

City University of Hong Kong
Course Syllabus

offered by Department of Chemistry
with effect from Semester A 2024/25

Part I Course Overview

Course Title:	Advanced Chemical Instrumentation
Course Code:	CHEM6118
Course Duration:	1 semester
Credit Units:	3 credits
Level:	P6
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites: <i>(Course Code and Title)</i>	Nil
Precursors: <i>(Course Code and Title)</i>	Nil
Equivalent Courses: <i>(Course Code and Title)</i>	BCH6118 Advanced Chemical Instrumentation
Exclusive Courses: <i>(Course Code and Title)</i>	CHEM8008 Advanced Chemical Instrumentation for Research

Part II Course Details

1. Abstract

This course enables students of postgraduate level to more in-depth understand concepts and principles of advanced chemical instrumentation (electron, vibration and NMR spectroscopies and mass spectrometry) applied for a wide variety of advanced chemistry disciplines (such as catalysis, synthetic chemistry, materials & biomaterials chemistry, analytical & bio-analytical sciences, computational chemistry, environmental chemistry and chemical biology). Through review and discussion on some recent literature, the latest instrumental developments will be introduced to students, and their advantages, limitations and challenges for chemical research and development will also be critically evaluated. Individual literature review will allow students to identify nowadays chemical problems and propose plausible usages of the advanced instrumentation to obtain chemical information to tackle the problems. On completion of this course, students should be able to design experiments with application of most appropriate instrumental tools or their combination to solve problems in chemistry and molecular sciences.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	A2	A3
1.	Explain and apply the fundamental concepts and working principles of advanced instrumentation, such as electron, vibration and nuclear magnetic resonance spectroscopies and mass spectrometry, for chemical analysis.	30%	✓	✓	
2.	Discuss the latest developments in the above techniques and critical evaluate their advantages, limitations and challenges for research and development in chemistry and molecular sciences, with special emphasis on molecular design and chemical methodology in synthetic and analytical chemistry.	40%	✓	✓	
3.	Propose plausible innovative and practical applications of the above advanced instrumentation for modern chemical research and development. Justify the selection of the most appropriate instrumental method or their combination to analyse and solve defined chemical problems.	30%	✓	✓	✓
		100%			

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.

3. Learning and Teaching Activities (LTAs)

(LTAs designed to facilitate students' achievement of the CILOs.)

LTA	Brief Description	CILO No.			Hours/week (if applicable)
		1	2	3	
Lectures and Tutorials	Students will engage in a combination of interactive lecture and tutorial activities to discuss and explain the fundamental concepts and working principles of the latest developments in electron, vibration and nuclear magnetic resonance spectroscopies and mass spectrometry.	✓		✓	
Lectures and Tutorials	Students will engage in a combination of interactive lecture and tutorial activities to discuss and critical evaluate chemical information and key findings in some recent chemical literature, and discuss and evaluate the advantages, limitations and challenges of the advanced instrumentation methods for research and development in chemistry and molecular sciences.		✓	✓	

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.			Weighting	Remarks
	1	2	3		
Continuous Assessment: <u>30%</u>					
Assignment: Basic concepts, working principles of various chemical instrumental techniques	✓	✓		15%	
Assignment: Literature reviews on latest instrumental developments and proposing potential applications	✓	✓	✓	15%	
Examination: <u>70%</u> (duration: 3 hours)					
Explain the fundamental concepts and working principles of advanced chemical instrumentation.	✓	✓		20%	
Discuss and critical evaluate their advantages, limitations and challenges of different instruments.	✓	✓		30%	
Propose and justify the selection of the most appropriate instrumental method or combination of methods to analyse and solve these defined chemical problems.	✓	✓	✓	20%	
				100%	

Starting from Semester A, 2015-16, students must satisfy the following minimum passing requirement for courses offered by CHEM:

“A minimum of 40% in both coursework and examination components.”

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

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

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
Assignment: Basic concepts, working principles of various chemical instrumental techniques	Capacity for self-directed learning (including preview and review of teaching materials) to understand the principles of advanced chemical instrumentation	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	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	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	Minimal Able to discuss and explain a few basic concepts and working principles, and evaluate the capabilities of commonly used advanced chemical instrumentations precisely and concisely with some errors	Not even reaching marginal levels Unable to discuss and explain most basic concepts and working principles of commonly used advanced chemical instrumentations
Assignment: Literature reviews on latest instrumental developments and proposing potential applications	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.	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	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	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	Minimal Able to present a few required knowledge and concepts with some errors; and able to propose reasonable instrumental approaches with scientific basis	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
Examination	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	High Able to correctly answer almost all the examination questions precisely and concisely with no errors	Significant Able to correctly answer a substantial number of the examination questions precisely and concisely with no errors	Basic Able to correctly answer most of the examination questions precisely and concisely with only a few errors	Minimal Able to correctly answer a few examination questions with some errors	Not even reaching marginal levels Unable to correctly answer most of the examination questions

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

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
Assignment: Basic concepts, working principles of various chemical instrumental techniques	Capacity for self-directed learning (including preview and review of teaching materials) to understand the principles of advanced chemical instrumentation	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	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	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	Not even reaching marginal levels Unable to discuss and explain most basic concepts and working principles of commonly used advanced chemical instrumentations
Assignment: Literature reviews on latest instrumental developments and proposing potential applications	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.	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	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	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	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
Examination	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	High Able to correctly answer almost all the examination questions precisely and concisely with no errors	Significant Able to correctly answer a substantial number of the examination questions precisely and concisely with no errors	Basic Able to correctly answer most of the examination questions precisely and concisely with only a few errors	Not even reaching marginal levels Unable to correctly answer most of the examination questions

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

Advanced optical spectroscopic techniques and their relationships with electronic and bonding structures, Fourier transform 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, *in situ* IR and NMR, COSY, NOESY, mass spectrometry, time-of-flight, linear quadrupole, quadrupole ion trap, orbitrap, Fourier transform ion cyclotron resonance, hybrid instruments, electron/chemical ionization, fast atom bombardment, electrospray, laser desorption, tandem mass spectrometry, collision activation, IR/UV photodissociation, electron-capture/transfer dissociation, ion-mobility spectrometry.

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

Nil

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

1.	Principles of Instrumental Analysis; D. A. Skoog, F. J. Holler, S. R. Crouch; (Cengage Learning, 2018, 7th Ed.)
2.	Introduction to Spectroscopy; D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan; (Cengage Learning 2015, 5th Ed.)
3.	Mass Spectrometry - A Textbook; J. H. Gross; (Springer-Verlag, 2017, 3rd Ed.)
4.	Mass Spectrometry: Principles and Applications; E. de Hoffmann, V. Stroobant; (John Wiley & Sons Ltd., 3rd Ed., Reprinted 2012)