CHEM8154: ADVANCED CHEMICAL BONDING AND MOLECULAR SPECTROSCOPY

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Advanced Chemical Bonding and Molecular Spectroscopy

Subject Code
CHEM - Chemistry
Course Number
8154

Academic Unit
Chemistry (CHEM)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
4

Level
R8 - Research Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
BCH8154 Advanced Chemical Bonding and Molecular Spectroscopy

Exclusive Courses
Nil

Part II Course Details

Abstract

This course is a postgraduate taught course tailored for postgraduate research students only. The aim of this course is to help students to develop an understanding of the theories of chemical bonding and applications of some important spectroscopic techniques which are essential in all branches of chemistry.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe chemical bonding using quantum mechanics.	20	x	x	
2	Describe the interaction between electromagnetic radiations and atoms/ molecules.	20	x	x	
3	Discover the spectra for simple organic and inorganic compounds qualitatively based on information of chemical bonding theories and spectroscopic techniques.	20	x	x	x
4	Extract useful chemical information such as bonding and reactivity from spectroscopic data.	20		x	x
5	Design appropriate spectroscopic methods for chemical analysis.	20		x	x

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Students will learn the origin of quantum mechanics through literature searches; large group interactive activities will enable students to understand light-matter interactions	1, 2	
2	Tutorials	Through a number of case studies the students will discover the techniques of assigning spectra	3, 4, 5	

3	Presentations	Student-centered learning and student oral presentation to provide students opportunities in rationalizing the relationship between chemical bonding and spectroscopic data; problem-based learning activities to provide opportunities for students to design appropriate spectroscopic methods for chemical analysis	3, 4, 5	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Homework	1	5	-	Yes
2	Presentations	4	5	-	Yes
3	Tests and Reports	1, 2, 3	15	-	Yes
4	Individual Project	5	5	-	Yes

Continuous Assessment (%)

30

Examination (%)

70

Examination Duration (Hours)

3

Minimum Continuous Assessment Passing Requirement (%)

40

Minimum Examination Passing Requirement (%)

40

Assessment Rubrics (AR)

Assessment Task

For students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter

Excellent

(A+, A, A-) Student completes all the assessment tasks/activities (quizzes, laboratory reports, group presentations, and exams) and demonstrates excellent grasp of the important concepts to various aspects of the topic covered in this course, and can apply these concepts to solve problems with clear and logical explanations. Strong evidence of superior writing and presentation skills.

Good

(B+, B, B-) Student completes all assessment tasks/activities and can describe and explain the important concepts to several aspects of the topic covered in this course. Shows, to some extent, the ability to use concepts for rationalization and to solve problems. Displays effective writing and presentation skills.

Fair

(C+, C, C-) Student completes most of the assessment tasks/activities and can describe some key elements on the topics covered in the course. Shows limited ability to apply concepts, and competent writing and presentation skills.

Marginal

(D) Student has little participation and interest, and demonstrates limited ability in analysis.

Failure

(F) Student has no participation, interest or original thought.

Assessment Task

For students admitted from Semester A 2022/23 to Summer Term 2024

Excellent

(A+, A, A-) Student completes all the assessment tasks/activities (quizzes, laboratory reports, group presentations, and exams) and demonstrates excellent grasp of the important concepts to various aspects of the topic covered in this course, and can apply these concepts to solve problems with clear and logical explanations. Strong evidence of superior writing and presentation skills.

Good

(B+, B) Student completes all assessment tasks/activities and can describe and explain the important concepts to several aspects of the topic covered in this course. Shows, to some extent, the ability to use concepts for rationalization and to solve problems. Displays effective writing and presentation skills.

Marginal

(B-, C+, C) Student has little participation and interest, and demonstrates limited ability in analysis.

Failure

(F) Student has no participation, interest or original thought.

Part III Other Information

Keyword Syllabus

Quantum Mechanics

Schrödinger Equation, Quantum Mechanical Postulates, Particle in a Box, Hydrogen Atom, Molecular Orbital Theory, Valence-Bond Theory, Hybridization

Symmetry, Group Theory and Quantum Mechanics

Irreducible Representations, Direct Products, Projection Operators

Nature of Radiation, Atomic and Molecular Transitions

Electromagnetic radiation-Matter Interaction, Quantized Transition in Atomic and Molecular Levels, Born-Oppenheimer Approximation, Selection Rules

Electronic Absorption Spectroscopy

Franck-Condon Principle, Spin-Orbit Coupling, Vibronic Coupling, Configuration Interaction, Oscillator Strength

Vibration and Rotation Spectroscopies

Infrared and Raman Spectroscopies, Harmonic Oscillator Approximation, Normal Mode of Vibration, Resonance Raman Spectroscopy, Microwave Spectroscopy

Nuclear Magnetic Resonance and Electron Paramagnetic Resonance Spectroscopies

Spin Quantum Number, Field Strength and Chemical Shift, Spin-Spin Splitting, Nuclear Hyperfine Splitting

Photoelectron Spectroscopy

Ultraviolet Photoelectron Spectroscopy, X-ray Photoelectron Spectroscopy

Reading List

Additional Readings

	Title
1	Quantum Chemistry and Spectroscopy, Thomas Engel, 3rd Ed.(ISBN-13: 978-0321766199)