DEPARTMENT OF

# CHEMISTRY

## CHEM UG Courses

### UG Courses offered in Spring Term 2023-2024 but the courses outlines are not time-specific

| Course Code | Course Title |
|---|---|
| CHEM 1004 | Chemistry in Everyday Life |
| CHEM 1008 | Introductory Chemistry |
| CHEM 1020 | General Chemistry I |
| CHEM 1030 | General Chemistry II |
| CHEM 1050 | Laboratory for General Chemistry I |
| CHEM 1055 | Laboratory for General Chemistry II |
| CHEM 2111 | Fundamentals of Organic Chemistry |
| CHEM 2155 | Fundamentals Organic Chemistry Laboratory |
| CHEM 2311 | Analytical Chemistry |
| CHEM 2355 | Fundamental Analytical Chemistry Laboratory |
| CHEM 3120 | Organic Chemistry II |
| CHEM 3220 | Inorganic Chemistry II |
| CHEM 3320 | Instrumental Analysis |
| CHEM 3420 | Physical Chemistry II |
| CHEM 3550 | Synthetic Chemistry Laboratory |
| CHEM 3555 | Molecular Characterization Chemistry Laboratory |
| CHEM 4110 | Structural Elucidation in Organic Chemistry |
| CHEM 4230 | Materials Characterization Method |

| | |
|---|---|
| CHEM 4240 | Intermediate Inorganic Chemistry |
| CHEM 4330 | Separation Science |
| CHEM 4420 | Statistical Machine Learning Methods for Chemical Data Analysis |
| CHEM 4430 | Symmetry in Chemistry and Spectroscopy |
| CHEM 4680 | Undergraduate Research |
| CHEM 4689 | Capstone Project |
| CHEM 4691 | Capstone Research I |
| CHEM 4692 | Capstone Research II |

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

# CHEM 1004 – Chemistry in Everyday Life

**Spring Semester 2023-24**

3 credits

| | |
|---|---|
| Lectures: | Rm 2407 (2/F, Lift 17/18)<br>Tuesdays and Thursdays<br>13:30 – 14:50<br><br>No lectures on 13 Feb, 28 Mar, 2 Apr, 4 Apr |
| Course Instructor: | **Prof. Emily M.W. TSANG**<br>Assistant Professor of Science Education<br>Department of Chemistry, HKUST<br><br>Email: **chetsang@ust.hk**<br>Office: Rm 4536 (4/F, between Lifts 25/26 and 27/28) |
| Course website: | **https://canvas.ust.hk** |

## Course Description

CHEM 1004 is an introductory course provided for students who have never taken a Chemistry course, but would like to learn what chemistry is and how it may affect the world we live in.

Course objectives are as follows:
1. Introduce basic concepts of Chemistry.
2. Connect Chemistry with everyday life and modern technology.
3. Explain the importance of Chemistry in the environment, medicine, and daily life.

## Course Outline

The course is divided into six Chapters:

| | |
|---|---|
| Chapter 1: | What is everything made of? |
| Chapter 2: | The Air. |
| Chapter 3: | The air and our environment. |
| Chapter 4: | The metals in our daily life. |
| Chapter 5: | Metals in the industry. |
| Chapter 6: | Fire and fuels. |

## Lectures

The lectures are critical to your understanding of course materials. You should try to attend all the lectures. We will show some interesting experiments during some of the classes and they are best viewed in person. Lecture recordings will be provided on Canvas after **each class**, so please catch up promptly when you missed a class.

## Course Contents

Comprehensive **lecture notes** will be provided for this course. These notes should be very helpful to you as they provide more details of the lecture materials than power point slides. However, the version of the notes you receive is incomplete. You will need to fill in some important details or draw diagrams to complete the notes during the lectures.

You should print out hard copies of the lecture notes and bring them to the class. You can staple each chapter's notes into a booklet.
It would be advisable to print them single sided, so that you can use the blank page to jot down extra notes that the lecturer mentions but are not in the notes, or to write some references you obtained from other sources or your revision notes.

The **power point slides** will be mostly pictures or graphics. The slides will usually be released on Canvas after the end of each lecture, so please make notes on the lecture notes instead.

The lecture notes will be released by chapter. New chapters will be released on Canvas towards the end of the current chapter. You can read through the notes before the lecture to familiarise yourself with the materials.

## Textbooks/Reading List

You don't need a textbook for this course, and since we draw examples from many different areas of chemistry in everyday life, no one textbook is a perfect fit for the course. Therefore for each chapter, some reading materials will be suggested to you for optional reference.

## End of Chapter Exercises and Tutorial Sessions

To help you prepare for the examination, each chapter will finish with a short **exercise**. These exercises will require you to work through a set of problems, using some knowledge from the lectures and also to teach you some new knowledge through the exercise.

These exercises will not be formally graded, but they will be examinable.

## Office Hours of the Instructor and TAs

Please feel free to approach the instructor, Prof. Emily Tsang to ask questions or to discuss any chemistry or course-related issues. You may approach her after the lectures, or you may email her to arrange an appointment. There is no fixed office hour schedule: if you need one, feel free to email and book a time.

In addition, our TAs are all postgraduate research students working in the forefront of chemistry research. They are here to help you also if you want to ask any questions or if you want to find out more about their research. You should email them directly to arrange an appointment.

## Online Graded Quizzes (15 % of the course)

There will be two online graded quizzes in addition to the end-of-chapter exercises, the first quiz is **after Chapter 4** (covering Chapters 1 – 4), and the second quiz is at the end of the course (covering mainly Chapters 5 – 6). You should complete them within the given time (typically around 1 week). The accumulated points from the online quizzes will carry 15 % to the course grade, but the main purpose is to help you further understand the course materials and have a chance to practice and receive answers immediately after submission. When these quizzes are available, you will receive email notification as well as instructions during the lectures.

## Individual Study-Project (30 % of the course)

This course will have a study project component for you to learn more about a particular area of everyday chemistry that interests you. The project period will commence about 3 weeks into the course. In view of the time needed for this project, **there will be no mid-term examination** for this course.

Every student will undertake an *individual* written study project. At the end of the project, each student should submit a piece of written original research. You will choose a topic yourself that is about any chemistry phenomenon or chemicals that is in your everyday life. Be creative and explore interesting topics!

You are expected to read widely, using resources available to you, not limited to the internet – you also have access to books, journal articles and other multimedia resources. You may report also real experiences yourself and report them. Photographs would be needed to demonstrate that your topic is truly something you can connect to in the real world.

The article should bring together many ideas to draw up an original story. Originality checks will be performed so you must do the writing yourself.

More information will be announced during a lecture around week 3.

## Final Examination (55 %)

*On-campus proctored examination:* This course will end with a *closed-book* final examination (2 hours). This will cover all the lecture materials and exercises that were taught in the course. You will mainly be tested on your understanding and ability to solve problems rather than solely on the memorisation of facts, but you should also be familiar with some key chemical details – some of these will inevitably require some memorisation.

The date, time and venue for the final exam will be announced later.

## Grades

The final grade for the course will be consisted of:
**15% from the Online Quizzes**
**30% from the Study Project**
**55% from the Final Examination**
The course is graded from A+ to F. An F grade will not earn you credits for the course.

## Intended Learning Outcomes (ILOs)

At the end of the course, the students will have:

1. An ability to recognize physical/chemical properties, physical/chemical changes.
2. An ability to apply knowledge of chemical reactions, stoichiometry, atomic structure, chemical bonding, molecular structure, states of matter, acid-base chemistry, and redox reactions.
3. A basic knowledge of organic chemistry, polymer chemistry, biochemistry, and food chemistry.
4. An ability to link chemistry to modern technology, environment, and daily life.

**Assessment Scheme**

| Weight | Assessment | Course ILOs | CHEM Program ILOs |
|---|---|---|---|
| 15% | Online Revision Quiz | 1, 2, 3, 4 | 1, 2, 3 |
| 30% | Study Project | 1, 2, 3, 4 | 3, 6, 11, 12, 13 |
| 55% | Final Exam | 1, 2, 3, 4 | 1, 2, 3 |

**Teaching and Learning Activities (Non-assessed)**

| Activities | Course ILOs | CHEM Program ILOs |
|---|---|---|
| Lecture | 1, 2, 3, 4 | 1, 2, 3 |
| End of chapter exercises and Tutorials | 1, 2, 3, 4 | 1, 2, 3 |

**Topics by Chapter**

| | | |
|---|---|---|
| Chapter 1:<br>What is everything made of? | **~2 Lectures** | Introduction of the course<br>Discovery of the atomic structure<br>Elements; relative atomic mass<br>relative molecular mass<br>The mole<br>Chemical calculations<br>Relationship between mole and mass, mole and concentration, mole and gas volume<br>Calculations, Common elements |
| Chapter 2:<br>The Air | **~3 Lectures** | Gases in the Air, Electronic configuration<br>Forming covalent bonds<br>States of matter, separation of gases in air,<br>Intermolecular forces: London dispersion force<br>Electronegativity, Polar and non-polar molecules,<br>Intermolecular forces: dipole-dipole interactions |
| Chapter 3:<br>The air and | **~5 Lectures** | Electromagnetic waves<br>Greenhouse gases, Greenhouse effect, |

| | | |
|---|---|---|
| our environment | | Global Warming, Carbon cycle, Reducing $CO_2$ emission<br>Acids and Bases<br>Air Pollution: Acid Rain and other air pollutants<br>Reading organic chemical structures<br>Air Pollution: VOCs, smog, PMs<br>Controlling air pollution<br>Ozone and ozone depletion |
| Chapter 4:<br>The metals in<br>our daily life | **~5 Lectures** | Different groups of metals in the periodic table:<br>Alkali metals, Alkaline earth metals,<br>Transition metals, Lanthanides,<br>metals in Group 13-15,<br>Radioactivity and the Actinide elements<br>Structure of Metals, Metallic bonding<br>Metal lattice systems<br>Physical properties of typical metals; Alloys<br>Alloys: types and applications<br>Compounds of metals: Ionic bonding<br>Name and Formula of ionic compounds<br>Structure of complex ions<br>Solid structure of ionic compounds<br>Ionic lattice systems<br>Physical properties of ionic compounds<br>Reaction of metals with oxygen<br>Reaction of metals with water<br>Reaction of metals with acids |
| Chapter 5:<br>Metals in<br>the industry | **~6 Lectures** | Metal extraction industry<br>Calculate %mass of metal in a compound<br>Redox<br>Oxidation number<br>Metal displacement reactions<br>Metal displacement reactions<br>Extraction of Metals by heating with carbon:<br>Copper, Iron (Blast Furnace, Basic Oxygen Converter) |

| | | |
|---|---|---|
| | | Electrolysis of molten ionic compounds:<br>Extraction of sodium<br>Electrolysis of molten ionic compounds:<br>Extraction of aluminium<br>Electrolysis of aqueous solution<br>The chloroalkali industry<br>The refining of copper metal<br>Electroplating<br>Anodising aluminium<br>Half cells and standard electrode potentials<br>Electrochemical cells<br>Fruit batteries, zinc-carbon batteries<br>Alkaline batteries<br>Silver oxide cells<br>Rechargeable batteries: Ni-MH batteries<br>Lithium metal batteries<br>Lithium-ion batteries |
| Chapter 6:<br>Fire and fuels | **~4 Lectures** | Fire and combustion, Fire triangle<br>How to fight a fire<br>Fire extinguishers<br>Introduction to fossil fuels: coal, natural gas and crude oil<br>Alkanes: naming and isomers<br>Fractional distillation of crude oil<br>Fractions from crude oil<br>Cracking<br>Alkenes<br>Polymers<br>Calculating energy from combustion reactions<br>Starting a fire<br>Fireworks<br>Explosives |

**The Hong Kong University of Science and Technology**
**Department of Chemistry**

**Instructor:** Prof. Emily M. W. Tsang
**Office:** Rm 4536 (Lift 25/26)
**E-mail:** chetsang@ust.hk

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## CHEM 1008 – Introductory Chemistry (3-credits) Spring 2023 -2024

**Course Description:**
This course targets science or engineering students with very little to no chemistry background. It provides a general introduction to basic principles of chemistry. Key topics include state of matters, atoms and elements, molecules and compounds, atomic structures and periodicity, molecular structures, quantities in chemical reactions, bonding theories, acids and bases, and solution chemistry.

**Exclusions:** Level 3 or above in HKDSE 1/2x Chemistry OR HKDSE 1x Chemistry, a passing grade in AL/AS Chemistry, any CHEM courses at or above 1004-level

**Lecture:** Tues, Thurs, 10:30 – 11:50

**Venue:** LT-C

**Instructor Office Hours:** By email appointment

**Course Content/Topics:**

| | |
|---|---|
| Chapter 1: Matter and Energy | Chapter 7: Electrons in Atom and the Periodic Table |
| Chapter 2: Atoms and Elements | Chapter 8: Chemical Bonding |
| Chapter 3: Molecules and Compounds | Chapter 9: Solids, Liquids, and Intermolecular Forces |
| Chapter 4: Chemical Composition | Chapter 10: Properties of Solutions |
| Chapter 5: Chemical Reactions | Chapter 11: Acids and Bases |
| Chapter 6: Reaction Stoichiometry | Chapter 12: Chemical Equilibrium |

**Intended Learning Outcomes:**
Upon successful completion of this course, students are expected to be able to:

1. Develop a microscopic view of the worlds in terms of atoms and molecules
2. Recognize physical/chemical properties, physical/chemical changes
3. Apply knowledge of states of matter, chemical reactions, stoichiometry, atomic structure, chemical bonding, molecular structure, and intermolecular interactions.
4. Obtain a basic knowledge of solution chemistry, acid-base chemistry, chemical equilibrium.
5. Recognize and appreciate the impact and significance of chemistry to our society.

## Course Grading Scheme

| | |
|---|---|
| Online Quizzes (2 x 10% each) | 20% |
| In-class Midterm Exam | 40 % |
| In-class Final Exam | 40 % |

# CHEM 1020, General Chemistry I
# CHEM 1020 Spring 2023-2024

**1. Instructors:**


Name: Prof. Guocheng JIA (1st half)
Prof. Haipeng LU (2nd half)
Email: chjiag@ust.hk (Prof. Jia)
haipenglu@ust.hk (Prof. Lu)
Extension: 2358 7361 (Prof. Jia)
3469 2097 (Prof. Lu)


**2. Meeting Time and Venue**

*Lectures:*

**Section L1:**

| | | |
|---|---|---|
| **10:30-11:50** | **Tuesday** | **LT-D** |
| **10:30-11:50** | **Thursday** | **LT-D** |

**Section L2:**

| | | |
|---|---|---|
| **09:00-10:20** | **Monday** | **LT-D** |
| **09:00-10:20** | **Wednesday** | **LT-D** |

*Office Hours:*

| | Time | Venue |
|---|---|---|
| **Instructor:** Prof. Guocheng JIA | Thur. 14:00 – 15:00 | CYT 6009 |
| **Instructor:** Prof. Haipeng LU | Thur. 14:00 – 15:00 | 4533 |
| **Instructional Assistant:** Dr. Ken NG | Mon. 15:30 – 18:30 | 4507 |

**3. Course description:**

Credit Points: 3

Pre-requisite: Level 3 or above in HKDSE 1/2x OR level 3 or above in HKDSE 1x Chemistry OR CHEM 1004 OR CHEM 1008

Exclusion: CHEM 1010

Brief Information/synopsis:

This course targets at students who have acquired more advanced knowledge in fundamental Chemistry in high school. Key topics include atomic structure and periodicity, bonding theories, chemical energy, and properties of gases, liquids and solids. Other topics such as chemical kinetics, chemical equilibrium and organic molecules will be briefly reviewed.

## 4. Intended Learning Outcomes

At the end of the course, the student will be able to:

1. Describe and apply elementary concepts and terminologies of chemistry
2. Describe the structure of atoms and periodicity, and determine electron configurations.
3. Describe and apply the primary concepts of bonding theory.
4. Perform chemical stoichiometric calculations.
5. Describe common reactions in aqueous solutions.
6. Describe and apply the basic concepts of thermochemistry.
7. Describe properties of gases, liquids and solids

## 5. Assessment Scheme

| | | |
|---|---|---|
| Midterm Exam | 50% | ILOs 1–3 |
| Final Exam | 50% | ILOs 1, 4–7 |

## 6. Student Learning Resources

Textbook:

Text(s): "Chemistry: An Atoms First Approach", Zumdahl, Zumdahl and DeCoste, 3rd Edition, Cengage Learning

## 7. Teaching and Learning Activities

Scheduled activities: 3 hrs lecture per week
Homework assignments after each chapter
Tutorials before mid-term exam and final exam

## 8. Course Schedule

Chapter 1. Chemical Foundations
Chapter 2. Atomic Structure and Periodicity
Chapter 3. Bonding: General Concepts
Chapter 4. Molecular Structure and Orbitals
Chapter 5. Chemical Stoichiometry
Chapter 6. Chemical Reactions in Aqueous Solution
Chapter 7. Thermochemistry: Chemical Energy
Chapter 8. Gases
Chapter 9. Liquids and Solids

# CHEM 1030 General Chemistry II (3:3-0-0)

Pre-requisite: Grade C+ or above in CHEM 1008 OR Level 4 or above in HKDSE 1x Chemistry OR CHEM 1010 OR CHEM 1020

This course is designed for students who have taken General Chemistry I and want to continue to expand their chemistry knowledge. It will cover topics related to stoichiometry and chemical reactions, properties of aqueous solutions, acids and bases, thermodynamics and equilibrium, electrochemistry, general aspects in chemistry of the main-group elements, and introduction to transition metal elements and coordination compounds.

**Spring 2024**

**Instructor:**

**Dr. Frederick Fu Kit SHEONG (1st half of the course)**
(Room 4543; Tel. 3469 2098; Email: chemfksheong@ust.hk)

**Prof. Zhenyang LIN (2nd half of the course)**
(Room 4518; Tel. 2358 7379; Email: chzlin@ust.hk)

**Instructional Assistant:**
**Dr. Tsz Kin NG** (Room 4506; Tel. 2358 7404; Email: ngken@ust.hk)



**Textbook:** Chemistry – an atoms first approach (3e)
**Authors:** Steven S. Zumdahl, Susan A. Zumdahl and Donald J. Decoste

| | |
|---|---|
| Chapter 10: | Properties of Solutions |
| Chapter 12: | Chemical Equilibrium |
| Chapter 13: | Acids and Bases |
| Chapter 14: | Acid-Base Equilibria |
| Chapter 15: | Solubility and Complex Ion Equilibria |
| Chapter 16: | Spontaneity, Entropy, and Free Energy |

**Midterm Exam (Chapters 10, 12-16) 2pm – 4pm March 23 (Sat)**

| | |
|---|---|
| Chapter 11: | Chemical Kinetics |
| Chapter 17: | Electrochemistry |
| Chapter 18: | The Nucleus: A Chemist's View |
| Chapter 19: | The Representative Elements |
| Chapter 20: | Transition Metals and Coordination Chemistry |

**Final Exam (Chapters 11, 17-20)**

## Learning Outcomes

## On completion of the course, students will be able to

1. Analyze properties of solutions and determine stoichiometry of chemical transformations.
2. Describe different definitions of acids and bases theories and understand acid-base equilibrium.
3. Apply the laws of thermodynamics and account for the factors that lead to spontaneous physical and chemical changes.
4. Describe redox reactions, use electrochemical data to predict the spontaneity of redox reactions, and comprehend the structures of electrochemical cells.
5. Describe and explain the trends and patterns of structures, physical properties and reactivities of selected main group compounds, transition metal compounds.
6. Recognize the impact of chemistry to society.



**Lecture Hours:** Section L1: 10:30 am – 11:50 am; Tuesday, Thursday at LT-J
Section L2: 3:00 pm – 4:20 pm; Wednesday, Friday at LT-D

**Office Hours:**
**Monday 3:30pm – 6:30pm: At Room 4507, or other time upon email request**

**Assessment:**

| | |
|---|---|
| Mid-term exam | 45% |
| Final exam | 45% |
| Assignments 1 & 2 | 5% × 2 |

**Assessment Scheme:**

| Weight | Assessment | Course ILOs |
|---|---|---|
| 5% | Assignment 1 | 1, 2, 3 |
| 5% | Assignment 2 | 4, 5 |
| 45% | Midterm exam | 1, 2, 3, 6 |
| 45% | Final exam | 4, 5, 6 |
| | Participation | 1, 2, 3, 4, 5, 6 |



**Ungraded Problem Set will be given on Canvas for each chapter.**

# CHEM 1050 Laboratory for General Chemistry I

## 2023–24 Spring

## Course Outline

**Instructor**

Dr. CHEUNG Man Sing (Rm4535; Tel: 2358 7401; Email: sing@ust.hk)

**Instructional Assistant (IA)**

Ms. TSANG Sammi C. Y. (Rm4501C; Tel: 3469 2080; Email: sammitsang@ust.hk)

**Technical Officer**

Mr. TSE M. L. (Rm4531; Tel: 2358 7371; Email: mltse@ust.hk)

**Class Schedule**

| Section | Date | Time | Venue |
|---|---|---|---|
| LA1 | Tuesday | 10:30AM – 01:20PM | 1004, CYT Building |
| LA2 | | 01:30PM – 04:20PM | |
| LA3 | Wednesday | 10:30AM – 01:20PM | |
| LA4 | | 01:30PM – 04:20PM | |
| LA5 | Thursday | 10:30AM – 01:20PM | |
| LA6 | | 01:30PM – 04:20PM | |

**Course Information**

Credit Units: 1

Pre-requisite: Nil

Co-requisite: CHEM 1020

Exclusion: Nil

Grade: P/F

Description:

This course is the laboratory class designed for students who are enrolled in CHEM 1020. With laboratory experience acquired in this course, students will be able to relate the physical and chemical principles and theories in practice, perform basic chemical laboratory techniques, and develop their data analyzing skills.

**Intended Learning Outcomes (ILOs)**

Upon successful completion of this course, students should be able to:

**Knowledge/Content Related:**

1. recognize various kinds of equipment in chemistry laboratory
2. conduct standard laboratory procedures involved in basic chemistry experiments

**Academic Skills/Competencies Related:**

3. conduct risk assessments concerning the use of chemicals in basic chemistry experiments
4. keep records of experimental work in basic chemistry experiments
5. interpret experimental results for physical and chemical phenomena in basic chemistry experiments

**Assessment Scheme**

| Assessment | Assessing Course ILOs |
|---|---|
| Pre-course Tests | 1, 2, 3 |
| Lab Attendance and Performance | 1, 2, 3, 4, 5 |
| Lab Reports | 4, 5 |

To pass the course, students have to get satisfactory performances in all abovementioned assessment tasks/activities.

**Student Learning Resources**

- Reference Book: James Hall, *Experimental Chemistry: An Atoms First Approach*, Brooks/Cole, Cengage Learning, **2012**.
- Other learning resources can be accessed through Canvas.

**Teaching and Learning Activities**

Laboratory: focus on experiments related to co-requisite course

**Course Schedule**

Keyword Syllabus:

- Laboratory safety
- Common laboratory apparatus
- Basic techniques for measurements in chemistry laboratory
- Gas law
- Boiling point and intermolecular forces
- Solution stoichiometry and volumetric titration
- Chemical energy and calorimetry

# CHEM1055 Laboratory for General Chemistry II

***2024 Spring***

## Course Outline

***LA1 to LA6***

**1. Instructor**

*Name: Dr TSE, W.P. Veronica (email:chvaipui@ust.hk)*

*Office Room 4537; Tel: 2358-7364*

**2. Technical support staff & Teaching Assistant:**

***Technical support staff:***

*Name: Mr. SEETO, Ki (email:chkseeto@ust.hk)*

*Name: Miss LEE, Layla (email:laylalee@ust.hk)*

***Teaching Assistants:***

*Name: [to be provided on a separate file on Canvas]*

**3. Class Schedule**

| Section | Date | Time | Venue |
|---|---|---|---|
| LA1 | Tuesday | 10:30 – 13:20 | CYT Building UG001 |
| LA2 | | 13:30 – 16:20 | |
| LA3 | Wednesday | 10:30 – 13:20 | |
| LA4 | | 13:30 – 16:20 | |
| LA5 | Thursday | 10:30 – 13:20 | |
| LA6 | | 13:30 – 16:20 | |

**4. Course Information**

Credit Units: 1

Pre-requisite: CHEM 1010 'General Chemistry I A' or CHEM 1020 'General Chemistry I B'

Co-requisite: CHEM 1030 'General Chemistry II'

Exclusion: NIL

Grade: **P / F**

*Description:*

This course is a laboratory class designed for students who enrolled in CHEM 1030. Students will perform experiments based on the theory learned in courses. By conducting experiments independently, students are able to experience the whole process, from pre-lab and studying Material Safety Data Sheet (MSDS), to using suitable labwares, experimental techniques, and data treatment.

## 5. Intended Learning Outcomes

Upon successful completion of this course, students should be able to:

**Knowledge/Content Related:**

1. Recognize various kinds of equipment in chemistry laboratory
2. Conduct standard laboratory procedures involved in basic chemistry experiments

**Academic Skills/Competencies:**

3. Conduct risk assessments concerning the use of chemicals in basic chemistry experiments
4. Keep record of experimental work in basic chemistry experiments
5. Interpret experimental results for physical and chemical phenomena in basic chemistry Experiments
6. Work independently and collaborate in teamwork.

## 6. Assessment Scheme

| Assessment | Assessing Course ILOs |
|---|---|
| Lab Attendance and Performance | 1,2,3,4,5,6 |
| Lab Reports | 3,4,5 |

**To pass the course, students must get satisfactory performances in all above-mentioned assessments/tasks/activities.**

- *Lab attendance and performance*

  Students are required to complete the experiments according to this course. Various laboratory techniques are included in the experiments. Explanation of theory and demonstrations will be given for each experiment. The students will then complete the experiment under our supervision.

- *Lab report*

  A laboratory report is required for each experiment based on the experimental data. Students should follow the format given in the guidelines provided. Two points per day will be deducted for late submission of any lab reports.

## 7. Student Learning Resources

- Reference books:
  - James Hall, *Experimental Chemistry an Atoms First Approach*, Brooks/Cole: Cengage©2012.
  - Jo A. Beran, *Laboratory Manual for Principles of General Chemistry 9th edition*, NY: McGraw-Hill©2011.
- Other learning resources can be accessed through Canvas.

## 8. Teaching and Learning Activities

Laboratory Demonstration: focus on experiments related to its co-requisite course

## 9. Course Schedule

Keyword Syllabus:

- Liquids and solids
- Properties of solutions
- Acids and bases
- Acid-base equilibria
- Colligative property
- Spontaneity, entropy and free energy
- Electrochemistry
- Transition metals

# CHEM 2111 Fundamental of Organic Chemistry

***Spring Semester 2024 (Jan 31 – May 10)***

**Venue:** 1409
**Lecture hours:** Mondays and Wednesday, 10:30 – 11:50 AM

**Credits:** 3
**Pre-requisite:** CHEM 1010 or CHEM 1020
**Exclusion:** CHEM 2110

## INSTRUCTOR

Prof. Kenward VONG
Office: 4521 (lifts 25/26)
E-mail: kvong@ust.hk

## COURSE DESCRIPTION

Various classes of organic compounds, emphasizing organic chemical reactions and mechanisms of major functionalities and their importance in the area of biological chemistry. For engineering students under the four-year degrees who prefer to learn organic chemistry in a single term.

The course will treat selected topics from a mechanistic viewpoint and illustrate their usefulness in the wider body of organic chemistry. Examples of concepts in organic synthesis will be given. The course does not aim to provide a comprehensive coverage of organic reactions, rather it will seek to encourage students to think about organic chemical reactions, and to apply key concepts to other reactions not covered in the course.

## INTENDED LEARNING OUTCOMES

Upon successful completion of the course, students should be able to:

1. Recognize fundamentals of organic chemistry including structures, reaction mechanisms, and some transformations of carbon-derived compounds.
2. Explain the essential facts and principles of organic chemistry.
3. Demonstrate awareness of organic chemistry topics relevance to social and daily life.
4. Formulate and analyze mechanisms and products of some general organic transformations by applying organic chemistry principles.

## ASSESSMENT SCHEME

Midterm 1 (open book): 30%
Midterm 2 (open book): 30%
Final Exam (closed book): 40%

**SCHEDULE**

| | | |
|---|---|---|
| Week 1 | | |
| | Jan 31 | Chemical Bonding (*chap 1*) |
| Week 2 | Feb 5 | Chemical Bonding (*chap 1*) |
| | Feb 7 | Chemical reactions (*chap 2*) |
| Week 3 | Feb 12 | Holiday |
| | Feb 14 | Stereochemistry (*chap 3*) |
| Week 4 | Feb 19 | Alkanes and Cycloalkanes (*chap 4*) |
| | Feb 21 | Alkanes and Cycloalkanes (*chap 4*) |
| Week 5 | Feb 26 | Alkenes and Alkynes (*chap 5*) |
| | Feb 28 | Alkenes and Alkynes (*chap 6*) |
| Week 6 | Mar 4 | Review session |
| | Mar 6 | **Midterm 1 (*open book*)** |
| Week 7 | Mar 11 | Aromatic compounds (*chap 7*) |
| | Mar 13 | Alkyl halides (*chap 8*) |
| Week 8 | Mar 18 | Nucleophilic substitution (*chap 9*) |
| | Mar 20 | Alcohols, Ethers, and Phenols (*chap 10*) |
| Week 9 | Mar 25 | Aldehydes and Ketones (*chap 11*) |
| | Mar 27 | Carboxylic acids (*chap 12*) |
| | Apr 1 | Mid-Term Break |
| | Apr 3 | Mid-Term Break |
| Week 10 | Apr 8 | Carboxylic acid derivatives (*chap 13*) |
| | Apr 10 | Amines (*chap 14*) |
| Week 11 | Apr 15 | Review session |
| | Apr 17 | **Midterm 2 (*open book*)** |
| Week 12 | Apr 22 | Retrosynthesis |
| | Apr 24 | Chemistry of Biomolecules |
| Week 13 | Apr 29 | Chemistry of Biomolecules |
| | May 1 | Holiday |
| Week 14 | May 6 | Free study |
| | May 8 | Review session |
| Exam period | May 17 – May 29 | **Final Exam (*closed book*)** |

## STUDENT LEARNING RESOURCES

Textbook:

"Organic Chemistry, A Brief Course" by Robert C. Atkins, Francis A. Carey, and Chi Wi Ong, McGraw-Hill Education (Asia), 2013

*or*

"Organic Chemistry, A Brief Course, 3rd Edition" by Robert C. Atkins and Francis A. Carey, McGraw-Hill Education, International Edition, 2007

Solutions Manual:

"Student Solutions Manual to accompany Organic Chemistry, A Brief Course, 3rd Edition" by Robert C. Atkins and Francis A. Carey, McGraw-Hill Education, International Edition, 2007

## RESERVE ITEMS IN LIBRARY

| | |
|---|---|
| CALL NUMBER | QD253.2 .A74 2002 |
| AUTHOR | Atkins, Robert C. (Robert Charles) |
| TITLE | Organic chemistry, a brief course |
| EDITION | 3rd ed. |
| IMPRINT | Boston : McGraw-Hill, c2002. |
| # Copies: | 3 copies |

| | |
|---|---|
| CALL NUMBER | QD251.2 .A82 2002 |
| AUTHOR | Atkins, Robert C. (Robert Charles) |
| TITLE | Organic chemistry, a brief course: student solutions manual |
| EDITION | 3rd ed. |
| IMPRINT | Boston : McGraw-Hill, c2002. |
| # Copies: | 2 copies |

# CHEM 2155 Fundamental Organic Chemistry Laboratory

*2024 spring*

## Course Outline

**1. Instructor**

*Prof. CHAN, Ho Wai Dennis (email: chanhw@ust.hk )*
Office Room 4528; Tel: 3469-2099

**2. Technical support staff / Teaching Assistant:**

*Technicial support staff:*

*LAU, Chun Tak Disney (email: disney@ust.hk)*
*CHAN, Ka Lok Kelvin (email: chkelvin@ust.hk)*
*WONG, Ka Man Joanne (email: joannewong@ust.hk)*
*LEUNG, Yan Wai Sally (email: sallyleung@ust.hk )*
Contact Details: CYT-1003 and CYT-1004; Tel: 3469-2611 or 3469-2612

*Teaching Assistant:*

*Name: [to be provided on a separate file on Canvas]*

**3. Meeting Time and Venue:**

| | | |
|---|---|---|
| Date/Time: | Tue | LA1 10:30 – 13:20 |
| | Tue | LA2 13:30 – 16:20 |
| Venue: | CYT-1003 and CYT-1004 (1/F, CYT buidling) | |

**4. Course Description**

Credit Points: 1
Pre-requisites: (CHEM 1010 or CHEM 1020) & CHEM 1050
Co-requisites: CHEM 2110 or CHEM 2111
Exclusions: CHEM 2150
Brief Information/synopsis:

*This is the laboratory course designed for non-CHEM students who enrolled in CHEM 2110 or CHEM 2111. Students will perform a series of organic experiments related to the theories learnt in the related lecture courses. Students will be trained to practice a wide range of fundamental organic laboratory techniques, operate chemical instruments, relate the physical and chemical principles and theory in practice, and develop their data interpretation and analytical skills. For non-CHEM students in programs that designate this course as required course/specified elective.*

**5. Intended Learning Outcomes (ILOs)**

Upon completion of the course, students should be able to:

| | |
|---|---|
| 1 | Conduct analysis and interpretation of experimental data related to organic experiments. |
| 2 | Assess and manage the risk of chemical substances and laboratory procedures, and to evaluate their potential impact on the environment. |
| 3 | Conduct standard laboratory procedures involved in synthetic and instrumental work related to organic experiments. |
| 4 | Equipped with hands on experiences in the operation of chemical instrumentation. |
| 5 | Able to show self awareness, to interact with other people in team working, and to work independently. |

## 6. Assessment Scheme

In lab. reports, you are allowed to use generative artificial intelligence (AI) to aid you in any manner. However, you must give proper credit for any use of generative AI.

| Assessment items | Weighting | ILOs to be assessed |
|---|---|---|
| Safety assignment | 5% | 2 |
| Performance | 30% | 2, 3, 4, 5 |
| Lab Report | 30% | 1, 2 |
| Examination | 35% | 1, 2 |

* *Overall score for getting a Pass (i.e. Grade C- or above): 50%*

## 7. Student Learning Resources

Reference books:
Kenneth L. Williamson, "*Macroscale and Microscale Organic Experiments*" 3rd edition, Boston: Houghton Mifflin ©1999; or the 4th edition (Boston: Houghton Mifflin ©2003), or Kenneth L. Williamson, Kathrine M. Maters, "*Macroscale and Microscale Organic Experiments*" 6th edition, Australia: Brooks/Cole ©2011; or the 7th edition (Australia: Cengage ©2017).

** Other course materials can be obtained from Canvas (https://canvas.ust.hk ). Please log in using your ITSC username and password.*

## 8. Teaching and Learning Activities

Scheduled activities: 2 hr 50 min (Tutorial + Laboratory work)

## 9. Keyword syllabus:

- Recrystallization of Organic Solids
- Distillation of Organic Liquids
- Separation of Organic Components from a Mixture
- Isolation of Organic Components
- Organic Synthesis
- Nucleophilic Substitution
- Melting Point Measurement
- Infra-Red Spectroscopy

# CHEM 2311 Analytical Chemistry [3-0-0:3]

## Spring 2024

**Instructor:** **Prof. Ian D. Williams Rm CYT 6005 chwill@ust.hk**

**Time:** **16.30 Wed, Fri LT D**

### Curriculum:

according to academic calendar
"Fundamental and practical aspects of chemical analysis, including titrimetric, electrical and spectroscopic methods, analytical separations by GLC and HPLC"

### Course text:

Much of the material covered and lecture notes will be based on the following

**"Exploring Chemical Analysis" 4th Edition**
**Daniel C. Harris, WH Freeman 2009**

available in bookstore w discount ca HK$271 (ca 80 copies); there is not much difference with older 3rd edition
a slightly more thorough text covering same and additional material is:

**"Quantitative Chemical Analysis" 8th Edition**
**Daniel C. Harris, WH Freeman 2010**

There should be several copies of these texts (maybe as older editions) on reserve in HKUST library. Most other Analytical Chemistry text books eg **Skoog et al 'Fundamentals of Analytical Chemistry' 8th Ed**. will cover much of the same UG curriculum but are useful to gain different perspective. They will also offer alternative worked problems. Topics that are proving difficult to you in class are often the most useful to seek new insight through reading an alternative source.

Lecture notes will be made available in pdf format before the class on the lmes2.ust.hk website. A more detailed curriculum guide follows so that background reading of relevant chapters of the course text (or equivalent) can be made in preparation. The lectures will be video-taped to enable replay, catch-up or for revision.

# Teaching Assistants for CHEM 2311 Spring 2024

## Teaching Assistants

- Mr LAU, Kwan Shing
- Mr. LI, Chunliang
- Mr. LIU, Yuan
- Miss WANG, Cengan
- Mr. ZENG, Xianghao
- Mr. ZHAO, Chaoyue

- We will schedule TA hours and Prof Williams Office hours once everyone's timetables are finalized.

**Course Grading Scheme:**

The grading will be calculated as follows

**Spring 2024 Grading Scheme:**

| | |
|---|---|
| Attendance/ PRS Quiz | 10% |
| Homework/ Assignments | 15% |
| Mid-term (1hr 20min) | 30% |
| Final exam (2hr) | 45% |

Problem sets will be assigned as homework most weeks and two of these (7.5% each) will be graded. Another 5% will be based on responses to questions given in class, via the iPRS system!

Homework submission will be through web via the LMES2 server. The homework answers will be Multi-choice or require your numerical input; much of the Mid Term and Final exam questions will be based on the style and type of problem set in homeworks, so these should be studied independently

## Curriculum Details and suggested Background Reading:

Background reading Chapters from Exploring Chemical Analysis (ECA) Harris

| | | |
|---|---|---|
| **Week 1** | **Background/ Introduction** | **Lectures 1 and 2** |
| Chapter 0. | The Analytical Process | |
| Chapter 1. | Chemical Measurements | |
| Chapter 2. | Tools-of-the-Trade | |
| **Week 2** | **Introductory Maths and Statistics** | **Lectures 3 and 4** |
| Chapter 3. | Math Toolkit, Sig Figs, Errors | |
| Chapter 4. | Statistics | |
| **Week 3** | **QA and Gravimetry** | **Lectures 5 and 6** |
| Chapter 5. | Least Squares and Quality Assurance | |
| Chapter 7. | Gravimetric and Combustion Analysis | |
| **Week 4** | **Titrations I** | **Lectures 7 and 8** |
| Chapter 6. | Good Titrations | |
| Chapter 8. | Introducing Acids and Bases | |
| **Week 5** | **Titrations II** | **Lectures 9 and 10** |
| Chapter 9 | Buffers | |
| Chapter 10 | Acid Base Titrations & N-Analysis | |
| **Week 6** | **Titrations III** | **Lectures 11 and 12** |
| Chapter 11 | Polyprotic Acids and Bases | |
| Chapter 13 | EDTA Titrations | |
| **Week 7** | **Mid-term Review** | **Review 1 and Lecture 13** |
| Review of Weeks 1-6 | | |
| Chapter 12 | Chemical Equilibrium | |

**Mid-term Exam 1.5 hr** **MT Exam**

(time & venue to be determined, but probably in evening in Week 7)

| | | |
|---|---|---|
| **Week 8** | **Electrochemistry I** | **Lectures 14 and 15** |
| Chapter 14 | Electrode Potentials | |
| Chapter 15 | Potentiometry | |
| **Week 9** | **Electrochemistry II & Biosensors** | **Lectures 16 and 17** |
| Chapter 15 | Electrode Measurements | |
| Chapter 16 | Redox Titrations | |
| **Week 10** | **Electrochemistry III & Spectroscopy** | **Lectures 18 and 19** |
| Chapter 17 | Instrumental Electrochemistry | |
| Chapter 18 | Let there be Light | |
| **Week 11** | **AA and related Spectroscopy** | **Lecture 20 and 21** |
| Chapter 19 | Spectrophotometry: Instruments and Applications | |
| Chapter 20 | Luminescence and Atomic Spectroscopy | |
| **Week 12** | **Chromatography and Mass Spectrometry** | **Lectures 22 and 23** |
| Chapter 21 | Chromatography and Mass Spectrometry | |
| **Week 13** | **Chromatography II** | **Lectures 24 and 25** |
| Chapter 22 | Gas and Liquid Chromatography | |
| Chapter 23 | Chromatographic Methods | |
| **Week 14** | **Chromatography III** | **Lecture 26** |
| Chapter 23 | Capillary Electrophoresis | |
| Review of Weeks 8-14 | | **Review 2** |
| Revision and Preparation for Final Exam | | |

**Final Examination (2hr)** schedule will be determined by ARR

**CHEM 2355 Fundamental Analytical Chemistry Laboratory**
Course Outline – Spring 2024

**1. Instructor**
*Name:* Dr Joanne W T Tung <*jwttung@ust.hk*>
*Contact: Office: Rm 4541 (Lift 25/26); Tel: 2358 7395*

**2. Technical Officers/ Instructional Assistant/ Teaching Assistants**
***Technical Officers****:*
*Name:* Rowena LEUNG <*chlsy@ust.hk*>; Wilson LEUNG <*wilsonleung@ust.hk*>
*Contact: Lab: CYT-3007 (Lift 35/36); Tel: 2358 7244; 2358 7245*

***Instructional Assistant:***
*Name: Jennifer WONG* <*wongyc@ust.hk*>
*Contact: Lab: CYT-3007 (Lift 35/36); Tel: 2358 7402; 2358 7382*

***Teaching Assistants:*** *Separate file*

**3. Meeting Time and Venue**
LA1: Tuesdays 10.30 - 13.20
LA2: Tuesdays 13.30 - 16.20

**Venue:** CYT-3007

**4. Course Description**
**Credit Points:** 1
**Pre-requisites:** CHEM1010 General Chemistry IA or CHEM1020 General Chemistry IB, or
CHEM1050 Laboratory for General Chemistry I
**Co-requisites:** CHEM2311 Analytical Chemistry, or
CHEM2310 Fundamentals of Analytical Chemistry

**Course Description:** Practical aspects of fundamental chemical analysis.

**Course Objective:** With the use of analytical instruments and lab equipment, the course applies what the students learned in lectures in practical term.

**5. Intended Learning Outcomes (ILOs)**

On completion, students should be able to:

| | |
|---|---|
| **1** | Explain the essential facts, principles and theories in the area of analytical chemistry. |
| **2** | Analyze and interpret experimental data and extract useful data from it |
| **3** | Conduct standard laboratory procedures involved in instrumental work. |
| **4** | Assess and manage the risks of chemical substances and laboratory procedures by evaluating their potential impact on the environment |
| **5** | Operate a range of chemical instrumentation with adequate hands-on experiences. |

**6. Assessment Scheme**

*Course Grading*

| Weight | Assessment | Course ILOs |
|---|---|---|
| 60% | Report | 1 - 2 |
| 30% | Lab Quiz | 1 - 2 |
| 10% | Lab Performance | 3 - 5 |

**7. Syllabus**

| Expt No. | Title of Experiment |
|---|---|
| 1 | Calibration of Volumetric Glassware |
| 2 | Quantitative Analysis of Xylene Isomers (meta-Xylene and para-Xylene) Using Fourier Transform- Infrared Spectrometer (FT-IR) |
| 3 | Determiantion of *n*-Heptane, *n*-Octane and *n*-Decane in unknown sample using Gas Chromatograph - Flame Ionization Detector (GC-FID) |

**8. Student Learning Resources**

- Harris D. C., Charles A. Lucy, ***Quantitative Chemical Analysis***, 10th Ed., Macmillian Learning, 2020.
- Skoog D A, West D M, Holler F J, ***Fundamentals of Analytical Chemistry***, 9th Ed, Brooks/Cole, 2013.

*(A few copies of each of the above textbooks have been reserved at the Course Reserve in HKUST library.)*

**9. Teaching and Learning Activities**

Students can gain their hands-on experience from bench-top work and sample preparation to equipment/instrument operations in the practicals. There will have tutorials for experiments conducted by the Instructor.

# CHEM 3120 Organic Chemistry II

## Spring Semester, 2024


**INSTRUCTOR**:

Dr. Jianwei Sun
Office: CYT6010
Telephone: 2358 7351
E-mail: sunjw@ust.hk

Dr. Hugh Nakamura
Office: Rm 4520
Telephone: 3469 2552
E-mail: hnakamura@ust.hk


**TEACHING ASSISTANTS**:

| | |
|---|---|
| LI, Shangzhao | slieo@connect.ust.hk |
| WANG, Jingyi | jwanghr@connect.ust.hk |
| ZHOU, Zhijie | zzhoucj@connect.ust.hk |

**LECTURE TIME**: Tuesday, 09:00 - 10:20
Thursday, 09:00 - 10:20

**VENUE**: Rm 4619 (Lifts 31/32)

**COURSE DESCRIPTION:**

CHEM3120 is the second half of a two-semester, introductory level organic chemistry course designed for chemistry and biochemistry majors. The complete course will prepare students for further studies in organic chemistry and/or biochemistry. Topics to be covered include IR, MS, and NMR spectroscopy; dienes, resonance and aromaticity; electrophilic aromatic substitution and nucleophilic aromatic substitution; benzylic and allylic reactivity; the chemistry of carbonyl compounds and carboxylic acid derivatives; the chemistry of amines; pericyclic reactions.

**TEXTBOOK**:

"*Organic Chemistry*" 8th edition by J. McMurry; Brooks/Cole, Thomson Learning, Inc. 2012
"*Study Guide and Student Solutions Manual for McMury's Organic Chemistry, 8th Edition*" by Susan McMurry, Brooks/Cole, Thomson Learning, Inc.

## COURSE OBJECTIVES AND INTENDED LEARNING OUTCOMES:

This is the Part II of a two-semester, introductory level organic chemistry course designed for chemistry/biochemistry major undergraduates. The complete two-semester course will prepare students for further studies in organic chemistry and/or biochemistry. Upon the end of the course, students should be able to:

1 Recognize fundamentals of organic chemistry including structures, reaction mechanisms, and transformations of carbon-derived compounds.
2 Explain the essential facts, principles, and theories of organic chemistry.
3 Demonstrate awareness of organic chemistry topics relevant to social and daily life.
4 Formulate and analyze mechanisms and products of organic transformations by applying organic chemistry principles.

## EXAMS AND GRADING SCHEME:

1. Midterm examination, 40%
2. Final examination, 60%

## SYLLABUS

| | | |
|---|---|---|
| Week 1 | Feb. 1 | *Chapter 12. Mass Spectrometry & Infrared Spectroscopy (1)* |
| Week 2 | Feb. 6 | *Chapter 12. Mass Spectrometry & Infrared Spectroscopy (2)* |
| | Feb. 8 | *Chapter 13. Nuclear Magnetic Resonance Spectroscopy (1)* |
| Week 3 | Feb. 15 | *No class (swap with mid-term exam)* |
| Week 4 | Feb. 20 | *Chapter 13. Nuclear Magnetic Resonance Spectroscopy (2)* |
| | Feb. 22 | *Chapter 14. Conjugated Dienes and UV Spectroscopy (1)* |
| Week 5 | Feb. 27 | *Chapter 14. Conjugated Dienes and UV Spectroscopy (2)* |
| | Feb. 29 | *Chapter 15. Benzene and Aromaticity* |
| Week 6 | Mar. 5 | *Chapter 16. Electrophilic Aromatic Substitution (1)* |
| | Mar. 7 | *Chapter 16. Electrophilic Aromatic Substitution (2)* |
| Week 7 | Mar. 12 | *A Preview of Carbonyl Compounds* |
| | | *Chapter 19. Aldehydes/Ketones: Nucleophilic Addition Reaction (1)* |
| | Mar. 14 | *Chapter 19. Aldehydes/Ketones: Nucleophilic Addition Reaction (2)* |
| Week 8 | Mar. 19 | *Tutorial (1)* |

**Mar. 21 (Thur) Mid-Term Exam, 8:20 – 10:20 am**
Covering Chapters 12-16 and 19, inclusive; Venue: **LT-B**

| | | |
|---|---|---|
| Week 9 | *Mar. 26* | *Chapter 20. Carboxylic Acids and Nitriles* |
| | *Mar. 28* | *No class (Mid-Term Break)* |
| Week 10 | *Apr. 2* | *No class (Mid-Term Break)* |
| | *Apr. 4* | *No class (Chin Ming Festival)* |
| Week 11 | Apr. 9 | *Chapter 21. Carboxylic Acid Derivatives: Nucleophilic Acyl Substitution Reactions (1)* |
| | Apr. 11 | *Chapter 21. Carboxylic Acid Derivatives: Nucleophilic Acyl Substitution Reactions (2)* |
| Week 12 | Apr. 16 | *Chapter 22. Carbonyl Alpha-Substitution Reactions (1)* |
| | Apr. 18 | *Chapter 22. Carbonyl Alpha-Substitution Reactions (2)* |
| Week 13 | Apr. 23 | *Chapter 23. Carbonyl Condensation Reactions (1)* |
| | Apr. 25 | *Chapter 23. Carbonyl Condensation Reactions (2)* |
| Week 14 | Apr. 30 | *Chapter 24. Amines and Heterocycles (1)* |
| | May 2 | *Chapter 24. Amines and Heterocycles (2)* |
| | May 7 | *Chapter 30. Orbitals and Organic Chemistry: Pericyclic reactions (1)* |
| | May 9 | *Chapter 30. Orbitals and Organic Chemistry: Pericyclic reactions (2)* |
| Week 15 | May 14 | *Tutorial (2)* |

**Final Exam, to be announced**

## SUPPORTING READING MATERIALS AND SOLUTION MANNUAL:

| | |
|---|---|
| Call Number | QD251.3 .M364 2008 c.1-3 |
| AUTHOR | McMurry, John. |
| TITLE | Organic chemistry / John McMurry. |
| EDITION | 7th ed. |
| IMPRINT | Belmont, CA : Thomson Brooks/Cole, c2008. |
| # Copies: | 3 copies |

| | |
|---|---|
| Call Number | QD251.3 .M3642 2008 c.1-3 |
| AUTHOR | McMurry, Susan |
| TITLE | Study guide and student solutions manual for McMurry's Organic chemistry |
| EDITION | 7th ed. |
| IMPRINT | Australia : Thomson Brooks/Cole, c2008. |
| # Copies: | 3 copies |

| | |
|---|---|
| Call Number | QD251.3 .M364 2004 c.1-4 |
| AUTHOR | McMurry, John. |
| TITLE | Organic chemistry / John McMurry. |
| EDITION | 6th ed. |
| IMPRINT | Pacific Grove, CA : Brooks/Cole, c2004. |
| # Copies: | 4 copies |

| | |
|---|---|
| Call Number | QD251.3 .M3642 2004 c.1-4 |
| AUTHOR | McMurry, Susan. |
| TITLE | Study guide and solutions manual for McMurry's Organic chemistry |
| EDITION | 6th ed. |
| IMPRINT | Pacific Grove, CA : Brooks/Cole, c2004. |
| # Copies: | 5 copies |

| | |
|---|---|
| Call Number | QD251.2 .M43 2000 |
| AUTHOR | McMurry, John. |
| TITLE | Organic chemistry / John McMurry. |
| EDITION | 5th ed. |
| IMPRINT | Pacific Grove, CA : Brooks/Cole, c2000. |
| # Copies: | 4 copies |

| | |
|---|---|
| Call Number | QD251.2 .M432 2000 |
| AUTHOR | McMurry, Susan. |
| TITLE | Study guide and solutions manual for McMurry's Organic chemistry, |
| EDITION | 5th ed. |
| IMPRINT | Pacific Grove, Calif. : Brooks/Cole, c2000. |
| # Copies | 4 copies |

| | |
|---|---|
| Call Number | QD251.2 M43 1996 |
| AUTHOR | McMurry, John |
| TITLE | Organic Chemistry / John McMurry |
| EDITION | 4th ed. |
| IMPRINT | Pacific Grove: Brooks/Cole Pub. Co., c1996. |
| # Copies: | 4 copies |

| | |
|---|---|
| Call Number | QD251.2 M432 1996 |
| AUTHOR | McMurry, Susan |
| TITLE | Study guide and solution manual for organic chemistry, fourth edition / Susan McMurry |
| IMPRINT | Pacific Grove, CA: Brooks/Cole Pub. Co., c1996. |
| # Copies: | 4 copies |

# CHEM 3220 Inorganic Chemistry II Spring 2024

**Course instructor**: Prof. Yangjian Quan (office: Rm 4532; phone: 34692550; e-mail: chyjquan@ust.hk)

**Class schedule**
Lecture: Wednesday (4:30-5:50 pm), Friday (4:30-5:50 pm), Rm 2465, Lift 25/26

**Course website**: http://canvas.ust.hk/

**Textbook:**
*Inorganic Chemistry*, International edition, by M. Weller et al., OUP (2018)

**Reference book:**
"*Inorganic Chemistry*", 4th ed., by C. E. Housecroft and A. G. Sharpe, Pearson (2012) [online access to the 3rd edition]

**Assessment scheme (to be announced)**
Quizzes
Assignments
Midterm exam
Final exam
Others (e.g. PRS, participation in class and tutorials)

**Course Contents**
*(1) Coordination Chemistry*

- Classification of ligands, naming of inorganic complexes
- Crystal field theory: d-orbital splitting for octahedral, tetrahedral, tetragonal and square planar complexes
- Factors that affect the size of crystal field splitting, spectrochemical series
- High-spin and low-spin electron configurations, ligand field stabilization energies
- Geometry of $d^8$ complexes: square planar versus tetrahedral geometry
- Spectral properties of metal ions: d-d and charge-transfer transitions
- Magnetic properties of transition metal ions
- Correlation of enthalpies of hydration of metal ions and lattice enthalpies of metal oxides with ligand field stabilization energies
- Coordination equilibria, stepwise and overall formation constants, Irving-Williams series
- Chelate and macrocyclic effects, applications of chelate ligands
- Jahn-Teller distortion of Cu(II) compounds
- Molecular orbital energy level diagrams of metal complexes, comparison of MO theory with crystal field theory

*(2) Organometallic chemistry of transition elements*

- The 18-electron rule: rationale, examples, and exceptions
- Electron count: ionic and covalent models

- Carbonyl compounds: bonding and structures, factors affecting IR C-O stretching frequencies of metal carbonyls, synthesis and reactions of metal carbonyls, acidity of metal carbonyl hydride compounds
- Ligands that are isoelectronic with CO ($NO^+$, $CN^-$, $N_2$)
- Alkene and alkyne compounds
- Organometallic reactions: oxidative addition, reductive elimination, and migratory insertion
- Homogeneous catalysis: catalytic cycles for Rh-catalyzed alkene hydrogenation, Co-catalyzed alkene hydroformylation, metal-catalyzed polymerization of alkenes, Pd-catalyzed cross-coupling reactions
- Selectivity of catalytic reactions, Tolman cone angles of phosphines

*(3) Main group hydride compounds*

- Classification of hydride compounds: saline, covalent, and metallic hydrides
- Electron-deficient, electron-precise and electron-rich hydrides: bonding, structures, and stability, acid-base properties
- Synthesis and reactions of hydride compounds

*(4) Main group alkyl/aryl compounds*

- Thermodynamic and kinetic stabilities of metal alkyl compounds
- Trends of M-C bond energies for transition and main group alkyl compounds
- Bonding and structures of main group alkyl compounds
- Inert pair effects
- Synthesis and reactions of main group alkyl compounds

*(5) Element-element multiple bonds*

- Trends of element-element sigma and pi bonds
- $N_2$ vs. $P_4$, $O_2$ vs. $S_8$
- Multiple bonds between heavier elements, bonding and structure of $Sn_2R_4$
- $d\pi$-$p\pi$ interactions in $R_3Si$-O-$SiR_3$ and $R_3P{=}O$

*(6) Inorganic rings and cages*

- Inorganic rings: borazine, polysiloxane, phosphazenes
- Inorganic cages
- Boranes and carboranes: *closo*, *nido* and *arachno* polyhedra, Wades rules

# CHEM3320
# Instrumental Analysis

**Lecture venue:** Rm 4619, Lift 31-32
**Lecture time:** Tuesday &Thursday (3:00-4:20 pm)


**Instructors:**

Prof. YU, Jianzhen
Rm 4534, Tel: 2358-7389, chjianyu@ust.hk

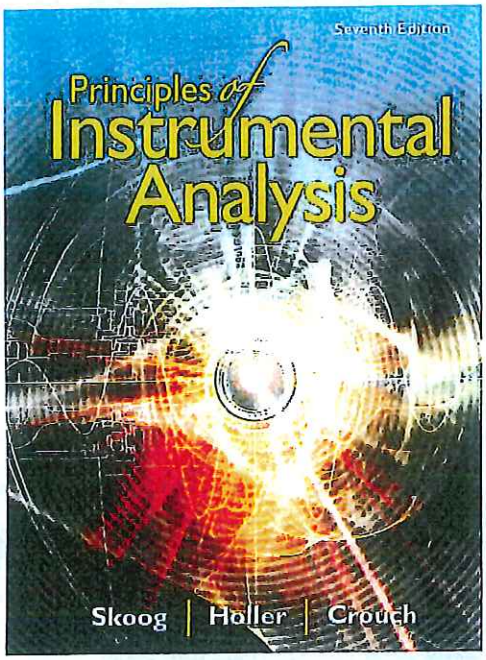
Prof. Wu, Hongkai
Rm 4515, Tel: 2358-7246, chhkwu@ust.hk

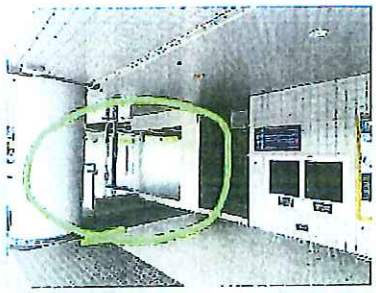
**Teaching Assistants**

LIANG, Shumin | sliangam@connect.ust.hk
VORWERK, Anna Mae |amvorwerk@connect.ust.hk
WEI, Peiqi | pweiab@connect.ust.hk




## Textbook:
## Principles of Instrumental Analysis




| Print Book | eBook |
|---|---|
| Student could visit the booth which available from **30th Jan 2024- 29th Feb 2024** to purchase the print book.<br><br>**Address**<br>The Commercial Press – The Hong Kong University of Science and Technology<br>Address: Entrance Piazza G012 (Ex-Bank of East Asia's site)<br><br>  | **eBook purchase link:**<br>Principles of Instrumental Analysis, Cengage eBook, 12 Months Digital Access<br>https://www.cengageasiaestore.com/hk/principles-of-instrumental-analysis-cengage-ebook-12-months-digital-access.html<br><br>**Discount code:**<br>HK30124<br><br>**Promotional period:**<br>1st Jan 2024- 29th Feb 2024<br><br>**Discount:**<br>HKD $30 off<br><br>**eBook registration guide:**<br>eBook-Student Registration Guide.pdf |

# CHEM3320 Course Outline (Spring 2024)

- Introduction to Instrumental Method: Chapter 1
- Introduction to Instrument Method: Statistical data evaluation: Appendix 1
- Introduction to mass spectrometry
- Atomic Mass Spectrometry (Chpt 11)
- Molecular Mass Spectrometry (Chpt 20)
- Introduction to Optical Spectrometric Methods: Chapters 6&7
- Introduction to Optical Atomic Spectrometry: Chapter 8

Prof. Yu, Jianzhen

⇧ Exam-1

- Atomic Absorption and Emission Spectrometry: Chapters 9&10
- Atomic X-Ray Spectrometry: Chapter 12
- Ultraviolet/Visible Molecular Absorption Spectrometry: Chapters 13&14
- Molecular Luminescence Spectrometry: Chapter 15
- Infrared Spectrometry: Chapters 16&17
- Raman Spectrometry: Chapter 18
- Nuclear Magnetic Resonance Spectroscopy: Chapter 19
- Electroanalytical Chemistry-An Introduction: Chapter 22
- Potentiometry: Chapter 23
- Coulometry: Chapter 24
- Voltammetry: Chapter 25
- Surface Characterization by Spectroscopy and Microscopy: Chapter 21

⇩ Final

Prof. Wu, Hongkai



# Grade Assessment

- Homework: 0%
  - Submissions not required
- Exam I: 35%
  - Topics examined (see previous slide)
  - Date: 9 March 2024 (Saturday, 10 am-12nn)
  - Venue: to be announced
- Final exam: 65%
  - Topics examined (see previous slide)
  - Date and time: To be announced by the university

# Course Syllabus

# CHEM 3420 'Physical Chemistry II'
# Term: Spring Term 2023-24


**Instructors:**

Prof. Tengteng Chen (Topic 1-2) and Prof. Jinqing Huang (Topic 3-4)

Room: 4542, 4544, Lift 25/26

Tel: 2358-7387, 3469-2627

E-mail: tengtengchen@ust.hk, jqhuang@ust.hk

**Teaching Assistants:**

Topic 1-2

UMAR, Nitish nkumaraa@connect.ust.hk

HUANG, Duan dhuangaw@connect.ust.hk

Topic 3-4

ZHANG, Jianing jzhangia@connect.ust.hk

CHOY, Ka Hei khchoyab@connect.ust.hk


**Lectures:**

| | | |
|---|---|---|
| Monday | 15:00-16:20 | Rm2306 (Lift 17/18) |
| Friday | 10:30-11:50 | Rm2306 (Lift 17/18) |

**Office Hours:**

| | | |
|---|---|---|
| Monday | 16:30-18:00 | Room 4542/4544 (Lift 25/26) |
| Friday | 12:00-13:30 | Room 4542/4544 (Lift 25/26) |

**Course Website:**

https://canvas.ust.hk/courses/55619

**COURSE DESCRIPTION**

*Chem3420: Physical Chemistry II* aims to provide the students with a basic knowledge of the concepts, mathematics, and results of quantum mechanics and its application to chemical systems. Specifically, we will cover topics including the principles and mathematics tools in quantum mechanics, one-dimensional problems, particle-in-box, harmonic oscillator, angular momentum theory, spin, and introduction to methods of modern electronic structure theory, with applications in atomic and molecular structures, spectroscopy, and chemical bonding.

## LEARNING OUTCOMES

Upon the study of this course, students are expected to establish a recognition of the fundamentally important role of Physical Chemistry in molecular science, to gain a better understanding of the relationship between Physical Chemistry and other sub-areas of chemistry, to develop an appreciation of the relationship between chemistry and Physics, Mathematics and other disciplines in science, and to be able to assess and judge some of the pressing societal issues in health, environment, and new technologies from the point of view of Physical Chemistry.

## TEXTBOOK

Physical Chemistry, 11th Edition, by Peter Atkins, Julio de Paula, James Keeler

Oxford University Press, 2018.

https://learninglink.oup.com/access/pchem11eLinks to an external site.

## STUDENT REQUIREMENT

- Students need to be familiar with the syllabus and the class schedule, and be aware of the course requirements and progress.
- Students need to check the course website (https://canvas.ust.hk/courses/55619) and their UST e-mails on regular basis. All assignments, slides and any other course materials will be posted on the course website. Furthermore, course announcements will also be make on the course website and/or via UST e-mail.
- Students are required to be familiar with HKUST Academic Integrity Policy (http://www.ust.hk/vpaao/integrity/). These policies will be strictly enforced in this course to keep academic honesty.
- Students need to follow proper classroom ethics, so that we can make a comfortable learning environment to each and every student in the class.

## GRADING

| | |
|---|---|
| Midterm Exam | 40% |
| Final Exam | 50% |
| Assignments | 10% |

Notes:

- Midterm Exam and Final Exam are in-class closed-book examinations.
- Assignments: There will be four sets of homework assignments in total. **Two** out of **FOUR** with highest scores will each contribute 5% to the final grade.

## COURSE SCHEDULE

| | |
|---|---|
| Feb 2 | Introduction &<br>Topic 1: Introduction to Quantum Theory<br>*Textbook: Chapter 7.*<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Feb 5 | Topic 1: Introduction to Quantum Theory (continued)<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Feb 9 | Topic 1: Introduction to Quantum Theory (continued)<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |

| | |
|---|---|
| Feb 12 | No class (Lunar New Year's Day) |
| Feb 16 | Topic 1: Introduction to Quantum Theory (continued)<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Feb 19 | Topic 2: The Quantum Theory of Motion – Translation<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Feb 23 | Topic 2: The Quantum Theory of Motion – Translation (continued)<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Feb 26 | Topic 2: The Quantum Theory of Motion – Vibration<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Mar 1 | Topic 2: The Quantum Theory of Motion – Vibration (continued)<br>Prof. Tengteng Chen |

| | |
|---|---|
| | Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Mar 4 | Topic 2: The Quantum Theory of Motion – Rotation<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Mar 8 | Topic 2: The Quantum Theory of Motion – Rotation (continued)<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Mar 11 | Topic 2: The Quantum Theory of Motion – Rotation (continued)<br>Prof. Tengteng Chen<br>Lecture notes are available on "Files".<br>Video lecture recordings are available on "Pages". |
| Mar 15 | Topic 3: Atoms – Atomic Structure of Hydrogen-like atoms<br>*Textbook: Chapter 8A*<br>Prof. Jinqing Huang |
| Mar 18 | Topic 3: Atoms – Atomic Structure of Hydrogen-like atoms (continued) |

| | |
|---|---|
| | Prof. Jinqing Huang |
| Mar 22 | Topic 3: Atoms – Atomic Structure of Hydrogen-like atoms (continued)<br>Prof. Jinqing Huang |
| Mar 25 | Topic 3: Atoms – Atomic Structure of Hydrogen-like atoms (continued)<br>Prof. Jinqing Huang<br>Actions |
| Mar 29 | No class (Good Friday) |
| Apr 1 | No class (Mid-term Break) |
| Apr 5 | No class (Mid-term Break) |
| Apr 8 | **Midterm Exam** (covers Topic 1 & 2)<br>Time: 3:00 - 4:20 pm (Lecture Time)<br>Location: Room 2306 and Room 2404 (Lift 17/18)<br>Prof. Tengteng Chen |
| Apr 12 | Topic 3: Atoms – Atomic Structure of many electron atoms<br>*Textbook: Chapter 8B* |

| | |
|---|---|
| | Prof. Jinqing Huang |
| Apr 15 | Topic 3: Atoms – Atomic Spectra<br>*Textbook: Chapter 8C*<br>Prof. Jinqing Huang |
| Apr 19 | Topic 4: Molecules – Valence Bond theory<br>*Textbook: Chapter 9A*<br>Prof. Jinqing Huang<br>Oppenheimer \| Official Trailer 2:02 |
| Apr 22 | Topic 4: Molecules – Valence Bond theory (continued)<br>Prof. Jinqing Huang |
| Apr 26 | Topic 4: Molecules – Valence Bond theory (continued)<br>Prof. Jinqing Huang |
| Apr 29 | Topic 4: Molecules – Molecular Orbital theory *Textbook: Chapter 9B-D*<br>Prof. Jinqing Huang |

| | |
|---|---|
| May 3 | Topic 4: Molecules – Molecular Orbital theory (continued)<br>Prof. Jinqing Huang |
| May 6 | Topic 4: Molecules – Hückel theory<br>*Textbook: Chapter 9E*<br>Prof. Jinqing Huang |
| May 10 | Review<br>Prof. Jinqing Huang |

Information for the Final Exam:

| | |
|---|---|
| May 27 | **Final Exam** (covers Topic 3 & 4)<br>Time: **9:30AM - 11:30AM**<br>Location: **LG1 Table Tennis Room**<br>Prof. Jinqing Huang |

Updated at May 10, 2024

# CHEM 3550 Synthetic Chemistry Laboratory II

**2024 Spring**

**Course Outline**

## 1. Instructor

*Name: Prof. CHAN, Ho-Wai Dennis (email: chanhw@ust.hk )*
Contact Details: Office Room 4528; Tel: 3469-2099

## 2. Technical support staff / Teaching Assistant:

*Technical support staff:*

*Names: LAU, Chun Tak Disney (email: disney@ust.hk)*
*CHAN, Ka Lok Kelvin (email: chkelvin@ust.hk)*
*WONG, Ka Man Joanne (email: joannewong@ust.hk)*
*LEUNG, Yan Wai Sally (email: sallyleung@ust.hk )*

Contact Details: CYT-1003 & CYT-1004; Tel: 34692611 & 34692612

*Teaching Assistant:*

*Names: [to be provided in a separate file]*

## 3. Meeting Time and Venue:

Date/Time: LA1 Wednesday (12:30 – 16:20);
LA2 Thursday (12:30 – 16:20)
Venue: CYT-1003 and CYT-1004 (CYT buidling)

## 4. Course Description

Credit Points: 2
Pre-requisite: CHEM 2550
Corequisite: CHEM 3120 and CHEM 3220
Exclusion: NIL
Brief Information/synopsis:

*This course was designed and introduced to suit chemistry major students who are enrolling in CHEM 3120 Organic Chemistry II and CHEM 3220 Inorganic Chemistry II, in which it provides students some hands-on experience in organic synthesis and metal complexes formation. Different spectroscopic methods will also be used for characterization of products. The topics of experiments covered in the laboratory course will be related to those taught in the lecture courses.*

## 5. Intended Learning Outcomes (ILOs)

Upon completion of this course, students are expected to be able to:

| | |
|---|---|
| 1 | Describe the fundamentals of organic and inorganic chemistry. |
| 2 | Assess and manage the risks of organic and inorganic chemical substances and laboratory procedures. |
| 3 | Conduct analysis and interpretation of experimental data of synthetic chemistry. |
| 4 | Conduct standard laboratory procedures involved in fundamental chemical synthesis and instrumental work. |
| 5 | Operate a range of chemical instrumentation. |
| 6 | Work independently and collaborate in team work. |

## 6. Assessment Scheme

In lab. reports, you are allowed to use generative artificial intelligence (AI) to aid you in any manner. However, you must give proper credit for any use of generative AI.

| # | Items | | Weighting | ILO(s) to be assessed |
|---|---|---|---|---|
| 1 | Risk Assessment | | 5% | 2 |
| 2 | Lab Quizzes† | | 20% | 1, 2, 3 |
| 3 | Performance | Attendance & Punctuality | 5% | 6 |
| | | Lab Performance | 25% | 4, 5, 6 |
| | | Products / Results | 10% | 4, 5 |
| 4 | Lab Reports | | 35% | 1, 2, 3, 4, 5, 6 |

† *a short lab quiz (about 8-10 minutes) before each experiment.*

## 7. Student Learning Resources

Reference books:

(a) Kenneth L. Williamson, Katherine M. Masters, *Macroscale and Microscale Organic Experiments 7th edition*, Australia: Cengage ©2017. (or *6th edition*)

(b) A. I. Vogel, (editor), *Vogel's Textbook of Practical Organic Chemistry 5th edition*, London : Longman Scientific & Technical ©1989.

(c) Lutz F. Tietze, Theophil Eicher, Ulf Diederichsen, *Reactions and Syntheses: In the Organic Chemistry Laboratory*, Weinheim: Wiley ©2015. [*available online / UST library*]

(d) J. Derek Woollins, *Inorganic Experiments 3rd edition*, Weinheim: Wiley ©2010.

* *Other course materials can be downloaded from Canvas (https://canvas.ust.hk ). Please log in using your ITSC username and password.*

## 8. Teaching and Learning Activities

Scheduled activities: 3 hr 50 min (tutorial, laboratory work, demonstration, etc.)

## 9. Course Schedule

Keyword syllabus:

- Separation of an Organic Mixture by Column Chromatography
- Purification of Organic Compounds
- Chemical Resolution of a Racemic Mixture
- Carbon-Carbon Bond Formation by Aldol Condensation
- Reductive Amination
- Synthesis of Schiff Bases
- Synthesis of Transition Metal Complexes
- Characterization of Isomers of Transition Metal Complexes
- Measurement of Magnetic Susceptibility
- Polarimetry of Chiral Organic Compounds
- Measurement of Infrared Spectra
- Measurement of $^{1}H$ Nuclear Magnetic Resonance Spectra

**CHEM 3555 Molecular Characterization Chemistry Laboratory**
Course Outline – Spring 2024

**1. Instructor**
*Name:* Dr Joanne W T Tung <*jwttung@ust.hk*>
*Contact: Office: Rm 4541 (Lift 25/26); Tel: 2358 7395*

**2. Technical Officers/ Instructional Assistant/ Teaching Assistants**
***Technical Officers****:*
*Name:* Kwong K CHAN <*chankk@ust.hk*>; Alice WONG <*wongtingin@ust.hk*>
*Contact: Lab: CYT-3007 (Lift 35/36); Tel: 2358 7244; 2358 7402*

***Instructional Assistant:*** *Jennifer WONG <wongyc@ust.hk>*
*Contact: Lab: CYT-3007 (Lift 35/36); Tel: 2358 7402; 2358 7382;*

***Teaching Assistants:*** *Separate file*

**3. Meeting Time and Venue**
**Date & Time:**
LA1: 10.30 - 14.20 (Wednesday)
LA2: 10.30 - 14.20 (Thursday)

**Venue:** CYT-3007

**4. Course Description**
**Credit Points:** 2

**Pre-requisites:** CHEM 2350 Analytical Chemistry Laboratory; CHEM2450 Physical Chemistry Laboratory

**Co-requisites:** CHEM3320 Analytical Chemistry II; CHEM3420 Physical Chemistry II.

**Course Objective:** With the use of analytical instruments, equipment and computational software, the course applies what the students learned in lectures in practical term.

**Course Description:** Computational chemistry and instrumental methods in characterisation of molecular properties.

**5. Intended Learning Outcomes (ILOs)**
On completion, students should be able to:

| | |
|---|---|
| **1** | Explain the essential facts, principles and theories in the area of analytical & physical chemistry. |
| **2** | Formulate and analyze a wide range of chemical problems by applying chemical principles. |
| **3** | Analyze and interpret experimental data and extract useful data from it |
| **4** | Conduct standard laboratory procedures involved in instrumental work. |
| **5** | Operate a range of chemical instrumentation with adequate hands-on experiences. |
| **6** | Assess and manage the risks of chemical substances and laboratory procedures by evaluating their potential impact on the environment. |
| **7** | Work independently, safely and collaborate effectively in team work |

## 6. Assessment Scheme

*Course Grading*

| Weight | Assessment | Course ILOs |
|---|---|---|
| 55% | Report | 1 - 3 |
| 25% | Lab Quiz | 1 - 3 |
| 20% | Lab Performance | 4 - 7 |

## 7. Syllabus

| Expt No | Title of Experiment |
|---|---|
| 1 | Spectroscopic Evidence of Energy Quantisation from the UV-Visible Spectra of $SO_2$, $I_2$ and $NH_3$ Gases |
| 2 | Molecular Emission Method: Spectrofluorimetric Determination of Riboflavin in Vitamin Tablet |
| 3 | Illustration of 1-D Particle in a Box: Study of $\beta$-Carotene by UV-Visible Spectroscopy |
| 4 | Atomic Absorption Method: Lead Content in Hair Dye Sample by Atomic Absorption Spectrophotometry (AAS) |
| 5 | Electroanalytical Method: Determination of Chloride Content in Biscuit Samples with Ion-Selective Electrode (ISE) |
| 6 | Visualisation of Molecular Orbitals of a Heteronucleus Diatomic Molecule Simulated by a Computational Software - Gaussian |

## 8. Student Learning Resources

*Analytical Chemistry*

- Harris D. C., Charles A. Lucy, ***Quantitative Chemical Analysis***, 10th Ed., Macmillian Learning, 2020.
- Skoog D. A., Holler F. J., ***Principles of Instrumental Analysis***, 7th Ed., Australia: Cengage Learning, 2007.

*Physical Chemistry*

- Atkins P. W., Julio de Paula, James Keeler, ***Atkins' Physical Chemistry,*** 11th Ed., Oxford University Press, 2018.

*(A few copies of each of the above textbooks have been reserved at the Course Reserve in HKUST library.)*

## 9. Teaching and Learning Activities

Students can gain their hands-on experience from bench-top work, sample preparation to equipment/instrument operations in the practicals. There will have tutorials for experiments conducted by the Instructor.

## CHEM 4110 Structural Elucidation in Organic Chemistry — Spring Term 2024

**Course Instructors**: Prof. Rongbiao Tong, Office: Rm CYT6011. Email: rtong@ust.hk

**Teaching Assistant**: Yiqin Zhou

**Text Book:**
"*Introduction to spectroscopy*", Donald L. Pavia, Gary M. Lampman, George S. Kriz, James A. Vyvyan, 4th Ed. 2009; (Library only has the 3rd Edition: QD 272.S6 P38 2001 and is also available at Bookstore)
"*Spectrometric Identification of Organic Compounds*" 7th edition, Robert M. Silverstein, Francis X. Webster, David J. Kiemle., 2005.

**Course Notes:**
You are responsible to get the notes of CHEM4110 from the Canvas web (http://canvas.ust.hk), using your email account and password to get access) before class.

**Course Objectives:**
The emphasis of this course is on development of problem-solving techniques. After completion of CHEM4110, students will be able to: (i) recognize and comprehend the basic principles of 1D- & 2D-NMR, IR, and mass spectrometric techniques; (ii) analyze spectroscopic data of organic compounds; (iii) apply these spectrometric methods for structural determination of organic molecules.

**Course Prerequisite:**
CHEM 3120.

**Venue**:
Lectures are given at Rm 4620 from 13:30-14:50 am on every Tuesday and Thursday.

**Course Requirements**:

Midterm exam 35%
Final exam 65%

## Course Content

Lecture 1&2: Infrared Spectroscopy 1:
- Mode of Stretching and Bending
- How to Approach the Analysis of IR Spectrum
- Hydrocarbons: Alkanes, Alkenes and Alkynes

Lecture 3: Infrared Spectroscopy 2:
- Alcohols and Amines
- Carbonyl compounds; Effect of ring size
- Nitriles and Nitro Compounds

Lecture 4&5: Mass Spectroscopy:
- Basic principles of MS
- Ionization methods
- Ionization and fragmentation theory
- Determination of Molecular formula
- Isotopic effects

Lecture 6: Mass Spectroscopy:
- Cleavage mechanisms
- Functional group fragments
- MS spectra analysis

Lecture 7: 1D-NMR 1:
- Nuclear Magnetic Moments
- Mechanism of Resonance
- Population Densities of Nuclear Spin States
- Free Induction Decay (FID)

Lecture 8 & 9: 1D-NMR 2:- NMR Spectrometer: CW vs FT
- How to Approach the Analysis of NMR Spectrum
- Chemical Shift and Shielding
- Anisotropy

Lecture 10: 1D-NMR 3:
- Chemical Equivalence
- Integrals and Integration
- Multiplet Patterns for Common Fragments ($CH_3CH_2$-, -$CH(CH_3)_2$...)
- Examples of $^1$H-NMR Spectrum of Different Types of Compounds

Lecture 11: 1D-NMR 4:
- Types of Coupling
- Coupling Constant
- Pascal's Triangle and Splitting Diagram
- Mechanism of Coupling

Lecture 12: 1D-NMR 5:
- One Bond Couplings ($^1J$)
- Two Bond Couplings ($^2J$)
- Three Bond Couplings ($^3J$): Effect of Torsional and Dihedral angle
- Long Range Couplings ($^4J$-$^nJ$)

Lecture 13: 1D-NMR 6:
- Magnetic and Chemical Equivalence
- First Order Spectra
- Second Order Spectra
- Spin System Notation AB, AX, $AB_2$, $AX_2$...

Lecture 14: 1D-NMR 7:
- Homotopic, Enantiotopic and Diastereotopic System

- Dynamic NMR: Rapid Bond Rotation (C-N), Variable-Temperature NMR
- Protons on Oxygen: Alcohols
- Protons on Nitrogen: Amines

Lecture 15: 1D-NMR 9: - Carbon-13 NMR Spectroscopy
- Carbon-13 Chemical Shifts
- Proton-Decoupled Carbon-13 Spectra
- Nuclear Overhauser Effect

Lecture 16: 1D-NMR 10:- Advanced Carbon-13 NMR Techniques
- Attached Proton Test experiment (APT)
- Distortionless Enhancement by Polarization Transfer (DEPT)

Lecture 17: 2D-NMR 1: - Two dimension NMR theory
- $^{1}H$-$^{1}H$ COSY
- Analysis of COSY spectra
- Double Quantum Filtered COSY (DQF-COSY)

Lecture 18 &19: 2D-NMR 2:- Correlation Spectroscopy optimized for Long Rang (COSY-LR)
- Total Correlation Spectroscopy (TOCSY)
- Homonuclear Hartmann-Hann (HOHAHA)
- Nuclear Overhauser Effect
- 2D Nuclear Overhauser Effect Spectroscopy (2-D NOESY)
- 2D Incredible Natural Abundance Double Quantum Transfer Experiment ( 2D INADEQUATE)

Lecture 20&21: 2D-NMR 3:- Heteronuclear 2-Dimensional NMR Spectroscopy
- Heteronuclear Chemical Shift Correlation Spectroscopy (HETCOR)
- Heteronuclear Single Quantum Coherence (HSQC)
- Heteronuclear Multiple Quantum Coherence (HMQC)
- Correlation Spectroscopy via Long-range Coupling (COLOC)
- Heteronuclear Multiple Bond Correlation (HMBC)

Lecture 22: NMR 4: - Comprehensive NMR Techniques
- Strategies to analyze spectra of unknown compounds
- For examples: ethyl crotonate (H-NMR, C-NMR, DEPT,HMQC, COSY, TOCSY, HMBC, NOESY) & 2-phenyl ethanol (H-NMR, C-NMR, DEPT, HMQC, COSY, TOCSY, HMBC)

Lecture 23: Comprehensive strategies:- Comprehensive Spectral Analysis (NMR, IR & MS)
- Spectral Interpretation of IR, MS and NMR
- Strategies of determination of unknown structure
- For Example: Pinanediol (MS, IR, H-NMR, C-NMR, DEPT, HETCOR, COSY, COLOC, INADEQUATE,

Instructors: *Prof. Jonathan HALPERT* Spring, 2024

**Chem4230: Materials Characterization Methods**
(home: https://canvas.ust.hk/courses/55645)

**Description:**
This 3-credit course is an elective in analytical methods mainly for students majoring in chemistry.
It covers:
(a) The basic principles and applications of analytical methods of characterization for materials; and
(b) A description of types of nanomaterials and how to apply these methods to measures their properties

**Prerequisites:**
(a) CHEM2310: Fundamentals of Analytical Chemistry *(CHEM2311 will be considered)*
(b) CHEM2410: Physical Chemistry I

**Schedule/Venue:**
(a) **Lectures:** Wednesday (4:30 – 5:50 PM), Rm #2302 (Lift 17-18)
Friday (4:30 – 5:50 PM), Rm #2302 (Lift 17-18)
Lectures will be in the classroom, **not** live on Zoom (unless otherwise notified)

(b) **Instructors' Office Hours**: **Prof Halpert:** Friday: 11:00a – 12:00p *by appointment only (jhalpert@ust.hk)*

(c) **TA's Office Hours:** **Jianchao GE:** *by appointment only (jgeae@connect.ust.hk)*

(d) **Examinations** (tentative)
**Midterm (MC): March 15** (on Zoom/CANVAS)
**Final Presentations**: **May 8**

**Chem4230 TA(s) Contact Information:**
Name (email): Jianchao GE (jgeae@connect.ust.hk) Tel/Rm: *email or on Zoom (by appointment)*

**Credit/Grading** :

| | |
|---|---|
| Midterm: | 50% (covers *Lectures 1-12*) |
| Final Project: | 30% (Group + Individual Score) |
| Participation: | 20% (*class participation, in-class work and HW*) |

Worksheets and assignments must be handed on time and this will contribute directly to your final grade!

(i) Worksheets, HW and in-class assignments will be completed and handed in after class to TA.
(ii) Questions marked based on completeness and accuracy. Model answers are on CANVAS.
(iii) ALSO: Midterm exam questions: 20-30% from worksheets/HW/in-class, the rest from lectures
(iv) We will most of the exercises in-class and present model answers.
(v) ***Don't wait until exam time!*** By then it is too late to learn everything.

**REFERENCE TEXTS:**

- Sam Zhang, Lin Li and Ashok Kumar, *"Materials Characterization Techniques"*, CRC Press, Taylor & Francis Group 2009 (TA410.Z45 2009).
- Guozhong Cao and Ying Wang, "*Nanostructures and Nanomaterials*", World Scientific Publishing Co. Pte. Ltd., 2011.
- Douglas A. Skoog, F. James Holler and Stanley R. Crouch, "*Principles of Instrumental Analysis*", 6th Edition, Brooks/Cole, Cengage Learning, 2007.
- "Handbook of instrumentation and techniques for semiconductor nanostructure characterization", TA418.9.N35 H36 2012 v.1-2.

## CHEM 4230 Syllabus

| WEEK (Date) | Topic Summary |
|---|---|
| 1 | Course Intro + Zoom Basics + **L-1:** What are Nanomaterials? |
| | **L-2:** Properties of Materials and Nanomaterials |
| 2 | **L-3:** Synthesis and Purification of Nanomaterials |
| 3 | **L-4:** Benchtop Analysis, Absorbance/Fluorescence Spectroscopy – Light Matter Interactions: UV-vis, PL, PLE, PLQY, TCSPC lifetimes, DLS, turbidity and scattering |
| | **L-5:** Elemental Analysis Techniques: FAAS, ICP-AES, ICP-MS |
| 4 | **L-6:** X-ray absorption (XAS, XAFS, XANES, NEXAFS), |
| | **L-7:** X-ray emission (XRF, EDX, Auger, XPS) |
| 5 | **L-8:** Band Edge States: UV-photon Techniques: UPS, IPES, CV |
| | **L-9:** Microscopy, Scanning Electron Microscopy (SEM) w/ EDX |
| 6 | **L-10:** Transmission Electron Microscopy (TEM), High Resolution Transmission Electron Microscopy, HRTEM, and e-diffraction (SAED) |
| | **L-11:** Surface Probe Microscopies (SPM): STM + **L-12:** Surface Probe Microscopies (SPM): AFM |
| 7 | Midterm Revision + (finish L1-12 as needed) |
| | MIDTERM EXAM (*Fri Mar 15*) on Zoom (at class time) |
| 8 | *Special Topics: Ultrafast Spectroscopy of Nanomaterials I* |
| | *Special Topics: Ultrafast Spectroscopy of Nanomaterials II* |
| 9 | **L-13:** *X-ray Diffraction I: crystalline materials (XRD)* |
| ---------- | *Spring Break (F), Spring Break (W), Spring Break (F)*---------- |
| 10 | **L-14:** *X-ray Diffraction II: powder XRD* |
| | **L-15:** *X-ray Diffraction III: Single crystal X-ray diffraction, (S-XRD)* |
| 11 | **L-16:** IR methods (FTIR, microwave) |
| | **L-17:** Raman Spectroscopy (for solids and nanomaterials) |
| 12 | **L-18:** NMR for surface science (2D NMR) + *Final Project Introduction* |
| | **L-19:** Electrical Methods (JV, 3-probe, carrier density) + **L-20**: Electrical Methods II (C-V, trap density, impedance spectra) |
| | *Special Topic: Optoelectronics* + Group Work I |
| 13 | *Case Study: Perovskite Nanocrystals* + Group Work II |
| 14 | Presentations Live in-class (Wed May 8) |
| | *[makeup class – May 10, if needed]* |

**Lecturer for regular course topics:**
Week 1-14: **Prof Halpert**

**Guest lecturers for special topics:**
*Ultrafast guest lecturer: TBD*
*Magnetic methods guest lecturer: Prof. Rolf Lortz (PHYS)*
*Optoelectrronics: Prof Halpert*
*Perovskite Nanocrystals: Jianchao GE*

**CHEM 4230: Materials Characterization Methods**
**"Nanomaterials Characterization"**

## Course Description

*Credit Points:*3

*Pre-requisite:* CHEM 2310 and CHEM 2410

*Brief Information/synopsis:*
This course will introduce a selected series of materials characterization methods with an emphasis on the characterization methods of nanomaterials, especially chemically processed nanomaterials. The characterization methods will include electron spectroscopies, electron microscopies, scanning probe microscopies, and optical, thermal, mechanical, scattering and diffraction methods.

## Intended Learning Outcomes (ILOs)

Upon successful completion of this course, students should be able to:

1. Understand how to choose a characterization method for a given material property.
2. Understand the working principles of the materials characterization methods.
3. Understand how to get the maximum information from a characterization method for a given material

**CHEM 4240 Intermediate Inorganic Chemistry**

**Course Outline- Spring 2024**

1. **Instructor**

*Name:* Wa-Hung Leung

*Contact Details:* e-mail: chleung@ust.hk, ext. 7360, office: Rm 4538

2. **Teaching Assistant**

*Name:* Miss Chunteng WAN

*Contact Details:* e-mail: cwanac@connect.ust.hk

3. **Meeting Time and Venue**

*Lectures:*

**Date/Time:** Tuesday and Thursday, 10:30-11:50

**Venue:** CTY009B

*Tutorials:*

**Date/Time:** To be arranged

**Venue:** To be arranged

4. **Course Description**

Credit Points: 3

Pre-requisite: CHEM 3220

Exclusion: NIL

Brief Information/synopsis:

Intermediate Inorganic Chemistry is a 3-credit elective course for all Year 3 chemistry undergraduate students. The curriculum is designed to cover a range of topics on bonding, structure and reactivity of inorganic complexes, with intended learning outcomes focusing on developing students' intellectual and generic skills.

## 5. Intended Learning Outcomes

Upon successful completion of this course, students should be able to:

| No. | ILOs |
|---|---|
| 1 | Recognize fundamentals of chemistry, bonding, structures, reaction mechanisms, and spectral properties of inorganic compounds. |
| 2 | Explain essential facts, principles and theories of inorganic chemistry, e.g. spectral properties of inorganic complexes, mechanisms of inorganic reactions, lanthanide chemistry. |

## 6. Assessment Scheme

a. Examination duration: 3 hrs

b. Percentage of coursework, examination, etc.:

| Assessment | Assessing Course ILOs |
|---|---|
| 8% by assignments and other assessments | 1, 2 |
| 15% by quizzes | 1,2 |
| 40% by mid-term exam | 1,2 |
| 37% by oral presentation and written report | 1,2 |

c. The grading is assigned based on students' performance in assessment tasks/activities.

## 7. Student Learning Resources

Recommended Reading:

Text(s):

"Inorganic Chemistry", international edition, by M. Weller *et al.*, OUP (2018)

## 8. Teaching and Learning Activities

Scheduled activities: 3 hrs (lecture)

## 9. Course Schedule

Keyword Syllabus:

- Inorganic reaction mechanisms: Substitution (square planar and octahedral complexes). Redox reactions (outer-sphere and inner-sphere electron transfer). Intramolecular electron transfer.
- Electronic spectra: Russell-Saunder terms. Hund's rules. Spectral terms. Selection rules for electronic transitions. Tanabe-Sugano diagrams. Nephelauxetic effect. Ligand-field spectra. Charge-transfer spectra. Intervalence charge-transfer.
- Lanthanides chemistry: Electron configurations. Trends of atomic and ionic properties. Oxidation states. Spectral and magnetic properties. Applications.
- Special topics: Metal-ligand multiple bonds: Bonding and structures and chemical reactivity. Photochemistry of inorganic complexes

# CHEM 4330 Separation Science

***Course Instructor*:** Prof. Simon W. Chan; email: chanwan@ust.hk; tel.: 2358-7370

***Course TA:*** Ms. LUK, Wing-Laam; email: wllukaa@connect.ust.hk

***Lecture Hour*:** Tue & Thu 9:00AM - 10:20AM (videos will be released after lectures, if recorded; no video will be recorded for lab demonstrations)

***Venue*:** *G009B, CYT Bld* ***Office Hour*:** Walk-in *or* by appointment

***Course Outline*:** This course aims to provide an in-depth understanding of the working principles in separating substances by chemical and physical techniques. Topics in this course include: sample preparation for chromatographic analysis; instrumentation for gas and liquid chromatography; mass spectrometry, and etc. Applications (case studies) of various separation techniques for forensic, environmental, biological, pharmaceutical, food and drink analyses will be provided as illustrating examples.

***Experiential Learning*** will be adopted in this course, whenever applicable. In addition to the normal lecturing, students will be demonstrated *in situ* (lab tours at chemical testing/research labs) how separation techniques are being used for various applications as well, e.g. food safety and herbal medicine testing, forensics, environmental analysis, and/or chemical toxicology. For better understanding, students are expected to ***read course materials before attending the demonstrations/lectures***.

## *Reference Books:*

1: Principles of Instrumental Analysis, Skoog. Holler. Nieman, Brooks/Cole
2: Quantity Chemical Analysis, Daniel C. Harris, Freeman

***Welcomed:*** Open discussion; ***Not Welcomed:*** Chatting; Cheating

## *Assessment*:^

- Assignment (1 x 10%)
- Group Project (30% total; 15% by audience + 15% by instructor & TA)*; &
- Final exam (60%)

^ ***NOT graded "on curve"*; but follow University's "Guidelines for Use of Undergraduate Course Grade Distribution Bands", unless exception observed/applied.**

* In groups of 2, select an ***Interesting, Separating Science-related topic,*** do literature study, give a 15-20 min PowerPoint group presentation to the class. Topic to be approved by Dr. Simon Chan before *18th April, 2024*. Slides send to Dr. Chan and Ms. Luk at least 2 days ahead of presentation.

*Sample topics for projects:*

. Identification of drugs of abuse and metabolites of drugs of abuse in blood, urine, and saliva
. Monitoring gases in patient's breath during surgery
. Testing for the presence of drugs in blood in race horses and in Olympic athletes
. Dating archaeological specimens
. Analyses of aerosol particles
. Determination of pesticide residues in food
. Monitoring volatile organic species in water supplies

# ***Course Outline:***

| | |
|---|---|
| Week 1 | Introduction to separation science |
| Week 2 | Chromatographic theory |
| Week 3 | Gas Chromatography: Instrumentation |
| Week 4 | Gas Chromatography: Molecular interactions in GC |
| Week 5 | Liquid Chromatography: Instrumentation |
| Week 6 | Liquid Chromatography: Different modes of chromatography |
| Week 7 | 2-dimensional chromatography: 2D-GC, 2D-LC |
| Week 8 | Mass spectrometry: ionization techniques and mass analyzers |
| Week 9 | Tandem mass spectrometers and their applications in drug discovery, forensic, and food safety testing |
| Week 10 | Hyphenated GC/LC mass spectrometry with case study |
| Week 11 | Sample preparation methods for chromatographic separations & Chemical derivatization for chromatographic separation |
| Week 12 | Quantitative analysis with separation methods with case study: Application of separation science in toxicology study and/or for anti-doping programs |
| Week 13 | **Project presentations** |

# Tentative schedule. Topics/order/pace of lecturing subject to changes depending on progress. Make sure it sounds "worth investing your time", and not too easy/boring for you.

# CHEM4420 Spring Term 2023
# Statistical Machine Learning Methods for Chemical Data Analysis


**Class Schedules:** Wed. & Fri. 3pm – 4:20pm, Classroom 6591
**Instructor:** Prof. Haibin SU
Office: Room 4540, 4/F, Lifts 25/26 Email: haibinsu@ust.hk
Office Tel. Number: 2358-7388

**TA:** Mr. Yuzhou TAO
Email: ytaoar@connect.ust.hk


| | |
|---|---|
| **Subject Code** | CHEM4420 |
| **Subject Title** | Statistical Machine Learning Methods for Chemical Data Analysis |
| **Credit Value** | 3 |
| **Level** | 4 |
| **Description** | Design for students would like to learn the basics of machine learning-based data analysis, visualization and to apply these techs to process chemical data. |
| **Pre-requisite/ Co-requisite/ Exclusion** | Pre-Requisite: CHEM 2409 AND CHEM 2410<br>Exclusion: COMP 4211, MATH 4432 |
| **Objectives** | 1. Introduce basic concepts of machine learning and data analysis.<br>2. Enable chemistry students to create their own analytical model.<br>3. Connect chemistry knowledge with data science. |
| **Intended Learning Outcomes** | Upon completion of the subject, students will be able to:<br><br>Category A: Professional/academic knowledge and skills<br>1. Comprehend the fundamentals of statistics and probability.<br>2. Comprehend key ideas, methods, and techniques of machine learning methods<br>3. Appreciate typical machine learning methods<br>4. Implement basic chemical data collection, representation and processing<br>5. Develop machine learning models for a given problem<br><br>Category B: Attributes for all-roundedness<br>6. Present ideas and findings effectively.<br>7. Think critically.<br>8. Learn independently.<br>9. Work in a team and collaborate effectively with others. |

<table>
<tr><td rowspan="6">Teaching/Learning Activities</td><td>Class Contact (time-tabled):</td><td></td></tr>
<tr><td>Lecture</td><td>13 * 3= 39 hours</td></tr>
<tr><td>Other Student Study Effort</td><td></td></tr>
<tr><td>preview/review of lecture notes; homework/assignment;</td><td>21 hours</td></tr>
<tr><td>preparation for group project (presentation and report)</td><td>45 hours</td></tr>
<tr><td>Total Student Study Effort</td><td>105 hours</td></tr>
<tr><td>Grading Type</td><td colspan="2">Letter Grades</td></tr>
<tr><td>Assessment Tasks and Grading Policy</td><td colspan="2">Group project (100% of the course)<br><br>• Preliminary proposal (no score):<br>To help students prepare a plan for group project, a preliminary proposal is needed. This proposal should contain: Motivations and objectives, data sets, methodology and expected outcomes.<br><br>• Group presentation (50% of the course):<br>Each group must give a 20-minute presentation at the end of the semester about the project.<br><br>• Final report (50% of the course):<br>A final report should be summited. This report should contain all detailed information about the project and contribution of each member in the group.</td></tr>
<tr><td>Subject Synopsis</td><td colspan="2">Syllabus:<br>• Chap 1: Math Background<br>• Chap 2: Regression and Classification<br>• Chap 3: Supporting Vector Machine<br>• Chap 4: Neural Network<br>• Chap 5: Convolution Neural Network<br>• Chap 6: Chemical/Biological Data Representation<br>• Chap 7: Recurrent Neural Network<br>• Chap 8: Graph Neural Network<br>• Chap 9: Monte Carlo Tree Search Algorithm<br>• Chap 10: Transformer<br>• Chap 11: Decision Tree / Random Forest<br>• Chap 12: Selected applications</td></tr>
</table>

| | |
|---|---|
| **Reading List and References** | If you want to learn more about performing data analysis by machine learning, we have a list of suggested books/materials for you:<br>• "Hands-on Machine Learning with Scikit-Learn, Keras, and TensorFlow", 2nd Edition by Aurélien Géron<br>• "Neural Networks - A Comprehensive Foundation", 3rd Edition by Simon Haykin<br>• "Notes on Statistics and Data Quality for Analytical Chemists", By Michael Thompson and Philip J Lowthian (World Scientific, 2011) |

# CHEM 4430 [3-0-0:3]

# *Symmetry in Chemistry and Spectroscopy:*

## *Chemical Applications of Symmetry Principles and Group Theory*

**Spring 2024**


**Xiao-Yuan Li（李曉原）**

**Department of Chemistry**
**The Hong Kong University of Science and Technology**






# Chapter 0:

# Course Description, Syllabus and Requirements

- ***Course Description***
- ***Course Syllabus***
- ***Main Textbooks and References***
- ***Intended-Learning Outcomes (ILOs)***
- ***Requirements, Office Hour and Off-hour Help***
- ***Assessments and Grades***

# Course Description

- Chem-4430 is an *elective* course for the *year-4* UG and the *year-1 PG* students majoring in *Chemistry* or *Interdisciplinary Programs* involving chemistry.
- The *first half* of the course covers the *fundamentals* of symmetry principles and group theory that are most relevant to common chemistry problems. *(Symmetries of molecular structures are classified, represented and correlated in this part).*
- The *second half* of the course covers the *applications* of symmetry principles and group theory in various chemistry problems. *(Applications in bonding, physical/chemical properties, reactions, and various spectroscopies are discussed in this part).*
- Students intend to enroll in this course are expected to have completed the *four core subjects* in chemistry, since all the illustrative examples and applications are selected from different areas of chemistry, including *inorganic, organic, physical* and *analytical* chemistry, as well as from *biochemistry, supramolecular* chemistry, *materials* chemistry, and *various spectroscopies* among other subjects. It is also desirable(but *not* required) that you have had some basic knowledge of *linear algebra,* especially on the *vector algebra* and *matrix algebra.*

*Prof. Xiao-Yuan Li, Dept. of Chemistry, HKUST*

# Course Syllabus



*Prof. Xiao-Yuan Li, Dept. of Chemistry, HKUST*

# Course Syllabus.....*continues*

***PART II-options:*** *Individually Tailored Topics(ITT) in Chemical Application(s) of Group Theory*

- Many of you are in the final year of UG study or the first year of PG study, and are starting to get into specific research areas. If you attend this course with a specific topic in mind that could serve your research project, please make an appointment at chxyli@ust.hk to see me *before* the mid-term break 28 Mar. 2024. I like to have a chat with you to see how the syllabus in the second half of the semester can be amended to serve your need.

- In addition, the Final Exam of the course can also be tailored to serve your individual need for specific topics in *chemical application of symmetry principles and group theory*.



# The Main Textbooks and References

The contents will be adopted mainly from but ***not*** limited to the following textbooks. Materials from other sources and references will also be used wherever in need.

(i) Pre-requisite reading:

- Focus 10, « *Physical Chemistry* » P. W. Atkins *et al*, 11th Ed., *Oxford Univ. Press*, 2018. Note-1
- Chapter 3, « *Inorganic Chemistry* » M. Weller *et al*, 7th Ed., *Oxford Univ. Press*, 2018. Note-2

(ii) Most relevant reading:

✓ - « *Chemical Applications of Group Theory* » F. A. Cotton, 3rd ed., *Wiley*, 1990.

* - « *Group Theory Applied to Chemistry* » A. J. Ceulemans, *Springer*, 2013.

(iii) Supplementary reading:

- « *Symmetry and Spectroscopy* » D. C. Harris and M. D. Bertolucci, *Oxford Univ. Press*, 1978.
- « *Group Theory in Chemistry and Spectroscopy* » B. S. Tsukerblat, *Academic Press*, 1994.
- For each and every chapter, supplementary readings will be recommended when in need.

(iv) Useful resource (handbook type):

- « *Point-Group Theory Tables* » S. L. Altmann and P. Herzig, *Oxford Univ. Press*, 1994.

Note-1: Chapter 11, 10th Ed, 2014; or Focus 10, Vol-2, 12th Ed, 2023.

Note-2: Chapter 6, 6th Ed, 2014.

# Intended-Learning-Outcomes(ILOs):

- Be able to appreciate the *significance* and *limitations* of symmetry principles and group theory in chemistry;
- Be able to grasp the *symmetry operations* and their classifications;
- Be able to grasp the concepts of *point group theory* and *the structures of point groups*;
- Be familiar with the *classification* and *correlation* of molecular structures according to their *chirality* and other symmetry properties;
- Be able to correctly *assign a point group* to a molecular structure or a figure according to its symmetry properties, and especially be able to establish the *hierarchical relationships between different groups*;
- Be familiar with the structures, properties and usage of the *character tables* of point groups;

- Be able to apply the methods of point group theory to the analysis of the *ground state properties* of a molecule, such as the electric dipole moment, electric quadrupole moment, and optical activity;
- Be able to apply the methods of point group theory to analyzing the *bonding* from Molecular Orbital Theory (MOT) and Valence Bond Theory (VBT);
- Be able to apply the methods of point group theory to the analysis of *molecular vibrations* and their activities in Raman and IR spectroscopies;
- Be able to apply the methods of point group theory to the analysis of *electronic and vibronic transitions* in UV-Vis and fluorescence spectroscopies;
- Be able to apply the methods of symmetry/group theory to the analysis of *chemical reactions*;
- Be able to apply the methods of point group theory to the analysis of other *physical and chemical properties* of molecules from their structures and other experimental observables.

*Prof. Xiao-Yuan Li, Dept. of Chemistry, HKUST*

# Intended-Learning-Outcomes(ILOs):

**QUESTION:** I have already had a glimpse of this subject in *Inorganic Chemistry-I* (Chem-2210*) and *Physical Chemistry-II*(Chem-3420*), is it still necessary for me to take this course(Chem-4430)? How are the *syllabus* and *ILOs* of this course different from those mentioned above?

**ANSWER:** You are advised to take this course if you have plan for postgraduate study and/or for a career in research and teaching in chemistry. Knowledge-wise, this course intends to achieve the following specific goals that were not included in other courses:

- The relationships and conversions between different molecular symmetries;
- The quantitative representations of molecular symmetries;
- The relationships between molecular symmetries and their properties.

* Note-1: Focus 10, «*Physical Chemistry*» P. W. Atkins *et al*, 11th Ed., *Oxford Univ. Press*, 2018.
* Note-2: Chapter 3, «*Inorganic Chemistry*» M. Weller *et al*, 7th Ed., *Oxford Univ. Press*, 2018.

*Prof. Xiao-Yuan Li, Dept. of Chemistry, HKUST*

# Intended-Learning-Outcomes(ILOs):

**QUESTION:** In the rapidly emerging AI-age, the acquisition of knowledge on any subject, including those you will learn from this course, becomes relatively easy and less-challenging. What remains unchanged and still challenging is the *way of thinking* for adaptation and innovation. How are you going to adjust your way of learning and thinking along the way in the AI-age?

**Ultimately,** this course intends to add a *different* but *complementary* angle and perspective to

- your *view* of chemistry as a scientific discipline,
- your *mindset* as a chemist, and
- your way of *thinking* as a chemist.



# Requirements, LectureNotes and Office-Hour

## *Course Requirements:*

(i) Attendance of lectures.
(ii) Reading assignments + Non-graded questions/problems.
(iii) Assessment/Exam (The format to be decided. See the *In-class Survey Form*)

## *Lecture-notes/Lecture-PPTs:*

(i) All Lecture PPTs will be posted on Canvas.
(ii) Useful references will also be posted on Canvas.

## *Office Hour and Off-hour Help:*

(i) **Office Hour:** 2:00 – 3:00 pm, Every Tue., Room 4516, Academic Building.
(ii) **Off-hour Support:** Appointment by email to "*chxyli@ust.hk*"

## Assessment and Grading:

- *Exam/Assessment:* ***Previous years***
  - (i) Mid-term Exam (Closed-book).
  - (ii) Final Exam (Term Essay /± Oral presentation).
  - (iii) Course Grade = 50% Mid-Term + 50% Final Exam.

- *Exam/Assessment:* ***This year***
  - (i) To be decided after the ***In-class Survey***.
  - (ii) Most likely, a ***Term Essay*** only with the deadline at the end of the semester.
  - (iii) The guidelines for both the ***Term Essay*** and the ***Grading*** will be announced after the mid-term break(5 Apr. 2024).





# CHAPTER 0:

# END

The Hong Kong University of Science and Techonology
Department of Chemistry

# CHEM 4680 Undergraduate Research
## Course Outline

## 1. Course Description

Credit Points: 3
Pre-requisite: CHEM 2550
Instructor(s): Research Faculties of Chemistry Department

Brief Information/synopsis:

Students conduct original research in accordance with their ability and background, and under the supervision of a research faculty. The final course grade is determined based on an oral presentation and a written report to be submitted to a judging committee, which includes the faculty supervisor plus at least one other faculty. Enrollment in the course requires approval of the faculty supervisor.

## 2. Intended Learning Outcomes

Upon successful completion of this course, students are expected to be able to:

| | |
|---|---|
| 1 | Work independently, to handle and use appropriate instrumentation, interpret data, and complete given tasks in a research setting, and to prepare a written report. |
| 2 | Communicate more effectively in speaking and writting, both about their newly acquired knowledge and knowledge in general. |
| 3 | Recognize deficiencies in knowledge existing in chemistry, and to plan and mount a research study to address these deficiencies. |
| 4 | More critically assess data presented in textbooks, the primary literature or other sources, e.g. electronic data bases, patents. |
| 5 | In general, to appreciate the importance of research in relation to science, the definition of problems in research, and how the corpus of scientific knowledge is able to expand through the overall reserach effort for the betterment of humankind. |

## 3. Course Requirements and Grading

At the end of the course, **students are required to give an oral presentation and submit a written report to document their project work**. Course grades will be determined by a faculty panel consisting of their research supervisor and at least one other faculty member. Students will be evaluated based on their research performance, oral presentation (including the Q&A session), and written report.

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

# CHEM 4689 Capstone Project
## Course Outline (Spring 2023-2024)

### 1. Course Coordinator:

Prof. Emily Tsang (chetsang@ust.hk) Rm 4536; Tel: 3469-2100

**Faculty Supervisors: (You will be assigned under one supervisor)**


| | |
|---|---|
| Prof. Zhihong GUO | (chguo@ust.hk) |
| Prof. Ding PAN | (dingpan@ust.hk) |
| Prof. Hugh NAKAMURA | (hnakamura@ust.hk) |
| Prof. Emily M.W. TSANG | (chetsang@ust.hk) |
| Prof. Hongkai WU | (chhkwu@ust.hk) |
| Dr. Mirza M. F. A. BAIG | (faran@ust.hk) |
| Dr. Tsz Kin Ryan KWOK | (chryan@ust.hk) |
| Dr. Wing Yip Jacky LAM | (chjacky@ust.hk) |


**Library Referencing Advisors: (You will be assigned under one advisor)**


| | |
|---|---|
| Mr. Samson CHOI, Librarian (Learning Support) | (lbsamson@ust.hk) |
| Mr. Ernest LAM, Librarian (Learning Support) | (lbernest@ust.hk) |


### 2. Class Time and Venue:

Date/Time: 9:30 – 10:20 am, **Fridays** (*please refer to the class schedule*)
Venues: Room 5566 (Lift 27/28) OR Library Computer Barn
(*please refer to class schedule*)

### 3. Course Description:

Credit Points: 3 Pre-requisite: CHEM 3550 and CHEM3555

Brief Information/synopsis:
Under the supervision of a faculty member or teaching staff, students will complete a capstone project which requires the integration of the chemical knowledge learnt from their previous courses. Students will carry out a literature review on a mutually agreed topic. A written report and an oral presentation are required to document their learning experiences.

### 4. Intended Learning Outcomes:

| | |
|---|---|
| 1 | Demonstrate awareness of chemical topics relevant to social and daily life |
| 2 | Analyze and interpret experimental data, critically assess data in literature and extract useful data from it. |
| 3 | Carry out directed research by selecting appropriate topics and procedures, and presenting the results |
| 4 | Communicate effectively both orally and in writing with professionals and/or lay audience |
| 5 | Demonstrate information technology skills, especially in the areas of information retrieval, literature searching and use of library database. |
| 6 | Show self awareness, work independently and collaborate effectively with other people in a team |

## 5. Assessment Scheme:

| *Weight* | *Assessment* | *Course ILOs* |
|---|---|---|
| 10% | Participation | 1, 2, 3, 4, 5, 6 |
| 20% | Submission of a Scientific Poster and Library Training | 2, 4, 5 |
| 40% | Literature Research Presentation | 1, 4, 5, 6 |
| 30% | Literature Research Report | 1, 2, 3, 4, 5 |

## 6. Student Learning Resources (Reference books):

- Catherine E. Housecroft and Alan G. Sharpe, *Inorganic Chemistry* 3rd edition, Harlow: Pearson Prentice Hall ©2008. [QD151.2 .H68 2008] ♠
- Douglas A. Skoog, F. James Holler, Stanley R. Crouch, *Principles of Instrumental Analysis* 6th edition, Thomson Brooks/Cole, ©2007. [QD79.I5 S58 2007]
- Jonathan Clayden, Nick Greeves and Stuart Warren, *Organic Chemistry* 2nd edition: Oxford University Press ©2012 [QD251.3 .O64 2012]
- T.D.H. Bugg, *Introduction to Enzyme and Coenzyme Chemistry* 3rd edition, Wiley ©2012. [QP601.B955 2012eb] ♠

♠ *Free access online via HKUST Library*

^ *other course materials can be downloaded from Canvas website by logging in using your ITSC username and password (http://canvas.ust.hk).*

## 7. Teaching and Learning Activities:

**Tutorials/Workshops**: 1. Literature Search Training
2. SciFinder Workshop
3. Chemical Structure Drawing Training
4. Literature Referencing Training
5. Poster Design Workshop

**Consultations**: With your faculty supervisor (**at least 3 times**)

**Individual Coaching**: With your library referencing advisor (**at least once**)

**Oral presentation**: 10 minutes + 5 minutes Q&A

**Poster Mini-Conference**: 3 hours session at the end of semester

## 8. Course Schedule:

| Week | Date/Time | Activities [ † *denotes follow-up work required*] | Venue/Instructor |
|---|---|---|---|
| 1 | Feb 2 (Fri)<br>9:30-10:20<br><br>*before 16 Feb* | **Course Introduction**<br><br>[ † ***meet your supervisor for topic assignment***]<br>[ † ***upload topic to Canvas after assignment***] | **Room 5566 (Lift 27/28)**<br>Prof. Emily Tsang |
| 2 | Feb 9 (Fri)<br>9:30-10:20 | **Literature Search Training** | **Library LG1 Computer Room B**<br>Mr. Samson Choi/Mr. Ernest Lam |
| 3 | Feb 16 (Fri)<br>9:30-10:20<br><br>*before Feb 23*<br><br>***between Feb 19 – Mar 8*** | **SciFinder Workshop**<br><br>[ † ***submit Weekly Timetable to Canvas for scheduling Oral Presentation Time***]<br><br>**Individual Coaching Session on Literature Search** [***Compulsory***] (with your Referencing Advisor during Weeks 4 – 6) | **Zoom Meeting**<br>SciFinder vendor<br>(based in Singapore)<br><br>(by appointment with your referencing advisor) |
| 4 | Feb 23 (Fri)<br>9:30-10:20 | **Chemical Structure Drawing Training** | **Library LG1 Computer Room B**<br>Prof. Emily Tsang |
| 5 | During this week<br>(Feb 26 – Mar 1) | **1st Consultation with supervisor** | (by appointment with your supervisor) |
| 6 | Mar 8<br><br>*before Mar 11* | *Work on your project*<br><br>[ † ***submit Research Plan***] | |
| 7 | Mar 15 (Fri)<br>9:30-10:20 | **Referencing Training** | **Library LG1 Computer Room B**<br>Mr. Samson Choi/Mr. Ernest Lam |
| 8 | During this week<br>(Mar 18 – 22) | **2nd Consultation with supervisor** | (by appointment with your supervisor) |
| 9 | Mar 25 – Apr 5 | *Work on your project*<br>(Easter Holiday & Midterm Break) | |
| 10 | Apr 12<br><br>***between Apr 8 – 26*** | **Poster Design Workshop**<br><br>**Individual Coaching Session on Referencing**<br>[***Optional***] (with your Referencing Advisor during Weeks 10 – 12) | **Room 5566 (Lift 27/28)**<br>Prof. Emily Tsang<br><br>(by appointment with your referencing advisor) |
| 11 | During this week<br>(Apr 15 – 19) | **3rd Consultation with supervisor** | (by appointment with your supervisor) |
| 12 | Apr 26 | *Work on your project* | |
| 13 | May 3 | *Work on your project* | |
| 14 | May 10 (Fri)<br>***before May 5 (Sun)*** | **Oral Presentations**<br>[ † ***submit Poster file to Canvas***] | TBA |
| Study break | May 13 (Mon)<br>14:00-17:00 | **Poster Mini-Conference** | **Library LG4**<br>**Multi-function Room** |
| | May 26 (Sun) | † ***Deadline for Literature Research Report*** | |

**9. Supervisor Arrangements:**

| Student Name | Supervisor |
|---|---|
| LI, Yi Yin (yyliam@connect.ust.hk) | Prof. Zhihong GUO (chguo@ust.hk) |
| CHUNG, Wai Man (wmchungaa@connect.ust.hk) | Prof. Ding PAN (dingpan@ust.hk) |
| WONG, Wai Chong (wcwongbc@connect.ust.hk) | Prof. Hugh NAKAMURA (hnakamura@ust.hk) |
| LEE, Zenobia (zlee@connect.ust.hk)<br>YAU, Pok (pyauaa@connect.ust.hk) | Prof. Emily M.W. TSANG (chetsang@ust.hk) |
| XU, Chunying (cxubc@connect.ust.hk) | Prof. Hongkai WU (chhkwu@ust.hk) |
| LAM, Yi Fung (yflamaf@connect.ust.hk) | Dr. Mirza M. F. A. BAIG (faran@ust.hk) |
| CHEUNG, Ho Yiu Bryan (hybcheung@connect.ust.hk)<br>CHANG, Yuet Ting Kira (ytchang@connect.ust.hk) | Dr. Tsz Kin Ryan KWOK (chryan@ust.hk) |
| TSANG, Ling Ho (lhtsangac@connect.ust.hk) | Dr. Wing Yip Jacky LAM (chjacky@ust.hk) |

**10. Library Referencing Advisor Arrangements**

| **Advisor: Mr. Samson Choi**<br>Librarian (Learning Support)<br>(lbsamson@ust.hk) | **Advisor: Mr. Ernest Lam**<br>Librarian (Learning Support)<br>(lbernest@ust.hk) |
|---|---|
| LI, Yi Yin (yyliam@connect.ust.hk) | XU, Chunying (cxubc@connect.ust.hk) |
| CHUNG, Wai Man (wmchungaa@connect.ust.hk) | LAM, Yi Fung (yflamaf@connect.ust.hk) |
| WONG, Wai Chong (wcwongbc@connect.ust.hk) | CHEUNG, Ho Yiu Bryan (hybcheung@connect.ust.hk) |
| LEE, Zenobia (zlee@connect.ust.hk) | CHANG, Yuet Ting Kira (ytchang@connect.ust.hk) |
| YAU, Pok (pyauaa@connect.ust.hk) | TSANG, Ling Ho (lhtsangac@connect.ust.hk) |

**CHEM 4691 Capstone Research I**

**Course Outline (Spring 2023/24)**

## 1. Course Description

Pre-requisite: CHEM 3550 and CHEM 3555

Exclusion: CHEM 4689

Instructor(s)/Project Supervisor(s): Research Faculties of Chemistry Department

Course Coordinator: Prof. Emily M.W. Tsang

Reference Librarians:

Mr. Samson CHOI (lbsamson@ust.hk)

Mr. Ernest LAM (lbernest@ust.hk)

Brief Information/synopsis:

This is a project-based course that provides students an opportunity to integrate and apply their chemical knowledge learnt in regular lecture and lab courses. Students will carry out a research project under the supervision of a faculty member/teaching staff. At the end of the course, students are required to submit a written report and deliver an oral presentation to document their learning experiences. Students should seek instructor's approval prior to enrollment in the course.

## 2. Intended Learning Outcomes

Upon successful completion of this course, students are expected to be able to:

| | |
|---|---|
| 1 | Demonstrate awareness of chemical topics relevant to social and daily life. |
| 2 | Analyze and interpret experimental data, critically assess data in literature and extract useful data from it. |
| 3 | Carry out directed research by selecting appropriate topics and procedures, and presenting the results. |
| 4 | Communicate effectively both orally and in writing with professionals and/or lay audience. |
| 5 | Demonstrate information technology skills, especially in the areas of information retrieval, literature searching and use of library database. |
| 6 | Show self-awareness, work independently and collaborate effectively with other people in a team. |

## 3. Grading

| Weight | Assessment | Course ILOs |
|---|---|---|
| 50% | Lab Performance and Participation | 1,2,3,4,5,6 |
| 30% | Written Research Thesis | 1,2,3,4,5 |
| 20% | Oral Presentation | 4,5,6 |

4. **<u>Mandatory</u> Library Trainings Schedule:**

The following library training workshops are ***mandatory***. Attendances will be taken and counted towards your course participation scores.

| Date | Activity | Venue |
|---|---|---|
| **Feb 9 (Fri), 9:30 – 10:20** | **Library Workshop I: Literature Search Training** | Computer Room B (Library LG1) (Mr. Samson Choi/Mr. Ernest Lam) |
| **Feb 16 (Fri), 9:30 – 10:20** | **SciFinder-n Workshop** | Zoom Meeting (meeting link to be provided) |
| **Feb 23 (Fri), 9:30 – 10:20** | **Chemical Structure Drawing Training** | Computer Room B (Library LG1) (Prof. Emily Tsang) |
| **Mar 15 (Fri), 9:30 – 10:20** | **Library Workshop II - Referencing Training** | Computer Room B (Library LG1) (Mr. Samson Choi/Mr. Ernest Lam) |

# CHEM 4692 Capstone Research II
## Course Outline

### 1. Course Description

Credit Points: 3
Pre-requisite: CHEM 4691
Instructor(s): Research Faculties of Chemistry Department

Brief Information/synopsis:

Continuation of research project started in CHEM 4691 and to be conducted under the supervision of a faculty member/teaching staff. A written report and oral presentation are required to document their learning experiences. Students should seek instructor's approval prior to enrollment in the course.

### 2. Intended Learning Outcomes

Upon successful completion of this course, students are expected to be able to:

| | |
|---|---|
| 1 | Demonstrate awareness of chemical topics relevant to social and daily life |
| 2 | Analyze and interpret experimental data, critically assess data in literature and extract useful data from it. |
| 3 | Carry out directed research by selecting appropriate topics and procedures, and presenting the results |
| 4 | Communicate effectively both orally and in writing with professionals and/or lay audience |
| 5 | Demonstrate information technology skills, especially in the areas of information retrieval, literature searching and use of library database. |
| 6 | Show self awareness, work independently and collaborate effectively with other people in a team |

### 3. Grading

| Weight | Assessment | Course ILOs |
|---|---|---|
| 50% | Lab Performance and Participation | 1,2,3,4,5,6 |
| 20% | Oral Presentation | 4,5,6 |
| 30% | Written Research Thesis | 1,2,3,4,5 |