



NATIONAL OPEN UNIVERSITY OF NIGERIA
UNIVERSITY VILLAGE, PLOT 91 CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESS WAY,
JABI - ABUJA.
FACULTY OF SCIENCES
DEPARTMENT OF CHEMISTRY
2025_2 EXAMINATIONS

COURSE CODE: CHM 402
COURSE TITLE: THEORY OF MOLECULAR SPECTROSCOPY
COURSE UNIT: 2
TIME: 2 HOURS
INSTRUCTION: Answer question one and any other two questions.

QUESTION

Question 1 **(30 marks)**

a(i) Microwave frequency ranges from 300 MHz to 300 GHz. Calculate the range for (i) the energy and the change in energy (ii) the wavelength **(13 marks)**

a(ii) A diatomic molecule has masses equal to 1.002 and 1.003 amu and radius = 0.0004 m. Calculate the moment of inertia of the molecule **(5 marks)**

(b) Which region of the infrared spectrum covers the fingerprint and what is the basic feature in this region **(2 marks)**

(c) State four changes that can be observed in a molecule that absorbs radiation **(4 marks)**

(d) Define the following with respect to rotational motion of a body, rigid rotor, reduced mass, moment of inertia and linear momentum **(6 marks)**

Question **(20 marks)**

(a) Calculate the change in rotational energy for the following transition (i) $J = 0$ to state $J = 1$, (ii) State $J = 1$ to state $J = 2$ (iii) State $J = 2$ to state $J = 3$ (Based your calculation in terms of rotational constant, B) **(13 marks)**

(b) What is the range of wave numbers and application of the following Infrared regions? **(8 marks)**

Question 3 **(20 marks)**

(a) Sketch the block diagram of an NMR Spectrometer. **(4 marks)**

(b) With reference to $-\text{CH}_2$, sketch two types of in-plane and out of plane vibrations
(8 marks)

c(i) Which type of vibration occurs at higher energy between stretching and bending?
(2 marks)

(ii) Considering their moment of inertia and rotational energy, compare a linear molecule with a diatomic molecule
(6 marks)

Question 4

(a) In a tabular form give any three differences between ESR and NMR. (6 marks)

(b) Outline three limitations of Mössbauer Spectroscopy (6 marks)

c(i) What is the Raman Effect? (3 marks)

c(ii) Consider a non-linear molecule having 4 atoms. Calculate the various vibrational modes for this atom. What does each of the vibration represents? (6 marks)

Question 5 (20 marks)

(a) Calculate the vibrational modes in HCl, O_2 , N_2 , Cl_2 and state if they are infra-red or Raman active (10 marks)

(b) Explain the reason why Carbon-13 is suitable for NMR (6 marks)

(c) List three uses of Mössbauer Spectroscopy (4 marks)