23P405 (Pages: 2) Name: .....

Reg.No: .....

FOURTH SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2025

(CBCSS - PG)

(Regular/Supplementary/Improvement)

CC19P PHY4 C12 - ATOMIC AND MOLECULAR SPECTROSCOPY

(Physics)

(2019 Admission onwards)

Time : 3 Hours Maximum : 30 Weightage

Section A

Answer ***all*** questions. Each question carries 1 weightage.

1. Distinguish between singlet and triplet states with examples.
2. Give a brief account of the normal modes of vibrations of carbon dioxide molecule.
3. Explain why homonuclear diatomic molecules give no microwave or infrared spectra but give a rotational Raman spectrum.
4. Compare Hyper Raman effect and stimulated Raman scattering.
5. What are the informations do we get from the vibrational analysis of electronic spectra?
6. What do you mean by hyperfine structure in ESR spectroscopy?
7. What makes Mossbauer spectroscopy distinct as compared to other spectroscopic techniques?
8. Write brief note on (1) Mossbauer sources and (2) absorbers.

(8 × 1 = 8 Weightage)

Section B

Answer any ***two*** questions. Each question carries 5 weightage.

9. Explain the theory of anomalous Zeeman effect. Illustrate with diagrams of the Zeeman splitting of Sodium Yellow D lines. Comment on the relative intensities of the spectral lines.
10. Discuss in detail the spectrum of non- rigid rotator and obtain the expression for frequencies of the spectral transitions of a symmetric top molecule.
11. What is Deslandre's table? Explain progressions & sequences in electronic spectroscopy of molecules.
12. Explain the basic principles of Electron spin resonance spectroscopy. Discus the hyperfine components in the ESR spectrum of a system having an unpaired electron interacting with (1) two equivalent protons (2) two non equivalent protons.

(2 × 5 = 10 Weightage)

Section C

Answer any ***four*** questions. Each question carries 3 weightage.

13. Calculate the interaction energy terms in a strong magnetic field for a two electron system in sp configuration.

14. Derive expression for the frequencies of the Stark components of the $J = 1 \rightarrow J = 2$ transitions of a linear molecule.

15. The fundamental and first overtone transition of $^{14}N^{16}O$ are centred at 1876.06 cm $^{-1}$ and 3724.20 cm $^{-1}$ respectively. Evaluate the equilibrium vibration frequency and the anharmonicity constant.

16. The first three Stokes lines in the rotational Raman spectrum of $^{16}O_2$ are separated by 14.4 cm^{-1}, 25.8 cm^{-1} and 37.4 cm^{-1} from the exciting radiation. Using the rigid rotor model, obtain the value of bond length.

17. The rotational lines of a band system of electronic vibration spectra is given by $\bar{\nu} = (24762 + 25m - 2.1m^2)cm^{-1}$, where $m = \pm 1, \pm 2$ etc. Deduce the values of B', B" and the position of band head.

18. A particular NMR instrument operates at 30.256 MHz. What magnetic fields are required to bring ^1H and ^{13}C nuclei to resonance at this frequency. g value of ^1H is 5.585 and that of ^{13}C is 1.404. $\mu_N = 5.051 \times 10^{-27} JT^{-1}$

19. An NMR signal for a compound is found to be 180 Hz downward from TMS $[(CH_3)_4.Si]$ peak using a spectrometer operating at 60 MHz. Calculate its chemical shift in ppm.

(4 × 3 = 12 Weightage)

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