

FOURTH SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2025
(Regular/Improvement/Supplementary)

PHYSICS
FPHY4C12 - ATOMIC AND MOLECULAR SPECTROSCOPY

Time: 3 Hours**Maximum Weightage: 30**

Part A: Short answer questions. Answer *all* questions. Each carries *one* weightage.

1. Briefly explain the Paschenback effect.
2. Outline the effect of isotopic substitution on the rotational spectra of molecules.
3. What are hot bands? Why are they called so?
4. State and explain Franck Condon Principle.
5. CO₂ molecule obeys the mutual exclusion principle. Illustrate. Explain why water molecule is active in both IR and Raman spectra?
6. What is dissociation energy of a diatomic molecule? How does it differ from equilibrium dissociation energy?
7. What is ESR? Explain its principle.
8. Explain isomer shift with an example.

(8 × 1 = 8 weightage)

Part B: Essay questions. Answer any *two* questions. Each carries *five* weightage.

9. Define normal Zeeman effect. Explain normal Zeeman effect using quantum theory.
10. Discuss the various relaxation processes for nuclei and derive Bloch equations.
11. Explain Born-Oppenheimer approximation. Discuss on the normal modes and vibrations of H₂O and CO₂ molecules.
12. Describe with theory:
 - a) Rotational Raman spectrum of a symmetric top molecule.
 - b) Vibrational Raman spectra.

(2 × 5 = 10 weightage)

(P.T.O.)

Part C: Problems. Answer any *four* questions. Each carries *three* weightage.

13. Rotational and centrifugal distortion constants of HCl molecule are 10.593 cm^{-1} and $5.3 \times 10^{-4}\text{ cm}^{-1}$ respectively. Estimate the vibrational frequency and force constant of the molecule.
14. The first line in the rotational spectrum of carbon monoxide (CO) has a frequency of 3.8424 cm^{-1} . Calculate the rotational constant and hence the C-O bond length in carbon monoxide. Avogadro number is $6.022 \times 10^{23}/\text{mol}$.
15. 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 corresponding infrared band.
16. Explain Fortrat parabola and find band head and band origin.
17. Calculate the strength of the magnetic field required to give a precessional frequency of 100 MHz for ^{17}O nucleus. $g_N = 0.757$ $\mu_N = 5 \times 10^{-27}\text{ JT}^{-1}$ $I=5/2$. How many spectral lines are observed in NMR spectrum?
18. Calculate the recoil velocity and energy of the free Mossbauer nucleus ^{119}Sn when emitting a γ -ray of frequency $5.76 \times 10^{18}\text{ Hz}$. What is the Doppler shift of the γ -ray frequency to an outside observer? Avogadro number is $6.02 \times 10^{23}\text{ mol}^{-1}$.
19. Illustrate the progressions and sequences in the vibrational analysis of a spectrum.

(4 × 3 = 12 weightage)