CBMS188

Advanced Chemistry I

FY1 Day 2015

Dept of Chemistry & Biomolecular Sciences

Contents

General Information

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Credit points 3
Prerequisites Admission to BAdvSc
Corequisites CBMS102 and CBMS103
Co-badged status
Unit description This unit is a full-year unit based on contemporary topics in chemistry and biomolecular sciences. It is comprised of weekly research-focussed seminars and discussions. This unit caters for advanced students who are strong in chemistry and/or science and who are interested in pursuing a scientific career. It aims to encourage well-qualified students to reach their full potential. This unit is an extension of CBMS102 General Chemistry and CBMS103 Organic and Biological Chemistry. The unit will treat some topics in more depth and introduce others that are not covered in the regular undergraduate units. The weekly one-hour discussion sessions will also address recent advances in the molecular sciences. Student discussions are led by research scientists of the Department of Chemistry and Biomolecular Sciences and each student is mentored by a third year advanced chemistry student. In addition, students are encouraged to participate in the research activities of the department over the summer recess through vacation scholarships.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

understand the chemistry, thermodynamics and kinetics that drives protein folding, the physical techniques involved in protein structure determination and the role of small molecules in probing biological systems

understand the advantages and disadvantages of theoretical models of bonding, structure and intermolecular forces and how these control reactivity

describe the fundamental principles of electrochemistry and apply electrochemistry to simple chemical analysis, clinical diagnostics and environmental detection

You will be able to explain the chemical processes of precipitation, diffusion and osmosis as relating to "crystal gardens", and the origin of colour in transition metal salts, at an

introductory level
have the capability to use the chemical database Scifinder Scholar to retrieve information on specific chemicals, find methods for the synthesis of specific chemicals and find literature on chemistry
explain and rationalise the molecular forces that control how atoms bond into molecules and how molecules interact and react
be able to compare and contrast the different types of combinatorial chemistry and how these relate to chemical diversity, natural products and the creation of new matter
be able to draw and assign the stereochemistry of 8 monosaccharides and relate the biosynthesis of post-translational modifications to chemical reactions and functional groups and describe the limits to the heterogeneity found in oligosaccharide structures

Assessment Tasks

Name	Weighting	Due
module 1	16%	Weeks 5 and 6
module 2	17%	week 9
module 3	17%	weeks 13 and 14
module 4	17%	Week 21
module 5	17%	week 25
module 6	16%	week 28 and 29

module 1

Due: **Weeks 5 and 6**
Weighting: **16%**

Pick a macromolecule and make a group video on the role and structure of the macromolecule. In addition write an individual report on your macromolecule.

On successful completion you will be able to:

- understand the chemistry, thermodynamics and kinetics that drives protein folding, the physical techniques involved in protein structure determination and the role of small molecules in probing biological systems

module 2

Due: **week 9**

Weighting: **17%**

A laboratory experiment will be conducted, led by your third year mentor, to enhance understanding of principles presented in this section, as well as to gain hands-on experience of some advanced electroanalytical detection techniques. Students will then be required to deliver a verbal presentation of their independent research on selected sensor development and a written lab report.

On successful completion you will be able to:

- describe the fundamental principles of electrochemistry and apply electrochemistry to simple chemical analysis, clinical diagnostics and environmental detection

module 3

Due: **weeks 13 and 14**
Weighting: **17%**

Construction of a web page and write an essay, illustrating the science of crystal gardens.

On successful completion you will be able to:

- You will be able to explain the chemical processes of precipitation, diffusion and osmosis as relating to "crystal gardens", and the origin of colour in transition metal salts, at an introductory level
- have the capability to use the chemical database Scifinder Scholar to retrieve information on specific chemicals, find methods for the synthesis of specific chemicals and find literature on chemistry

module 4

Due: **Week 21**
Weighting: **17%**

Take home exam on structure and bonding

On successful completion you will be able to:

- understand the advantages and disadvantages of theoretical models of bonding, structure and intermolecular forces and how these control reactivity
- have the capability to use the chemical database Scifinder Scholar to retrieve information on specific chemicals, find methods for the synthesis of specific chemicals and find literature on chemistry
- explain and rationalise the molecular forces that control how atoms bond into molecules and how molecules interact and react

module 5

Due: **week 25**
Weighting: **17%**

You will make an oral presentation (PowerPoint; 3 slides) and then hand in a 2000 word essay on some aspect of combinatorial chemistry you find fascinating/intriguing/interesting

On successful completion you will be able to:

- have the capability to use the chemical database Scifinder Scholar to retrieve information on specific chemicals, find methods for the synthesis of specific chemicals and find literature on chemistry
- be able to compare and contrast the different types of combinatorial chemistry and how these relate to chemical diversity, natural products and the creation of new matter

module 6

Due: **week 28 and 29**
Weighting: **16%**

assignment on the chemistry of post-translational modifications.

On successful completion you will be able to:

- be able to draw and assign the stereochemistry of 8 monosaccharides and relate the biosynthesis of post-translational modifications to chemical reactions and functional groups and describe the limits to the heterogeneity found in oligosaccharide structures

Delivery and Resources

No required text. Background readings from co-requisite CBMS102 and CBMS103 may be required. You will be required to shoot 2 videos as part of this unit.

Lectures in Semester 1 will be Tuesday 1-2PM in E7B346 (200-300-level chemistry lab write-up room)

Unit Schedule

Semester 1

Wk 1:No Lecture. Download unit guide, familiarise yourself with the curriculum and expectations and participate in virtual meeting on the CBMS188 web site.

Wk 2-5 LB

This four-week section will introduce you to the chemistry of biological macromolecules, particularly proteins. You will gain an understanding for why the bigger a molecule becomes, the

more difficult it is to determine its structure. We will look at several novel approaches at the forefront of determining structures of biological macromolecules. We will also focus on several classes of proteins including molecular motors, light receptors and channels. We will dissect mechanisms behind how and why proteins can move and change shapes to perform their required functions.

Wk 2: Introductory remarks and overview of the unit. Introduction to properties of amino acids and protein folding. Explore conventional structural methods, including X-ray crystallography and NMR spectroscopy. Discussion on several notable biomacromolecules including examples of molecular motors, fluorescent proteins, membrane proteins Pick your own 'biomacromolecule'.

Wk 3: Introduction to primary literature for researching your chosen biomacromolecule. Group Task - Plan your YouTube video for filming in week 12.

Wk 4: Group task– film your YouTube video in small groups

Wk 5: Group presentations of your YouTube videos of your selected biomacromolecule. Discussion/Debate of the definition of chemistry and whether 'structural biology' can indeed be classified as chemistry.

Wk 6: Hand in your individual written report

Wk 6-9 DW

In this section, we will firstly extend principles of redox reactions already developed in high school chemistry, followed by their applications to analytical detection. More specifically, we will direct our attention to how electrochemistry is applied to modern development of sensitive and selective sensing technologies. This section build on Brown Ch 19 and involves some theory and a laboratory experiment will be conducted, led by your third year mentor, to enhance understanding of principles presented in this section, as well as to gain hands-on experience of some advanced electroanalytical detection techniques. Students will then be required to deliver a verbal presentation of their independent research on selected sensor development and a formal lab report, which is graded.

Wk 6: Review of basic electrochemistry; Hand in your individual written report for LB

Wk 7: Laboratory work

Wk 8: Discussion of results

Wk 9: Oral presentation and hand in lab report

Wk 10-13 IJ

Chemical gardens are the plant-like structures formed when a soluble metal salt in the form of a seed crystal is placed in an aqueous solution, typically, sodium silicate. Tubular structures form, rising up from the seed crystal. This process has some parallels with other precipitation processes, such as the huge black “smokers” that grow up to 30 m tall at hydrothermal vents on the ocean’s floor. At smaller length scales, it causes the growth of beautiful “soda-straw” stalactites in limestone caves. We will explore the chemistry of the formation of these crystal

gardens and use the technique of “slowmation” to document the process. The topics covered are an extension of CBMS102 (corequisite) and cover; transition metal salts (colours of as arising from electronic transitions, bonding of, geometry of), precipitation reactions, diffusion, osmosis and semi-permeable membranes. These are extensions of Brown Ch 1 (Modern Atomic Theory), Ch 3 (Stoichiometry) Ch 5 (Chemical Bonding), Ch 9 & 10 (Chemical Equilibrium; particularly "Ionic Equilibria" & solutions/solubility) and Ch 13 (Coordination Chemistry) presented in an integrated, holistic fashion.

Wk 10: Lecture on dissolution, precipitation, diffusion and osmosis with regards to the crystal gardens and electronic structure, including crystal field theory, of transition metal salts

Wk 11: Grow Crystal Gardens in the lab. Make photographic record

Wk 12: Class discussion. Construct webpage

Wk 13: Presentation of web page and 1st draft of essay

Wk 14: Hand in your essay

Wk 15: Examination week (CBMS188 has no mid-year exam)

Semester 2

Wk 16: introduction to SciFinder Scholar by your 3rd year mentors (in 200/300-level chem labs)

Week 2-5 FL

This section of the course will provide you with an overview of more advanced concepts in chemical bonding and structure, chemical and physical principles behind molecular recognition, and their applications in fundamental discoveries. This section is an extension of CBMS103 as it deals with more advanced theories on bonding, structures, conformations, H-bonds, and reaction energy controls. These are extensions of McMurry Ch. 1, 2, and 3 (Structure and bonding, nature of organic molecules, and nature of organic reactions). Specific topics include:

Wk 17: Localised and delocalised bonding: From Lewis to Schrödinger

Wk 18: Weak bonding interactions behind strong networks

Wk 19: Recognition motifs of the molecular world

Wk 20: Time-dependent chemical complexity

Wk 21 *hand in take-home exam*

Week 6-9 PK

This section of the course will provide you with an overview of Chemical Diversity, Combinatorial Chemistry and more advanced aspects of organic chemistry mechanisms that can lead to Diversity Orientated Synthesis. Topics covered are extension of McMurry Ch. 1 (structure and bonding), 2 (the nature of organic molecules) and Ch. 3 (the nature of organic reactions)

Wk 21: Introduction and history of chemical synthesis, chemical space, medicinal chemistry, natural products and combinatorial chemistry; Hand in your take-home exam for FL

Wk 22: *Advanced mechanistic chemistry + pick your research topic related to CombiChem*

Wk 23: Combinatorial Chemistry and Diversity Orientated Synthesis + prepare for your presentation

Wk 24: Oral Presentation on CombiChem

Wk 25: Hand in your CombiChem essay

Week 10-13 NP

This section of the course will provide an overview of the modifications that occur to a protein between the translation of a gene and the functional gene product. These "post-translational modifications" will be related to the functional groups you learn about in CBMS103 and the mechanisms of functional group transformations. For example, serine phosphorylation can be related to reaction of acid anhydrides (or esters) with alcohols, ATP being a phosphoric acid anhydride or "phosphodiester". Alkylation with SAM can be related to the reaction of alkyl-halides (eg MeI, which you learnt about from a chemical perspective in Ch 7 and Ch 8 and Ch 12). Acetylation with acetylCoA can be related to esterification (Ch 10) and amide bond formation (Ch 12). Emphasis will be on sugar chemistry (see Blackman, Ch22; McMurry Ch14 & 15), the addition of the many types of different carbohydrate structures to the proteins, and how their chemical properties modify the behaviour of the protein.

Wk 25: Discussion of the known modifications that occur to proteins and how their chemical properties may affect the behaviour, structure and localisation of the proteins. (plus hand in essay for PK)

Wk 26: Introduction to the types of oligosaccharide modifications that are found on proteins, with examples of the many different isomeric sugar structures found. Choice of a particular glycoprotein to review.

Wk 27: Exploration of the methods used to characterise glycoproteins and the basis behind the methods used.

Wk 28: Oral (10 min. + 5 min for questions)

Wk 29: study break and hand in written report for NP (2 pages max)

Wk 30: Examination week (CBMS188 has no final exam)

Learning and Teaching Activities

lectures

24 lecture/discussion groups

workshop

learn how to use SciFinder Scholar

videos

shoot 1 video for YouTube

presentation

deliver 3 presentation with PowerPoint

assignments

write 3 essays and one take-home exam

web page

create one web page for crystal gardens

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central. Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy http://mq.edu.au/policy/docs/academic_honesty/policy.html

Assessment Policy http://mq.edu.au/policy/docs/assessment/policy.html

Grading Policy http://mq.edu.au/policy/docs/grading/policy.html

Grade Appeal Policy http://mq.edu.au/policy/docs/gradeappeal/policy.html

Grievance Management Policy http://mq.edu.au/policy/docs/grievance_management/policy.html

Disruption to Studies Policy http://www.mq.edu.au/policy/docs/disruption_studies/policy.html *The Disruption to Studies Policy is effective from March 3 2014 and replaces the Special Consideration Policy.*

In addition, a number of other policies can be found in the Learning and Teaching Category of Policy Central.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/support/student_conduct/

Results

Results shown in *iLearn*, or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://informatics.mq.edu.au/help/.

When using the University's IT, you must adhere to the Acceptable Use Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcome

- You will be able to explain the chemical processes of precipitation, diffusion and osmosis as relating to "crystal gardens", and the origin of colour in transition metal salts, at an introductory level

Assessment task

- module 3

Learning and teaching activity

- shoot 1 video for YouTube

- write 3 essays and one take-home exam
- create one web page for crystal gardens

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning and teaching activities

- write 3 essays and one take-home exam

Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcomes

- understand the chemistry, thermodynamics and kinetics that drives protein folding, the physical techniques involved in protein structure determination and the role of small molecules in probing biological systems
- understand the advantages and disadvantages of theoretical models of bonding, structure and intermolecular forces and how these control reactivity
- describe the fundamental principles of electrochemistry and apply electrochemistry to simple chemical analysis, clinical diagnostics and environmental detection
- be able to compare and contrast the different types of combinatorial chemistry and how these relate to chemical diversity, natural products and the creation of new matter
- be able to draw and assign the stereochemistry of 8 monosaccharides and relate the biosynthesis of post-translational modifications to chemical reactions and functional groups and describe the limits to the heterogeneity found in oligosaccharide structures

Assessment tasks

- module 1
- module 2

- module 4
- module 5
- module 6

Learning and teaching activities

- 24 lecture/discussion groups
- deliver 3 presentation with PowerPoint
- write 3 essays and one take-home exam

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- understand the chemistry, thermodynamics and kinetics that drives protein folding, the physical techniques involved in protein structure determination and the role of small molecules in probing biological systems
- understand the advantages and disadvantages of theoretical models of bonding, structure and intermolecular forces and how these control reactivity
- describe the fundamental principles of electrochemistry and apply electrochemistry to simple chemical analysis, clinical diagnostics and environmental detection
- You will be able to explain the chemical processes of precipitation, diffusion and osmosis as relating to "crystal gardens", and the origin of colour in transition metal salts, at an introductory level
- have the capability to use the chemical database Scifinder Scholar to retrieve information on specific chemicals, find methods for the synthesis of specific chemicals and find literature on chemistry
- explain and rationalise the molecular forces that control how atoms bond into molecules and how molecules interact and react
- be able to draw and assign the stereochemistry of 8 monosaccharides and relate the biosynthesis of post-translational modifications to chemical reactions and functional groups and describe the limits to the heterogeneity found in oligosaccharide structures

Assessment tasks

- module 1
- module 2
- module 3
- module 4
- module 6

Learning and teaching activities

- 24 lecture/discussion groups
- write 3 essays and one take-home exam

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- understand the advantages and disadvantages of theoretical models of bonding, structure and intermolecular forces and how these control reactivity
- describe the fundamental principles of electrochemistry and apply electrochemistry to simple chemical analysis, clinical diagnostics and environmental detection
- You will be able to explain the chemical processes of precipitation, diffusion and osmosis as relating to "crystal gardens", and the origin of colour in transition metal salts, at an introductory level
- explain and rationalise the molecular forces that control how atoms bond into molecules and how molecules interact and react
- be able to compare and contrast the different types of combinatorial chemistry and how these relate to chemical diversity, natural products and the creation of new matter

Assessment tasks

- module 2
- module 3
- module 4
- module 5

Learning and teaching activities

- deliver 3 presentation with PowerPoint
- write 3 essays and one take-home exam

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

- describe the fundamental principles of electrochemistry and apply electrochemistry to simple chemical analysis, clinical diagnostics and environmental detection
- explain and rationalise the molecular forces that control how atoms bond into molecules and how molecules interact and react

Assessment tasks

- module 2
- module 4

Learning and teaching activities

- learn how to use SciFinder Scholar
- write 3 essays and one take-home exam

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcomes

- understand the chemistry, thermodynamics and kinetics that drives protein folding, the physical techniques involved in protein structure determination and the role of small molecules in probing biological systems
- You will be able to explain the chemical processes of precipitation, diffusion and osmosis

as relating to "crystal gardens", and the origin of colour in transition metal salts, at an introductory level
- be able to compare and contrast the different types of combinatorial chemistry and how these relate to chemical diversity, natural products and the creation of new matter
- be able to draw and assign the stereochemistry of 8 monosaccharides and relate the biosynthesis of post-translational modifications to chemical reactions and functional groups and describe the limits to the heterogeneity found in oligosaccharide structures

Assessment tasks

- module 1
- module 3
- module 5
- module 6

Learning and teaching activities

- deliver 3 presentation with PowerPoint
- write 3 essays and one take-home exam
- create one web page for crystal gardens

Changes from Previous Offering

CBMS188 is open to students outside the BAdvSc program, by permission and with an equivalent ATAR (>95) or with HD grade(s) in CBMS101, 102 and/or 103. CBMS188 is structurally the same as last year but there is some new content compared to previous years. The unit is now run through iLearn.

Changes since First Published

Date	Description
25/06/2015	updated learning objectives for module 6