CHEM8008: ADVANCED CHEMICAL INSTRUMENTATION FOR RESEARCH

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Advanced Chemical Instrumentation for Research

Subject Code
CHEM - Chemistry
Course Number
8008

Academic Unit
Chemistry (CHEM)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
R8 - Research Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
BCH8008 Advanced Chemical Instrumentation for Research

Exclusive Courses
CHEM6118 Advanced Chemical Instrumentation

Part II Course Details

Abstract

The course aims to provide the student with concepts and principles of some advanced and widely used research techniques and instrumental methods in chemistry. The course will introduce to the students the basic concepts, working principles and specific capabilities of different chemical instrumentations.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain and apply the basic concepts and working principles of electronic spectroscopy (UV-VIS absorption and fluorescence) and vibrational spectroscopy (Raman and IR), review the latest developments in laser based time-resolved electronic and vibrational spectroscopies, and evaluate their capabilities for chemical analyses in modern research.		x	x	
2	Explain and apply the basic concepts and working principles of mass spectrometry, characterize the capabilities of commonly used ion sources and mass analyzers for chemical analyses, review their latest instrumental developments in hyphened and tandem mass spectrometric techniques, and evaluate their capabilities for chemical analyses in modern research.		x	x	
3	Explain and apply the basic concepts and working principles of in situ IR and NMR spectroscopies, review their latest instrumental developments in 2D NMR techniques, and evaluate their capabilities for chemical analyses in modern research.		x	x	
4	Demonstrate critical thinking skills in proposing possible applications of UV-VIS, fluorescence, IR, Raman, NMR spectroscopies, and mass spectrometry for modern chemical researches; design and justify the selection of the most appropriate instrumental methods or their combination to perform chemical analyses for given research tasks.		x	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 and tutorials	Students will engage in a combination of interactive lecture and tutorial activities to discuss and explain the basic concepts, working principles; to review and evaluate latest instrumental developments in time-resolved electronic and vibrational spectroscopies with some recent applications in literature.	1, 4	
2	Lectures and tutorials	Students will engage in a combination of interactive lecture and tutorial activities to discuss and explain the basic concepts, working principles, and the capabilities of commonly used ion sources and mass analyzers in mass spectrometry; to review and evaluate latest instrumental developments in hyphened and tandem mass spectrometric techniques with some recent applications in literature.	2, 4	
3	Lectures and tutorials	Students will engage in a combination of interactive lecture and tutorial activities to discuss and explain the basic concepts and working principles of in situ IR and NMR; to review and evaluate latest instrumental developments in 2D NMR techniques with some recent applications in literature.	3, 4	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Assignment: Basic concepts, working principles of various chemical instrumental techniques	1, 2, 3	15	-	Yes
2	Assignment: Literature reviews on latest instrumental developments and proposing potential applications	1, 2, 3, 4	15	-	Yes
3	Examination: Explain the fundamental concepts and working principles of advanced chemical instrumentation.	1, 2, 3	0	-	No
4	Examination: Discuss and critical evaluate their advantages, limitations and challenges of different instruments.	1, 2, 3	0	-	No
5	Examination: Propose and justify the selection of the most appropriate instrumental method or combination of methods to analyse and solve these defined chemical problems.	1, 2, 3, 4	0	-	No

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

Literature reviews, group discussions and oral presentation (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Capacity for self-directed learning to understand the principles of advanced chemical instrumentation

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Literature reviews, group discussions and oral presentation (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to critically evaluate some selected literature on the usage of advanced instrumentation for modern chemical researches

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Literature reviews, group discussions and oral presentation (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to propose with detail explanation possible applications of advanced instrumentation for modern chemical researches

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to explain in detail and with accuracy the principles of advanced chemical instrumentation and their applications for modern chemical researches

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Assignment: Basic concepts, working principles of various chemical instrumental techniques (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Capacity for self-directed learning (including preview and review of teaching materials) to understand the principles of advanced chemical instrumentation

Excellent

(A+, A, A-) High: Able to discuss and explain the basic concepts and working principles, and evaluate the capabilities of commonly used advanced chemical instrumentations precisely and concisely with no errors

Good

(B+, B) Significant: Able to discuss and explain the basic concepts and working principles, and evaluate the capabilities of commonly used advanced chemical instrumentations precisely and concisely with a few errors

Marginal

(B-, C+, C) Basic; Able to discuss and explain the basic concepts and working principles, and evaluate the capabilities of commonly used advanced chemical instrumentations precisely and concisely with some errors

Failure

(F) Not even reaching marginal levels: Unable to discuss and explain most basic concepts and working principles of commonly used advanced chemical instrumentations

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Assessment Task

Assignment: Literature reviews on latest instrumental developments and proposing potential applications (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to critically evaluate some selected literature on the usage of advanced instrumentation for chemical analyses in modern research; apply knowledge to propose designs with justification the selection of the most appropriate instrumental methods or their combination to perform chemical analyses for a given research task.

Excellent

(A+, A, A-) High: Able to present all required knowledge and concepts precisely and concisely with no errors; and able to propose reasonable instrumental approaches with scientific basis

Good

(B+, B) Significant: Able to present most required knowledge and concepts precisely and concisely with no errors; and able to propose reasonable instrumental approaches with scientific basis

Marginal

(B-, C+, C) Basic: Able to present some required knowledge and concepts precisely and concisely with no errors; and able to propose reasonable instrumental approaches with scientific basis

Failure

(F) Not even reaching marginal levels: Unable to present most required knowledge and concepts precisely and concisely; and unable to propose reasonable instrumental approaches with scientific basis

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Assessment Task

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to explain in detail and with accuracy the principles of advanced instrumentation, discuss and critically evaluate their advantages, limitations and challenges, propose and justify their applications for modern chemical researches

Excellent

(A+, A, A-) High: Able to correctly answer almost all the examination questions precisely and concisely with no errors

Good

(B+, B) Significant: Able to correctly answer a substantial number of the examination questions precisely and concisely with no errors

Marginal

(B-, C+, C) Basic: Able to correctly answer most of the examination questions precisely and concisely with only a few errors

Failure

(F) Not even reaching marginal levels: Unable to correctly answer most of the examination questions

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Part III Other Information

Keyword Syllabus

UV-Vis absorption, fluorescence spectroscopy, Raman spectroscopy, Infrared (IR) spectroscopy, Fourier Transfer IR spectroscopy, time domain and frequency domain spectra, continuous wave laser, pulsed laser, time-resolved spectroscopy with time window ranging from femtosecond to millisecond, time-resolved fluorescence, transient absorption, time-resolved resonance Raman, fluorescence photocounting, laser flash photolysis, mass spectrometry, electron ionization, fast atom bombardment, chemical ionization, electrospray, laser desorption, quadrupole mass analyzer, quadrupole ion trap, time-of-flight, Fourier transform ion cyclotron resonance, hybrid instruments, tandem mass spectrometry, in situ IR and NMR.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	Principles of Instrumental Analysis; D. A. Skoog, F. J. Holler, S. R. Crouch; (Cengage Learning, 2018, 7th Ed.)
2	Mass Spectrometry - A Textbook; J. H. Gross; (Springer-Verlag, 2017, 3rd Ed.)
3	Mass Spectrometry: Principles and Applications; E. de Hoffmann, V. Stroobant; (John Wiley & Sons Ltd., 3rd Ed., Reprinted 2012)