Ollscoil na Gaillimhe
University of Galway

Scoil na nEolaíochtaí
Bitheacha agus Ceimiceacha

School of Biological
and Chemical Sciences

Chemistry

2BS Information Booklet

Academic Year 2024 – 2025

Compiled by Dr. David Cheung
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Welcome and General Information

Welcome to second year chemistry at the University of Galway. We look forward to working with you in your studies this year. This booklet summarises the key information about the structure and content of the third-year course, along with some important policies in the School. While every effort has been made to make sure the information in this booklet is accurate and up to date, it is inevitable that some changes to this may be needed throughout the year. These will be communicated through Canvas, the University's virtual learning environment, so please check this, along with your university email address, throughout the year. Canvas will also be used to host lecture notes and other resources.

Attendance at all timetabled lectures and tutorials is expected and will be monitored. Note that while attendance at lectures is a key part of learning, it is not on its own sufficient and you are expected to support this through independent study. For a 5 ECTS module, the total workload is expected to be in the range of 100-125 hours, so for each lecture you may expect to have undertake three to four hours of self-study.

Attendance at laboratory sessions is mandatory. For short term absences (e.g. through illness) authorized absences may be obtained by submitting appropriate documentation – this should be sent to the module coordinator and the school administrators. For absences due to sports or societies activities, you must contact the module coordinator in advance of these. If you are unfortunate to be absent for a longer period of time please refer to the university's extenuating circumstances policy (https://www.universityofgalway.ie/media/registry/exams/policiesprocedures/QA209-Extenuating-Circumstances.pdf). Note that persistent absence without appropriate explanation by a student from weekly laboratory sessions will lead to the student being marked incomplete and l be prohibited from passing and will be excluded from admission into the relevant Autumn Examination and have to repeat the whole year.

While we hope that you will not encounter any difficulties, academic or otherwise, during this year, the university has a range of supports in areas including academic skills, health, and finance. A guide to these is available here (https://www.universityofgalway.ie/media/collegeofscienceandengineering/CSE_StudentSupportMap_V.5_ColourblindFriendly-3.pdf).

You are expected to adhere to the university academic integrity policy (**https://www.universityofgalway.ie/media/registrar/docs/QA220-Academic-Integrity-Policy-Final.pdf**). Note that the unauthorised use of Artificial Intelligence is not permitted in assessments. Please check with your instructor if you have any questions about what is or is not allowed to be used.

Course Structure 2024/25

Code	**CH204**	**CH203**	**CH202**	**CH205**	**CH2101**
Title	**Inorganic Chemistry**	**Physical Chemistry**	**Organic Chemistry**	**Analytical & Environmental Chemistry**	**Medicinal Chemistry**
ECTS	5	5	5	5	5
Semester	I	I	II	II	II
Lectures	4 hr/week	4 hr/week	4 hr/week	4 hr/week	2 hr/week
Practical duration	3 hr/week	3 hr/week	3 hr/week	3 hr/week	3 hr/week
Delivery	Sem I (weeks 1-6)	Sem I (weeks 7-12)	Sem II (weeks 1-6)	Sem II (weeks 7-12)	Sem II
Assessment					
Examination (2 hr):	65 %	70 %	65%	70 %	65 %
Practical Marks **Online Homework**	30 % 5%	30 %	30 % 5%	30 %	35 %

Expected workload for each module

5 Credit Module	**100–125 h**
Contact with staff:	~48 h
Examinations (written and practical)	~2hr
Autonomous learning:	~50–75 h (about 4 h/week)

Autonomous learning includes time spent working independently reporting on practicals, learning, revising, additional reading, studying.

Initial Schedules

Semester I

CH204	Wednesday 11th September 2024
	MRA201 @ 10.00 am
CH203	Wednesday 23rd October 2024
	MRA201 @ 10.00 am

Semester II

CH202	Wednesday 15th January 2025
	MRA201 @ 10.00 am
CH205	Wednesday 26th February 2025
	MRA201 @ 10.00 am
CH2101	Monday 13th January 2025
	Room 231 Chemistry @ 1.00 pm

Key Contacts

2nd year coordinator – Dr David Cheung (david.cheung@universityofgalway.ie)

Chemistry Pathway coordinator – Constantina Papatriantafyllopoulou (constantina.papatriantafyllopo@universityofgalway.ie)

Medicinal Chemistry Pathway coordinator – Dr Eddie Myers (eddie.myers@universityofgalway.ie)

Biopharmaceutical Chemistry Programme coordinator – Prof Peter Crowley (peter.crowley@universityofgalway.ie)

Head of the School of Biological and Chemical Sciences – Prof. Olivier Thomas (olivier.thomas@universityofgalway.ie)

Chemistry administrators – Karen Kelly (karen.kelly@universityofgalway.ie), Judy Buckley (judy.buckley@universityofgalway.ie)

Module coordinators

CH204 Inorganic Chemistry – Dr Andrea Erxleben (andrea.erxleben@universityofgalway.ie)

CH203 Physical Chemistry – Dr David Cheung (david.cheung@universityofgalway.ie)

CH202 Organic Chemistry – Dr Eddie Myers (eddie.myers@universityofgalway.ie)

CH205 Analytical and Environmental Chemistry – Dr Stanislas Von Euw (stanislas.voneuw@universityofgalway.ie)

CH2101 Medicinal Chemistry – Dr Laura Cunningham (laura.cunningham@universityofgalway.ie)

CH204 - Inorganic Chemistry

Staff: Dr. Andrea Erxleben (Module co-ordinator), Dr. Pau Farras

Text Book: Brown, LeMay, Bursten, Chemistry The Central Science (online access via the library)

Lecture Course Outline

1. Introduction to the Practical Course (2 lectures, AE)

These lectures will cover some of the theory of the experiments that the student will carry out during the practicals. The learning outcomes that will be assessed will include:

- The student being able to interpret and explain the data and observations of the experiments carried out in the weekly laboratory sessions.

2. Structure and Bonding – Molecules, Metals and Modern Materials (8 lectures, AE)

This lecture series will cover Molecular Orbital theory, metallic lattices, metallic bonding, polymorphism, alloys, intermetallic compounds, semiconductors and inorganic materials. The learning outcomes that will be assessed will include:

- The student being able to apply MO theory to describe the bonding in diatomic molecules, to calculate the bonding order and to predict the magnetic properties.
- The student being able to describe common types of packing in metal lattices (cubic and hexagonal close-packing, simple cubic, body-centred cubic)
- The student being able to relate the properties of metals, alloys and semiconductors to their solid-structures and to a model for metallic binding
- The student being able to explain the following terms; polymorphism, alloy (substitutional, interstitial), intermetallic compound, metallic radius, unit cell, octahedral and tetrahedral sites in lattices.
- The student being able to demonstrate an understanding of the properties and structures of inorganic materials such as ceramics and their application as superconductors

3. The Periodic Properties of the Elements (6 lectures, AE)

This lecture series will give an overview of the properties and reactions of the elements of group 1, 2, 13 – 18. The learning outcomes that will be assessed will include:

- The student understanding trends in the physical and chemical properties in the main groups of the Periodic Table.
- The student being familiar with the physical and chemical properties of selected main group elements.

4. Introduction to Transition Metals (8 lectures, PF)

The reactions of transition metal compounds with ligands, the properties of the molecules formed and the theories used to explain these phenomena will be explored. The student will endeavour to be able to:

- Give valence shell electron configurations for coordination compounds of the transition metals and their ions
- Draw molecular structures for common ligands and the coordination compounds they form with the transition metals, to include isomers
- Use chemical equations to represent the reactions involved in the formation of transition metal coordination compounds
- Give scientific accounts, at the phenomenological level, of magnetism and colour and their measurement using Gouy balance and spectrometer
- Use crystal field theory to explain the origin of colour and magnetism in transition metal compounds and to account for measured magnetic moments and maximal wavelengths of absorption.

Practicals

The Inorganic Practical Course will take place over a 5 week period (4 hrs per week). There will be a tutorial at the end of each practical session. Attendance records are taken at practical classes and performance at each laboratory class will be assessed on a weekly basis. Part of the marks will be awarded for this continuous assessment. There will be an MCQ examination at the end of the practical course.

The principal objectives of the CH204 laboratory course are:

- To provide an appreciation of the scientific method in the observation, recording and interpretation of experimental data.
- To illustrate the chemical principles dealt with in the lecture course.
- To familiarise the student with important techniques fundamental to all chemical work.

The experiments include the following:
Week 1 Preparation and analysis of an iron oxalate compound.
Learning outcome: Obtaining accurate results in the analysis of complex materials, revision of redox reactions and calculations.
Week 2 Chemistry of selected transition metals.
Learning outcome: Observation and deduction, revision of balanced equations, use of redox potentials, introduction to transition metal chemistry
Week 3 Introduction to molecular modelling.
Lecture topic: Structure & Bonding
Week 4 Determination of the hardness of water.
Lecture topic: Periodic Properties of the Elements and Co-ordination Compounds
Week 5 The chemistry of two examples of oxyanions - Application of spot tests.
Lecture topic: Periodic Properties of the Elements

CH203 - Physical Chemistry

Staff: Dr David Cheung (Module Co-ordinator), Prof. Henry Curran, Dr Chong-Wen Zhou

Text Book: "Elements of Physical Chemistry", 4th or 5th Edition, by Atkins and De Paula, available in the library and in the university book shop, price €39.95. This text is also the prescribed text for third year physical chemistry. The Thermodynamics and Equilibrium section also draws heavily from "Thermodynamics Kept Simple" by Kjellander, which is available through the library.

Thermodynamics and Equilibrium (8 h, DC): Chapters 2–4 and 7 of textbook
On successful completion of this course the student will be able to:

- Relate entropy to the number of arrangements of matter and energy and show how this gives rise to the 2nd and 3rd laws of thermodynamics.
- Predict the direction of change in chemical systems from the change in free energy.
- Calculate changes in thermodynamic quantities in
- Relate the equilibrium constant for a chemical system to the change in the free energy.
- Apply the principles of thermodynamics and chemical equilibrium to common chemical systems.

Transitions and phases (8 h, HC): Chapters 5-6 of textbook
On successful completion of this course the student will be able to:

- Use the molar Gibbs energy to predict the tendency of a substance to change phase.
- Describe how the molar Gibbs energy of a substance varies with pressure and temperature.
- Use the molar Gibbs energy to give a condition for the transition temperature between two phases.
- Use the Clapeyron equation, and the Clausius-Clapeyron approximate equation, to predict the location of phase boundaries and the vapour pressure.
- Interpret phase diagrams and use the lever rule to determine the relative abundance of phases.
- Describe the differences between regular and ideal solutions.
- Describe azeotropes and eutectics.

Chemical kinetics (8 h, CZ): Chapters 10-11 of textbook
On successful completion of this course the student will be able to:

- Describe how the rates of chemical reactions can be measured by using techniques that monitor the concentration of species in a reaction mixture
- Use rate laws to relate the reaction rate to the concentrations of the species that occur in the overall chemical reaction
- Describe the change in reactant concentrations with time using integrated rate laws
- Use the Arrhenius law to give the temperature dependence of the rate constant
- Derive the rate law for a first- and second-order reaction and from that determine the half-life for a reaction and the rate of reaction.
- Determine the kinetics for an elementary reaction.
- Determine the rate constant of a reaction varies with temperature, and derive the frequency A-factor and activation energy of a reaction given the rate constant and different temperatures.
- Describe the dependence of kinetics on thermodynamics of reactants and products.

Practicals (4 hr per week, over a 6 week period)
The Physical Chemistry Practical Course will take place over a 5 week period (4 hrs per week), commencing with a library training session. There will be a tutorial at the end of most practical sessions. Attendance records are taken at practical classes and performance at each laboratory class will be assessed on a weekly basis. Part of the marks will be awarded for this continuous assessment. There will be an MCQ examination at the end of the practical course.

The principal objectives of the CH203 laboratory course are:

- To provide an appreciation of the scientific method in the observation, recording and interpretation of laboratory data.

- To illustrate applications of the chemical principles dealt with in the lecture course.
- To familiarise the students with important techniques fundamental to all chemical work.

The practicals are to be written up weekly as a separate report. Attendance and performance at each laboratory class will be assessed on a weekly basis and part of the marks will be awarded for this continual assessment.

The experiments include the following:

- Conductometric Titration of an Acid Mixture
- Temperature Dependence of the Equilibrium Constant
- Determination of the Vapour Pressure of Liquids
- Chemical Kinetics: Fading of Phenolphthalein
- Chemical Kinetics: Arrhenius equation

CH202 - Organic Chemistry

Staff: Dr. Eddie Myers (Module Co-ordinator), Prof. Paul Murphy, TBC

Textbook: *Organic Chemistry, 8th edition, John E. McMurry international edition. Available in the Library and the university bookshop. This text is also the prescribed text for third year Organic chemistry.* Relevant chapters: 1, 3, 4, 7, 8, 9, 11, 15, 16, 17, 19, 20, 21, 22 and 23. See online textbook map at:
https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_(McMurry)

Delivery: 24 lectures (4 per week over six weeks). Weekly practical sessions (one 4-hour session per week for 5 weeks). Tutorials (evenings, end of Semester 2)

Assessment: Continuous Assessment (35%): 5 practical sessions (one afternoon per week, 2-6 pm; Week 1-5; see schedule for your assigned day) and 3 biweekly homeworks based on material in 24 lectures (Canvas; due end of Week 3, 5, 7).

End of Semester Exam (65%)

Learning Outcomes:

- Understand that acyclic and cyclic molecules can adopt different shapes (conformations) and appreciate the factors that determine preferred shape
- Be able to name families of organic molecules and functional groups
- Understand the concept of hybridization of atomic orbitals for describing the bonding of tetravalent, trivalent and divalent carbon centres.
- Understand the factors governing substitution and elimination reactions
- Understand the factors governing the shape of amines and alcohols, appreciate the variety of synthetic methods for preparing nitrogen- and oxygen-containing molecules and understand the factors governing the basicity of amines and alcohols.
- Understand the structure and reactivity of carbonyl compounds (esters, carboxylic acids, acid chlorides, anhydrides, ketones and aldehydes) and nitriles
- Understand the structure and reactivity of alkenes and alkyne
- Understand the concept of aromaticity and appreciate the main types of reactions of aromatic systems
- To appreciate the safety risks and risk mitigation measures associated with the preparation and isolation of organic molecules
- To be able to analyse UV/Vis, IR and mass spectra of organic molecules for the identification of functional groups and molecules.
- To develop expertise in carrying out distillations, filtrations, recrystallisations, reflux reactions, liquid-liquid extraction and measuring melting-point ranges
- To develop expertise in the use of qualitative analysis in identifying functional groups.

For each practical a report will need to be submitted via Canvas Your attendance and performance at each laboratory class will be assessed and contributes to your continuous assessment mark. Each practical contributes 6% to your overall mark for the module! Students who do not attend a sufficient number of lab sessions may be deemed incomplete.

CH205 - Analytical & Environmental Chemistry

Staff: Dr Stanislas Von Euw (Module Co-ordinator), Dr Binh Mai, Prof. Olivier Thomas

24h of lectures + **20h of labs** (3h of lab work + one extra hour to complete the lab report that must be handed back at the end of the lab)

Course outline:

1. Principles of analytical chemistry (**4 h, SVE**)
    - Vocabulary of Analytical Chemistry
    - Common apparatus and basic techniques + practices
    - Sample preparation

2. Titrimetry and Gravimetry (**4 h, SVE**)
    - Titration
    - Gravimetry

3. Spectroanalytical methods (**8 h, BM**)
    - IR
    - UV-Vis
    - NMR (one-dimensional experiments)

4. Separative techniques (**8 h, OT**)
    - Extraction
    - Ion exchange
    - Chromatography TLC GC HPLC
    - Mass Spectrometry: principles

Practicals

- Water analysis: Determination of water Total Hardness by complexometric titration.
- Impact of Ocean Acidification on calcifying organisms.
- Estimation of Sulphate anion in a solution of $CuSO_4$ using a Cation Exchange Resin.
- Mid-Infrared Spectroscopy and Antioxidant Assay.
- Atmospheric VOCs analysed by NMR and Mass Spectrometry.

CH2101 – Medicinal Chemistry

Staff: Dr Laura Cunningham (module coordinator), Dr Eddie Myers

24h of lectures + **20h of labs**

Learning Outcomes

1. Gain knowledge of the structure of building blocks of biomolecules that are receptors for drugs. A focus will be on amino acids and proteins, and the chemistry influencing the three dimensional structure of proteins
2. Understand and apply chemical principles to describe and discuss how drug molecules interact with their biomolecular receptors such as proteins. This covers the interactions involved in protein-ligand complex formation.
3. Gain knowledge and understanding of how drug interaction with a target are measured. In this regard how the potency and selectivity of drugs for their target receptor or enzyme is measured and how structure activity relationships are established will be covered.
4. Gain an appreciation for how physicochemical properties of compounds are important in medicinal chemistry. These include solubility, lipophilicity, stability, ADMET etc.
5. Use synthetic and analytical techniques in the laboratory to prepare & evaluate drug molecules. Use computational techniques to gain appreciation for protein structure, and the chemical nature of drug-receptor complexes, as well as calculation of physicochemical properties of compounds.
6. Gain knowledge and understanding of selected drugs were identified and developed and their mechanism of action
7. Understand and apply strategies to optimize potential drugs to improve pharmacodynamic and pharmacokinetic properties

Assessment

- 2 hour exam (65 %)
- Practicals (35 %)