Lecture Plan

Name of the college: Government College of Arts, Science and Commerce, Sanquelim- Goa

Name of Faculty: Ms. Dipika Gosavi	**Subject:** Chemistry	
Paper code: CHC-302	**Program:** T Y BSc	**Division:** A
Academic year: 2025 - 2026	**Semester:** V	**Total Lectures: 15**

Course Objectives: : To develop a strong foundation in Molecular spectroscopy by understanding fundamental concepts, applying mathematical
and performing related problem-solving and experimental analysis.

Expected Course Outcome:

1. Explain the interaction of electromagnetic radiation with molecules and the significance of the Born–Oppenheimer approximation.
2. Analyze rotational spectra, apply selection rules, and calculate molecular parameters such as bond lengths and the effect of isotopic substitution.
3. Interpret vibrational spectra using classical and quantum models, compute force constants, dissociation energies, and understand anharmonicity and Morse potential.
4. Apply vibrational-rotational coupling concepts to study P, Q, R branches and deduce molecular vibrational-rotational transitions. Evaluate Raman spectra, explain the Raman effect, Stokes and Anti-Stokes lines, and apply the mutual exclusion principle to molecular systems.
5. Solve numerical problems related to rotational, vibrational, and Raman spectroscopy for diatomic and polyatomic molecules.

Student Learning Outcome:

1. Describe how molecules interact with electromagnetic radiation and differentiate between types of spectra.
2. Apply selection rules to predict rotational transitions and determine structural parameters of molecules.
3. Calculate force constants, vibrational frequencies, and dissociation energies using appropriate models.
4. Analyze normal modes of vibration in polyatomic molecules (H_2O, CO_2) and relate them to group frequencies.

5. Interpret vibration–rotation spectra and classify P, Q, R branches.
6. Explain Raman scattering, distinguish Stokes vs. Anti-Stokes lines, and justify intensity differences.
   Use quantum and classical approaches to interpret Raman effect and apply the mutual exclusion principle.
   Develop problem-solving skills through numerical exercises in spectroscopy.
7. Apply quantum mechanical models to simple systems such as free particles and particles in a box to determine energy quantisation.

Month	Lecture From	Lecture To	No. of lectures allotted	Topic, Subtopic to be covered	Exercise/ Assignment	ICT Tools	Reference books
June	20/06/2025	28/06/2025	1	Molecular Spectroscopy -I Interaction of electromagnetic radiation with molecules	Explain the interaction of electromagnetic radiation with matter, highlighting absorption, emission, and scattering processes.	Power point presentation/ Smart board	Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition.
July	30/06/2025	05/07/2025	1	and various types of spectra, Born-Oppenheimer approximation	Discuss the Born–Oppenheimer approximation and its importance in molecular spectroscopy. Differentiate between rotational, vibrational, and Raman spectra with suitable examples	Power point presentation/ Smart board	Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition.
July	07/07/2025	12/07/2025	1	. a. Rotational Spectroscopy: Selection rules, ,	Derive the selection rules for rotational spectra of diatomic molecules	Power point presentation/ Smart board	Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition.

July	14/07/2025	19/07/2025	1	intensities of spectral lines, determination of bond lengths of diatomic and	. A diatomic molecule shows a rotational spectrum with a line separation of 2.0 cm^{-1}. Calculate the bond length of the molecule.	Power point presentation/ Smart board	Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition.
July	21/07/2025	26/07/2025	1	linear triatomic molecules, isotopic substitution.	Explain the effect of isotopic substitution on the rotational spectrum with a worked-out example.	Power point presentation/ Smart board	Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition.
July/ August	28/07/2025	02/08/2025	1	Vibrational spectroscopy: Classical equation of vibration	Derive the classical equation of vibration and relate it to the concept of force constant	Power point presentation/ Smart board	Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition.
August	04/08/2025	09/08/2025	1	computation of force constant,	. Calculate the fundamental vibrational frequency of HCl given its force constant and compare the result with experimental data..	Power point presentation/ Smart board	Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition.
August	11/08/2025	16/08/2025	1	anharmonicity, Morse potential	Explain anharmonicity in vibrational spectra using the Morse potential curve. Discuss modes of vibration in H_2O and CO_2 molecules with diagrams	Power point presentation/ Smart board	Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition.

August	18/08/2025	23/08/2025	1	dissociation energies, fundamental frequencies, overtones, hot bands,	Explain anharmonicity in vibrational spectra using the Morse potential curve.	Power point presentation/ Smart board	Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition.
August	25/08/2025	30/08/2025	**CHATURTHI BREAK**				
September	01/09/2025	06/09/2025	1	degree of freedom for polyatomic molecules	Discuss modes of vibration in H_2O and CO_2 molecules with diagrams	Power point presentation/ Smart board	1. J.N. Gurtu, Physical Chemistry Vol-III, A pragati edition.
September	08/09/2025	13/09/2025	1	, modes of vibration (H2O and CO2), concept of group frequencies	Discuss modes of vibration in H_2O and CO_2 molecules with diagrams	Power point presentation/ Smart board	2. N. B. Laxmeshwar, S. M. Malushte, A. S. Mulye, V. N. Kulkarni, Concepts of Physical Chemistry, Chetana Prakashan
September	15/09/2025	20/09/2025	1	Vibration rotation spectroscopy:	Derive expressions for P, Q, and R branches in a vibration–rotation spectrum. For a given spectrum (provide a sample data set or graph), assign the P and R branch lines.	Power point presentation/ Smart board	1. J.N. Gurtu, Physical Chemistry Vol-III, A pragati edition.
September	22/09/2025	27/09/2025	1	Diatomic vibrating rotator, P, Q, R branches. c. Raman spectroscopy:	Differentiate between Stokes and Anti-Stokes lines, and explain why Anti-Stokes lines are weaker. Discuss the rotational Raman spectra and derive the expression for line positions.	Power point presentation/ Smart board	2. N. B. Laxmeshwar, S. M. Malushte, A. S. Mulye, V. N. Kulkarni, Concepts of Physical Chemistry, Chetana Prakashan
September/ October	29/09/2025	04/10/2025	1	Raman effect, qualitative treatment of Rotational Raman effect,	Differentiate between Stokes and Anti-Stokes lines, and explain why Anti-Stokes lines are	Power point presentation/ Smart board	Puri, Sharma and Kalia, Principles of Inorganic Chemistry, 33rd Edition, Vishal Publishing Co. (2018).

					weaker. Discuss the rotational Raman spectra and derive the expression for line positions.		
October	06/10/2025	11/10/2025	1	Vibrational Raman spectra, Stokes and Anti-stokes lines, their intensity difference, ,	Differentiate between Stokes and Anti-Stokes lines, and explain why Anti-Stokes lines are weaker. Discuss the rotational Raman spectra and derive the expression for line positions.	Power point presentation/ Smart board	Puri, Sharma and Kalia, Principles of Inorganic Chemistry, 33rd Edition, Vishal Publishing Co. (2018).
October	13/10/2025	18/10/2025	1	Quantum and Classical theories of Raman effect		Power point presentation/ Smart board	Puri, Sharma and Kalia, Principles of Inorganic Chemistry, 33rd Edition, Vishal Publishing Co. (2018).
October	21/10/2024	21/10/2024	1	rule of mutual exclusion principle. (numericals to be solved)		Power point presentation/ Smart board	Puri, Sharma and Kalia, Principles of Inorganic Chemistry, 33rd Edition, Vishal Publishing Co. (2018).

Assessment Rubrics

Component	Max Marks
ISA 1	7.5
ISA 2	7.5
Practical	-
Project	-
Semester End Exam	45