

ASSIGNMENT BOOKLET

**M.Sc. in Chemistry Programme
(MSCCHEM)**

ATOMIC AND MOLECULAR SPECTROSCOPY

(Valid from July, 2026 to June, 2027)

**It is compulsory to submit the assignment before filling in
the examination form**



**School of Sciences
Indira Gandhi National Open University
New Delhi
(2026-27)**

Dear Learner,

Please read the Section on Assignments in the Programme Guide for M.Sc. in Chemistry Programme that we sent you after your enrolment. A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation, which would consist of one tutor-marked assignment for this course. The assignment is in this booklet and covers all the four blocks of the course. The total marks of all the parts are 100, of which 40% are needed to pass it.

Instructions for Formatting Your Assignments

Before attempting the assignment, please read the following instructions carefully:

- 1) On top of the first page of your answer sheet, please write the details exactly in the following format:

ENROLMENT NO. :

NAME:

ADDRESS :.....

COURSE CODE :.....

COURSE TITLE :.....

ASSIGNMENT NO. :.....

STUDY CENTRE :

DATE :

(NAME AND CODE)

PLEASE FOLLOW THE ABOVE FORMAT STRICTLY TO FACILITATE EVALUATION AND TO AVOID DELAY.

- 2) Use only foolscap size paper (but not of very thin variety) for writing your answers.
- 3) Leave about 4 cm margin on the left, top and bottom of your assignment response sheet.
- 4) Your answers should be precise.
- 5) Submit the complete assignment answer sheets within the due date.
- 6) The assignment answer sheets are to be submitted to your Study centre within the due date.
Answer sheets received after the due date shall not be accepted.
We strongly suggest that you retain a copy of your answer sheets.
- 7) This assignment is valid from July, 2026 to June, 2027. If you have failed in this assignment or fail to submit it by June, 2027, then you need to get the new assignment, and submit it as per the instructions given in the Programme Guide.
- 8) You cannot fill the examination form for this course until you have submitted the assignment.

Wishing you good luck.

Tutor Marked Assignment

MCH-020: ATOMIC AND MOLECULAR SPECTROSCOPY

Course Code: MCH-020

Assignment Code: MCH-020/TMA/2026-27

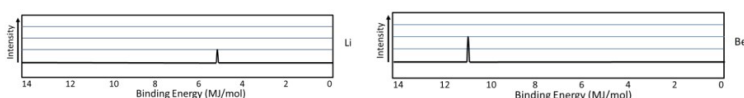
Maximum Marks: 100

Note: Answer all the questions given below.

You may use the following whenever required:

$$h = 6.626 \times 10^{-34} \text{ Js}; m_e = 9.11 \times 10^{-31} \text{ Kg}; c = 3.0 \times 10^8 \text{ ms}^{-1}$$

1. a) A photon of violet light has a wavelength of 500 nm. Calculate its energy. (5)
b) State the Lambert's Law and translate it into a mathematical expression. (5)
2. a) Explain the vector nature of orbital angular momentum. Predict the values of magnetic quantum number. With the help of a suitable diagram explain the concept of total angular momentum. (5)
b) What is Stark Effect? In which condition do we get linear stark effect and quadratic stark effect? (5)
3. a) Following spectra gives the relative positioning and intensity of the 2s peaks? Which of the following statements explain it best? (5)



- i) Be has a greater nuclear charge than Li and more electrons in the 2s orbital.
 - ii) Be electrons experience greater electron-electron repulsions than Li electrons.
 - iii) Li has a greater nuclear attraction on the 2s electrons, so it is harder to remove those
 - iv) Li has greater electron shielding by the 1s orbital, so the 2s electrons can be easily removed.
- b) With the help of suitable diagrams explain the rotation of BF_3 molecule as an example of an oblate symmetric top molecule. (5)
4. a) The first line in the rotational spectrum of HF molecule is observed to be at 60.22 cm^{-1} . Calculate the location of the band in DF molecule obtained by isotopic substitution of H atom in HF by D. Assume that there is no change in the bond length of the molecule. (5)
b) The oscillation frequency of $^1\text{H}^{35}\text{Cl}$ is determined to be 3660 cm^{-1} . Calculate the zero point energy and the force constant for the molecule. (5)
(Given: Atomic mass of Hydrogen: 1.008 u; atomic mass of ^{35}Cl =34.969 u)
5. a) What is meant by anharmonic oscillator? Apart from mechanical anharmonicity may arise? Why does it arise? With the help of a diagram show the allowed absorption transitions for an anharmonic oscillator according to the selection rule. (5)
b) What is meant by Fermi resonance? When are hot bands observed in transitions? (5)

Derive the expression for the frequency of a hot band under anharmonic conditions.

6. a) The Raman line for a substance was observed at 546.4 nm on irradiating with 322.4 nm radiation. Calculate the wave numbers of Stokes and anti-Stokes lines for the substance if the exciting line has a wavelength of 328.5 nm. (5)
- b) Explain the coherent anti-Stokes Raman Spectroscopy (CARS) technique. Give suitable illustrations. (5)
7. a) Illustrate the general procedure for determining the term symbols for $(\sigma_g)^1$ and $(\pi_u)^3$. (5)
- b) The vibrational frequency and anharmonicity constant of HF molecule in an excited electronic state are found to be 3456.25 cm^{-1} and 0.030 respectively. Calculate the dissociation energies, (D_e) and (D_0) of the HF molecule in this excited state. (5)
8. a) Explain the different mechanisms in fluorescence quenching. (5)
- b) (i) Describe the Nuclear Overhauser Effect (NOE) and its significance in structural elucidation using NMR. (2)
- (ii) Predict the number of signals in ^{13}C -NMR spectrum in the following compounds. (3)
 - I. 2,3-Dimethylbuta-1,3-diene
 - II. Cyclohexanol
 - III. p-Xylene
 - IV. Ethylbenzene
 - V. But-1-ene
 - VI. Pyrrole
9. a) (i) Free Mössbauer nucleus ^{119}Sn emits a γ -radiation of frequency $5.76 \times 10^{18} \text{ Hz}$. Calculate the recoil velocity and energy of the nucleus. [Given: Avogadro number = $6.02 \times 10^{23} \text{ mol}^{-1}$]. (2)
- (ii) For a system with an axially symmetric electric field gradient, derive the energy level scheme and determine the resulting quadrupole splitting for a transition from a ground state with spin $I_{gr} = 3/2$ to an excited state with spin $I_{ex} = 5/2$. (3)
- b) (i) The ESR spectrum of an organic radical containing two carbon atoms consisted of 12 lines having relative intensities of 1,2,3,1,6,3,3,6,1,3,2 and 1. Identify the radical. (3)
- (ii) Why does the g value in ESR spectroscopy become anisotropic in solid samples or molecules with low symmetry? (2)
10. a) What is Nuclear Overhauser Effect (NOE)? How does it arise. (5)
- b) In the ESR spectrum of $\text{K}_3\text{Mo}(\text{CN})_8$, 25% isotopes of Mo show in spin $I = 5/2$. Predict the pattern of lines around a central line from 75% non-magnetic isotope. (5)