first three rotational Raman lines in the spectrum ?

16. The vibrational structure of the absorption spectrum of O_2 becomes a continuum at 56876 cm^{-1}. If the upper electronic state dissociates into one ground state atom and one excited atom with excitation energy 15875 cm^{-1}, estimate the dissociation energy of the ground state of O_2 in cm^{-1} and in $kJmol^{-1}$.

17. What is the nuclear g_N factor for F^{19} nucleus which has a magnetic moment of 2.6273 μ_N. Nuclear spin quantum number $I = {}^{1}/_{2}$.

18. Calculate the recoil velocity of a free Mossbauer nucleus of mass 1.67×10^{-25} kg (equivalent at wt. 100) when emitting a γ-ray of wavelength 0.1 nm. What is the Doppler shift of the γ-ray frequency to an outside observer ?

19. A free electron is placed in a magnetic field of strength 1.3T. Calculate the resonance frequency if g = 2.0023.

(4 × 3 = 12 weightage)