CBMS307

Physical and Environmental Chemistry II

S2 Day 2014

Chemistry and Biomolecular Sciences

Contents

General Information

Unit convenor and teaching staff
Unit Convenor
Ian Jamie
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F7B 236
Anytime

Lecturer
Christopher McRae
christopher.mcrae@mq.edu.au
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F7B 328
Students are encouraged to arrange a meeting via email.

Credit points
3

Prerequisites
39cp including CBMS207

Corequisites

Co-badged status
This unit is co-badged with CBMS707.

Unit description
This unit explores the underlying principles that govern the properties and behaviour of chemical processes. Using environmental chemistry examples and contexts, we explore the what, why and how fast of chemistry: structure, energy, and rate. The theoretical foundations of these topics are respectively, quantum mechanics; thermodynamics and equilibrium statistical mechanics; and chemical kinetics. There is an emphasis on the chemistry of global climate change; ozone depletion; dispersal and transformation of chemicals in the environment; equilibrium and non-equilibrium processes in the world's oceans; and other environmentally relevant topics. The measurement and modelling of these systems is described and practiced.

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:

Upon completion of this unit students will be able to solve problems in kinetics, quantum mechanics (spectroscopy), thermodynamics and chemical transport, by identifying the essential parts of, and formulating a strategy for solving, them. You will be able to rationally estimate the solution to a problem, apply appropriate techniques to arrive at a solution, test the correctness of the solution, and interpret their results.

At the completion of this unit students will be able to exhibit an understanding of chemical transport and transformation in the environment.

At the completion of this unit students will be able to apply some concepts of group theory and quantum chemistry to simple polyatomic molecules, and will be able to explain the principles fluorescence and Raman spectroscopies.

At the completion of this unit students will be able to exhibit an understanding of the electronic states of some simple molecules, and their relationship to photochemical reactions.

At the completion of this unit students will be able to exhibit an understanding of the relationship of the chemical reactivity and quantum chemical properties of molecules to large-scale environmental issues such as global warming.

At the completion of this unit students will be able to explain Transition State Theory to in introductory level, and to apply concepts of kinetics to complex systems, including competitive reactions, and to reaction mechanisms to areas of environmental relevance, including an understanding of the role of kinetics in important environmental reactions, such as ozone depletion.

At the completion of this unit students will be able to exhibit an understanding of concepts of thermodynamics, including statistical thermodynamics, the Partition Function and the use of the heat capacity of gases to relate the classical and quantum chemical interpretations of molecular behaviour.

At the completion of this unit students will be able carry out laboratory-based experiments, data measurement and evaluation of results from fundamental concepts of physical chemistry, using modern equipment and techniques, use research literature to support experiment analysis, and work within the paradigm of safe laboratory practices;

By the unit's conclusion students will be able to discuss the use of models in developing theory and be able to critical analyse the strengths and weaknesses of the models used in the context of this unit.

Assessment Tasks

Name	Weighting	Due
Laboratory/Workshops	25%	TBA
Assignments	15%	TBA
In-semester Tests	10%	TBA
Final Examination	50%	University Examination Period

Laboratory/Workshops

Due: **TBA**
Weighting: **25%**

Practicals will encompass a range of topics, strongly aligned to the course-work of the unit. Practicals are nominally two weeks in duration, the first week being for the benchwork and data analysis and the second week for completion of the analysis and write-up.

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Assignments

Due: **TBA**
Weighting: **15%**

Assignments related to the coursework.

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In-semester Tests

Due: **TBA**
Weighting: **10%**

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Final Examination

Due: **University Examination Period**
Weighting: **50%**

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Delivery and Resources

Classes

Timetable: Please check www.timetables.mq.edu.au for the official timetable of the unit.

Lectures: The material presented in the lectures is important and you should not assume that all examinable material is available in the textbook or in printed notes. On the other hand, do not assume that all examinable material is to be found in the lecture notes.

Tutorial: Attendance at the lecture and tutorial is compulsory. Tutorial problems, which may form part of the material submitted for assessment, will be distributed by the lecturer.

Laboratory Work: You will undertake both experiments at the bench (wet-labs) and dry-lab workshops. The wet-labs will initially be held in E7B 347, the 2nd/3rd Year teaching Laboratories.

A laboratory roster will be issued to indicate which experiments you will be undertaking in which week.

Before commencing a new experiment you are required to complete a laboratory preparation exercise. You must have the pre-lab exercises checked by a lecturer BEFORE the lab session starts. You will not be allowed to commence the experimental work until the preparation exercise is completed in a satisfactory manner. A delay in sta1ting the experimental work due to poor pre-lab preparation may have a detrimental effect on your ability to perform the laboratory work satisfactorily. You should attempt the pre-lab exercises well in advance of each practical class. You are advised to read each experiment carefully.

Students unable to attend laboratory classes due to illness or misadventure (as defined in the Handbook of Undergraduate Studies) and who are unable to catch up in a reserve session must provide formal documentary evidence to the University as soon as possible after the absence. For one such justified absence st udents will receive the average mark from the sessions that they did attend. For any unjustified absences students will receice a zero mark and may be liable to compulsory withdrawal from the unit. You will need to submit a "special consideration request".

Some practical work will be undertaken before the corresponding material has been covered in lectures. The notes have been written with this in mind and some allowance will be made in the marking of reports.

Reports must be submitted no later than 5 pm, 14 days after completion of each experiment. Penalties for late submission will accumulate at the rate of 10% per day overdue.

Required and Recommended Texts and/or Materials

Recommended Text Book: We recommend that you obtain Atkins & de Paula "Atkins' Physical Chemistry" 9th ed, Oxford University Press (2009). The 8th edition is also acceptable.

Recommended Supplementary Text: The University Co-Op Bookshop carries copies of Monk "Maths for Chemistry: a Chemist's Toolkit of Calculations". If you are feeling a bit intimidated by the thought of maths, this text might be of use to you.

Alternative Text Book: Raymond Chang "Physical Chemistry for the Chemical and Biological Sciences", 3rd ed, University Science Books (2000) is reasonable, and somewhat more readable than "Atkins' Physical Chemistry", but is a bit light in the spectroscopy section.

You can find a number of textbooks with "Physical Chemistry" in the title in the University library. All cover similar material, but often use different notation. You may find that some of these other books explain certain topics more cl early. Some students find "Physical Chemistry" by R.A. Alberty and R.J. Silbey provides readable introductions to some topics, but is less helpful when it comes to problem solving. Two older books that can provide an alternative introduction to aspects of molecular spectroscopy are "Fundamentals of Molecular Spectroscopy" by C.N. Banwell and "Introduction to Molecular Spectroscopy" by G. M. Barrow.

Text titled *Environmental Chemistry* or similar tend to be too broad wi th respect to the chemistry, and there is limited depth of discussions on Physical Chemistry aspects. However, good background information on the broader aspects of Chemistry in the environmental context can be obtained from these texts. Examples of good Environmental Chemistry texts are S.E. Manahan "Environmental Chemistry" (TD193.M36), G.W. VanLoon and S.J. Duffy "Environmental Chemistry: A Global Perspective" (TD193 .V36) and C. Baird and M. Cann "Environmental Chemistry" (TO192 .B35)

There also many web resources, but material placed on the web is not necessarily checked for accuracy, so be careful when using it.

Technology Used and Required

It is important that you have a scientific calculator as hand-held calculators will be used in tutorials, practicals, for assignments, tests and in the final examination. Note that text-retrieval calculators are not allowed in the in-semester tests or final examination.

Use will be made of Excel and other data processing and display software. Computers carrying this software are available in the teaching laboratories. Items of interest and links to other on-line material will be placed on the unit Blackboard website.

General use computers are provided by the University, but it would be advantageous to have your own computer and internet access.

Unit Web Page: The URL of the CBMS307 web site is: ilearn.mq.edu.au. You will be asked for a username and password. Your username is your student MQID. Your MQID and password have been mailed to you by the University. If you have lost them go to the student portal:

my.mq.edu.au

What has Changed

There have been no significant changes from the previous offering.

Unit Schedule

A timetable and syllabus will be handed out in the first week.

Workshops/Practicals will start in Week 2.

Learning and Teaching Activities

Practicals

Laboratory exercises are designed to provide a concrete example of the abstract topics covered in the course work, and to give you the opportunity to discover the principles and applications for yourself. Laboratory exercises also offer the opportunity to explore the uncertainty inherent in scientific investigations and the limitations of models and theories by allowing comparison with real systems.

Lectures/Tutorials

The lecture/tutorials will be run in a largely “active learning” mode, which means that after a brief introduction to the topic you will work through exercises designed to deepen your understanding of the subject. You are required to attend the lecture/tutorials and laboratory classes. You are expected to be active participants in all these fora. This means that you are expected to ask questions during lectures and, particularly, at tutorials and laboratory classes. Learning is an active process, and as such, you must engage with the material. This means reading the text book (and beyond) before and after lectures, attempting the assignment questions and other questions, discuss the concepts with your classmates and lecturers. Do not be afraid to ask questions – your classmates will probably want to ask the same thing.

Assignments

Assignment questions are issued so that you will have the opportunity to use the information provided in the lectures and textbook to test your degree of understanding of those topics. The assignments are designed to help you learn the material during the semester, rather than trying to cram on the day before the examination. They are relatively low risk (a small component of the aggregate score) but they are very valuable for you as measures of your understanding of the topics.

In-Semester Tests

The in-semester tests are designed to help you learn the material during the semester, rather than trying to cram on the day before the examination. They are relatively low risk (a small

component of the aggregate score) but they are very valuable for you as measures of your understanding of the topics.

Final Examination

The final examination is an opportunity for you to display the knowledge that you have acquired over the course of the unit. It provides a challenge for the dedicated student and an incentive to learn the topics of the unit.

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/

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

The **Numeracy Centre** (C5A 225, www.maths.mq.edu.au/numeracy/) offers assistance for difficulties with the mathematical aspects of this unit.

Help on writing, **EDUCGATEWAY**, the Gateway to Academic Literacy is a useful resource (http://online.mq.edu.au/pub/EDUCGATEWAY/).

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

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 outcomes

- Upon completion of this unit students will be able to solve problems in kinetics, quantum mechanics (spectroscopy), thermodynamics and chemical transport, by identifying the essential parts of, and formulating a strategy for solving, them. You will be able to rationally estimate the solution to a problem, apply appropriate techniques to arrive at a solution, test the correctness of the solution, and interpret their results.
- At the completion of this unit students will be able to exhibit an understanding of chemical transport and transformation in the environment.
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theory and quantum chemistry to simple polyatomic molecules, and will be able to explain the principles fluorescence and Raman spectroscopies.

- At the completion of this unit students will be able to exhibit an understanding of the electronic states of some simple molecules, and their relationship to photochemical reactions.
- At the completion of this unit students will be able to exhibit an understanding of the relationship of the chemical reactivity and quantum chemical properties of molecules to large-scale environmental issues such as global warming.
- At the completion of this unit students will be able to explain Transition State Theory to in introductory level, and to apply concepts of kinetics to complex systems, including competitive reactions, and to reaction mechanisms to areas of environmental relevance, including an understanding of the role of kinetics in important environmental reactions, such as ozone depletion.
- At the completion of this unit students will be able to exhibit an understanding of concepts of thermodynamics, including statistical thermodynamics, the Partition Function and the use of the heat capacity of gases to relate the classical and quantum chemical interpretations of molecular behaviour.
- At the completion of this unit students will be able carry out laboratory-based experiments, data measurement and evaluation of results from fundamental concepts of physical chemistry, using modern equipment and techniques, use research literature to support experiment analysis, and work within the paradigm of safe laboratory practices;

Assessment tasks

- Laboratory/Workshops
- Assignments
- In-semester Tests
- Final Examination

Learning and teaching activities

- Laboratory exercises are designed to provide a concrete example of the abstract topics covered in the course work, and to give you the opportunity to discover the principles and applications for yourself. Laboratory exercises also offer the opportunity to explore the uncertainty inherent in scientific investigations and the limitations of models and theories by allowing comparison with real systems.
- The lecture/tutorials will be run in a largely “active learning” mode, which means that after a brief introduction to the topic you will work through exercises designed to deepen

your understanding of the subject. You are required to attend the lecture/tutorials and laboratory classes. You are expected to be active participants in all these fora. This means that you are expected to ask questions during lectures and, particularly, at tutorials and laboratory classes. Learning is an active process, and as such, you must engage with the material. This means reading the text book (and beyond) before and after lectures, attempting the assignment questions and other questions, discuss the concepts with your classmates and lecturers. Do not be afraid to ask questions – your classmates will probably want to ask the same thing.

- Assignment questions are issued so that you will have the opportunity to use the information provided in the lectures and textbook to test your degree of understanding of those topics. The assignments are designed to help you learn the material during the semester, rather than trying to cram on the day before the examination. They are relatively low risk (a small component of the aggregate score) but they are very valuable for you as measures of your understanding of the topics.
- The final examination is an opportunity for you to display the knowledge that you have acquired over the course of the unit. It provides a challenge for the dedicated student and an incentive to learn the topics of the unit.

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

- At the completion of this unit students will be able to apply some concepts of group theory and quantum chemistry to simple polyatomic molecules, and will be able to explain the principles fluorescence and Raman spectroscopies.
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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.

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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.

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- At the completion of this unit students will be able to exhibit an understanding of the relationship of the chemical reactivity and quantum chemical properties of molecules to large-scale environmental issues such as global warming.
- At the completion of this unit students will be able to explain Transition State Theory to in introductory level, and to apply concepts of kinetics to complex systems, including competitive reactions, and to reaction mechanisms to areas of environmental relevance, including an understanding of the role of kinetics in important environmental reactions, such as ozone depletion.
- At the completion of this unit students will be able to exhibit an understanding of concepts of thermodynamics, including statistical thermodynamics, the Partition Function and the use of the heat capacity of gases to relate the classical and quantum chemical interpretations of molecular behaviour.
- At the completion of this unit students will be able carry out laboratory-based experiments, data measurement and evaluation of results from fundamental concepts of physical chemistry, using modern equipment and techniques, use research literature to support experiment analysis, and work within the paradigm of safe laboratory practices;
- By the unit's conclusion students will be able to discuss the use of models in developing theory and be able to critical analyse the strengths and weaknesses of the models used in the context of this unit.

Assessment tasks

- Laboratory/Workshops
- Assignments
- In-semester Tests
- Final Examination

Learning and teaching activities

- Laboratory exercises are designed to provide a concrete example of the abstract topics covered in the course work, and to give you the opportunity to discover the principles and applications for yourself. Laboratory exercises also offer the opportunity to explore the uncertainty inherent in scientific investigations and the limitations of models and theories by allowing comparison with real systems.
- The lecture/tutorials will be run in a largely "active learning" mode, which means that after a brief introduction to the topic you will work through exercises designed to deepen

your understanding of the subject. You are required to attend the lecture/tutorials and laboratory classes. You are expected to be active participants in all these fora. This means that you are expected to ask questions during lectures and, particularly, at tutorials and laboratory classes. Learning is an active process, and as such, you must engage with the material. This means reading the text book (and beyond) before and after lectures, attempting the assignment questions and other questions, discuss the concepts with your classmates and lecturers. Do not be afraid to ask questions – your classmates will probably want to ask the same thing.

- Assignment questions are issued so that you will have the opportunity to use the information provided in the lectures and textbook to test your degree of understanding of those topics. The assignments are designed to help you learn the material during the semester, rather than trying to cram on the day before the examination. They are relatively low risk (a small component of the aggregate score) but they are very valuable for you as measures of your understanding of the topics.
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- The final examination is an opportunity for you to display the knowledge that you have acquired over the course of the unit. It provides a challenge for the dedicated student and an incentive to learn the topics of the unit.

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

- Upon completion of this unit students will be able to solve problems in kinetics, quantum mechanics (spectroscopy), thermodynamics and chemical transport, by identifying the essential parts of, and formulating a strategy for solving, them. You will be able to rationally estimate the solution to a problem, apply appropriate techniques to arrive at a solution, test the correctness of the solution, and interpret their results.
- At the completion of this unit students will be able to exhibit an understanding of

chemical transport and transformation in the environment.

- At the completion of this unit students will be able to apply some concepts of group theory and quantum chemistry to simple polyatomic molecules, and will be able to explain the principles fluorescence and Raman spectroscopies.
- At the completion of this unit students will be able to exhibit an understanding of the electronic states of some simple molecules, and their relationship to photochemical reactions.
- At the completion of this unit students will be able to exhibit an understanding of the relationship of the chemical reactivity and quantum chemical properties of molecules to large-scale environmental issues such as global warming.
- At the completion of this unit students will be able to explain Transition State Theory to in introductory level, and to apply concepts of kinetics to complex systems, including competitive reactions, and to reaction mechanisms to areas of environmental relevance, including an understanding of the role of kinetics in important environmental reactions, such as ozone depletion.
- At the completion of this unit students will be able to exhibit an understanding of concepts of thermodynamics, including statistical thermodynamics, the Partition Function and the use of the heat capacity of gases to relate the classical and quantum chemical interpretations of molecular behaviour.
- At the completion of this unit students will be able carry out laboratory-based experiments, data measurement and evaluation of results from fundamental concepts of physical chemistry, using modern equipment and techniques, use research literature to support experiment analysis, and work within the paradigm of safe laboratory practices;
- By the unit's conclusion students will be able to discuss the use of models in developing theory and be able to critical analyse the strengths and weaknesses of the models used in the context of this unit.

Assessment tasks

- Laboratory/Workshops
- Assignments
- In-semester Tests
- Final Examination

Learning and teaching activities

- Laboratory exercises are designed to provide a concrete example of the abstract topics covered in the course work, and to give you the opportunity to discover the principles

and applications for yourself. Laboratory exercises also offer the opportunity to explore the uncertainty inherent in scientific investigations and the limitations of models and theories by allowing comparison with real systems.

- The lecture/tutorials will be run in a largely “active learning” mode, which means that after a brief introduction to the topic you will work through exercises designed to deepen your understanding of the subject. You are required to attend the lecture/tutorials and laboratory classes. You are expected to be active participants in all these fora. This means that you are expected to ask questions during lectures and, particularly, at tutorials and laboratory classes. Learning is an active process, and as such, you must engage with the material. This means reading the text book (and beyond) before and after lectures, attempting the assignment questions and other questions, discuss the concepts with your classmates and lecturers. Do not be afraid to ask questions – your classmates will probably want to ask the same thing.
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- The final examination is an opportunity for you to display the knowledge that you have acquired over the course of the unit. It provides a challenge for the dedicated student and an incentive to learn the topics of the unit.

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 outcomes

- At the completion of this unit students will be able to apply some concepts of group theory and quantum chemistry to simple polyatomic molecules, and will be able to explain the principles fluorescence and Raman spectroscopies.

- At the completion of this unit students will be able to exhibit an understanding of the electronic states of some simple molecules, and their relationship to photochemical reactions.
- At the completion of this unit students will be able to exhibit an understanding of the relationship of the chemical reactivity and quantum chemical properties of molecules to large-scale environmental issues such as global warming.
- At the completion of this unit students will be able to explain Transition State Theory to in introductory level, and to apply concepts of kinetics to complex systems, including competitive reactions, and to reaction mechanisms to areas of environmental relevance, including an understanding of the role of kinetics in important environmental reactions, such as ozone depletion.
- At the completion of this unit students will be able carry out laboratory-based experiments, data measurement and evaluation of results from fundamental concepts of physical chemistry, using modern equipment and techniques, use research literature to support experiment analysis, and work within the paradigm of safe laboratory practices;
- By the unit's conclusion students will be able to discuss the use of models in developing theory and be able to critical analyse the strengths and weaknesses of the models used in the context of this unit.

Assessment tasks

- Laboratory/Workshops
- Assignments
- In-semester Tests
- Final Examination

Learning and teaching activities

- Laboratory exercises are designed to provide a concrete example of the abstract topics covered in the course work, and to give you the opportunity to discover the principles and applications for yourself. Laboratory exercises also offer the opportunity to explore the uncertainty inherent in scientific investigations and the limitations of models and theories by allowing comparison with real systems.
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- The final examination is an opportunity for you to display the knowledge that you have acquired over the course of the unit. It provides a challenge for the dedicated student and an incentive to learn the topics of the unit.

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

- At the completion of this unit students will be able to exhibit an understanding of the electronic states of some simple molecules, and their relationship to photochemical reactions.
- At the completion of this unit students will be able to explain Transition State Theory to in introductory level, and to apply concepts of kinetics to complex systems, including competitive reactions, and to reaction mechanisms to areas of environmental relevance, including an understanding of the role of kinetics in important environmental reactions, such as ozone depletion.
- At the completion of this unit students will be able to exhibit an understanding of concepts of thermodynamics, including statistical thermodynamics, the Partition Function and the use of the heat capacity of gases to relate the classical and quantum chemical interpretations of molecular behaviour.
- At the completion of this unit students will be able carry out laboratory-based experiments, data measurement and evaluation of results from fundamental concepts of physical chemistry, using modern equipment and techniques, use research literature to support experiment analysis, and work within the paradigm of safe laboratory practices;
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- The final examination is an opportunity for you to display the knowledge that you have acquired over the course of the unit. It provides a challenge for the dedicated student and an incentive to learn the topics of the unit.

Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

Learning outcomes

- Upon completion of this unit students will be able to solve problems in kinetics, quantum

mechanics (spectroscopy), thermodynamics and chemical transport, by identifying the essential parts of, and formulating a strategy for solving, them. You will be able to rationally estimate the solution to a problem, apply appropriate techniques to arrive at a solution, test the correctness of the solution, and interpret their results.

- At the completion of this unit students will be able to explain Transition State Theory to in introductory level, and to apply concepts of kinetics to complex systems, including competitive reactions, and to reaction mechanisms to areas of environmental relevance, including an understanding of the role of kinetics in important environmental reactions, such as ozone depletion.
- At the completion of this unit students will be able carry out laboratory-based experiments, data measurement and evaluation of results from fundamental concepts of physical chemistry, using modern equipment and techniques, use research literature to support experiment analysis, and work within the paradigm of safe laboratory practices;

Assessment tasks

- Laboratory/Workshops
- Assignments
- In-semester Tests
- Final Examination

Learning and teaching activities

- Laboratory exercises are designed to provide a concrete example of the abstract topics covered in the course work, and to give you the opportunity to discover the principles and applications for yourself. Laboratory exercises also offer the opportunity to explore the uncertainty inherent in scientific investigations and the limitations of models and theories by allowing comparison with real systems.
- The lecture/tutorials will be run in a largely “active learning” mode, which means that after a brief introduction to the topic you will work through exercises designed to deepen your understanding of the subject. You are required to attend the lecture/tutorials and laboratory classes. You are expected to be active participants in all these fora. This means that you are expected to ask questions during lectures and, particularly, at tutorials and laboratory classes. Learning is an active process, and as such, you must engage with the material. This means reading the text book (and beyond) before and after lectures, attempting the assignment questions and other questions, discuss the concepts with your classmates and lecturers. Do not be afraid to ask questions – your classmates will probably want to ask the same thing.

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- The final examination is an opportunity for you to display the knowledge that you have acquired over the course of the unit. It provides a challenge for the dedicated student and an incentive to learn the topics of the unit.

Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

Learning outcomes

- At the completion of this unit students will be able to exhibit an understanding of chemical transport and transformation in the environment.
- At the completion of this unit students will be able to apply some concepts of group theory and quantum chemistry to simple polyatomic molecules, and will be able to explain the principles fluorescence and Raman spectroscopies.
- At the completion of this unit students will be able to exhibit an understanding of the electronic states of some simple molecules, and their relationship to photochemical reactions.
- At the completion of this unit students will be able to explain Transition State Theory to in introductory level, and to apply concepts of kinetics to complex systems, including competitive reactions, and to reaction mechanisms to areas of environmental relevance, including an understanding of the role of kinetics in important environmental reactions, such as ozone depletion.
- At the completion of this unit students will be able carry out laboratory-based experiments, data measurement and evaluation of results from fundamental concepts of physical chemistry, using modern equipment and techniques, use research literature to support experiment analysis, and work within the paradigm of safe laboratory practices;

Assessment tasks

- Laboratory/Workshops
- Assignments
- In-semester Tests
- Final Examination

Learning and teaching activities

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- The lecture/tutorials will be run in a largely “active learning” mode, which means that after a brief introduction to the topic you will work through exercises designed to deepen your understanding of the subject. You are required to attend the lecture/tutorials and laboratory classes. You are expected to be active participants in all these fora. This means that you are expected to ask questions during lectures and, particularly, at tutorials and laboratory classes. Learning is an active process, and as such, you must engage with the material. This means reading the text book (and beyond) before and after lectures, attempting the assignment questions and other questions, discuss the concepts with your classmates and lecturers. Do not be afraid to ask questions – your classmates will probably want to ask the same thing.
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About this Unit

This unit explores the underlying principles that govern the properties and behaviour of chemical processes. Using environmental chemistry examples and contexts, we explore the what, why

and how fast of chemistry: structure, energy, and rate. The theoretical foundations of these topics are: quantum mechanics; thermodynamics, equilibrium statistical mechanics; and chemical kinetics. There is an emphasis on the chemistry of global climate change; ozone depletion; dispersal and transformation of chemicals in the environment; equilibrium and non-equilibrium processes in the World's oceans; and other environmentally relevant topics. The measurement and modelling of these systems is described and practiced.

This unit follows on from CBMS207 Physical and Environmental Chemistry I, broadening and deepening some the topics from that unit, and introducing some new topics.

Physical chemistry is the science that develops an understanding of the structure, properties and transformations of matter, from bulk behaviour down to the atomic level. It is the role of the physical chemist to collect, collate and analyse experimental data from all branches of chemistry and to construct predictive models. As such, physical chemistry underpins much of modern science and it drives advances in a very wide range of fields. Building on information and concepts from chemistry, physics and mathematics, physical chemistry contributes to and is stimulated by areas such as medicine, molecular biology, biochemistry, molecular engineering, chemical engineering, materials science and earth sciences.

Modern chemistry provides tools for elucidating structure at the molecular scale, for understanding the way in which reactions occur, and for analysing complex molecular systems. Chemists can determine the structures of simple molecules through to large assemblies, such as metal complexes, biological macromolecules and industrial polymers. This unit deals with tools that chemists use to investigate the sizes, shapes and amount of molecules and the rates of their reactions with other molecules.

The topics covered are:

- the transport and fate of chemicals in the environment;
- molecular spectroscopy, including molecular symmetry, electronic transition theory, fluorescence and Raman spectroscopies;
- chemical reaction kinetics, including complex reactions and competing reactions;
- thermodynamics, including statistical mechanics;

Office Hours

There are no formal office hours for this unit. Dr Jamie and Dr McRae are happy to receive students outside of the formal lecture and tutorial times but please be aware that we are not always to be found in our offices. It is generally wise to organise an appointment in advance, if possible.

Assumed Knowledge

Assumed knowledge for this unit is 200-level Physical and Environmental Chemistry I and

100-level General Chemistry. Some analytical and some organic chemistry is involved, but support for students weak in these areas will be provided. Some mathematics is inherent in this unit, but supporting material will be provided. A familiarity with high school level physics concepts would be an advantage but is not required.

Graduate Capabilities Statement

Graduate Capabilities: The course work and laboratory work in this unit will help you to develop the graduate capabilities that "the University's graduates would need to develop to address the challenges, and to be effective, engaged participants in their world". Graduate capabilities are viewed as essential for all graduates, irrespective of their course of study. Thus, in conjunction with discipline-specific skills and knowledge, they are the building blocks for developing the attributes valued in a university graduate. Some of the attributes and skills that CBMS307 can help you develop are:

- *Discipline Specific Knowledge and Skills*: The topics explored in CBMS307 are fundamental to the discipline of chemistry. You will be applying problem-solving skills in the chemistry context, applying chemistry theory to practice in order to design and carry out laboratory experiments, using chemistry specific apparatus and techniques, and to apply safe laboratory practices, performing data analysis applying appropriate statistical treatment to data and using standard and specialised computer programs in the analysis of data and presentation of results.

- *Critical, Analytical and Integrative Thinking*: Within this unit you will develop and practice your ability to apply strategic problem-solving in situations where there is a clear solution and in situations demanding critical, analytical and integrative thinking. You will be solving problems by analysing the information given or discovered, looking for other sources of information to apply, looking for the scope and limitation of the context in which the problem and solution lie. In many cases you will be using standard and specialised IT technology for the discovery of information, the analysis of data and the presentation of results.

- *Problem Solving and Research Capability and being Creative and Innovative*: In both the theory and the laboratory component of this unit you will have ample opportunities to develop your problem solving skills and research capabilities. Through set assignment and prac write-up problems, and through performing the laboratory experiments, where procedures, data collection and data analysis will require you to make various decisions, you will be deeply involved in problem solving and research processes in the chemistry context.

- *Effective Communication*: CBMS307 will help equip you with both oral and written communication skills, through your written prac write-ups and your assignments, and through the communications you will be engaged with your lecturers, your demonstrators and your class-mates. Part of your assessment will be concerned with your ability to communicate in clear, concise and appropriate, context-dependent modes (formal reports, informal team discussions, formal presentations, etc).

- *Engaged and Ethical Local and Global citizens*: Engaged and ethical behaviour will be addressed in the professional chemist context, that is, you will be concerned with collecting data and information with appropriate acknowledgement of sources, you will learn ways of performing

experiments and recording outcomes in a manner that conforms to the expectations of the profession and community at large. You will be working with people from a variety of cultural and economic backgrounds and you will be expected to be able to form cohesive and effective teams with anybody in your class. In the theory section of the course we will touch upon issues of interest to contemporary society, such as climate change, chemical processes in the body, and new materials, from the perspective of their underlying chemistry.

- *Socially and Environmentally Active and Responsible*: You will be working in small teams for much of CBMS307, especially in the laboratory component of the course, giving you the opportunity to develop your ability to work with others as a leader and a team player and to have a sense of connectedness and mutual obligation with others.

This unit deals explicitly with aspects of environmental science, allowing you to develop an understanding of environmental processes uninfluenced and influenced by human activity, giving you the knowledge and skills to formulate opinions and personal ideologies relating to the environment.

- *Capable of Professional and Personal Judgement and Initiative*: Especially during your laboratory work, you will be expected to develop discernment and common sense in your professional and personal judgement. You will also be given assignment and test questions that will give you the opportunity to exhibit these capabilities, especially in the context of the application of “models” in scientific knowledge and theorising.

- *Commitment to Continuous Learning*: We hope that you will have your enquiring minds and curiosity extended by CBMS307, and that the topics covered and skills developed will lead you to continue to pursue knowledge for its own sake. You will be have opportunities to reflect on your experiences, learn from them, and grow personally, professionally and socially.

Relationship between Assessment and Learning Outcomes

Assessment: The grades that you achieve at Macquarie University are descriptive rather than numeric. The assessments and conditions on your performance (attendance, completion, etc) help to decide which of these descriptive grades applies to your work for the entire unit.

Your raw marks from assessments are combined into a weighted sum. The weighted sums for the whole class are ranked, and compared with grades for the same unit in previous offerings and across other appropriate units to check for consistency. This process of comparison allows for the identification any unusual influences on class performance that might warrant the weighted sums of marks being altered. The numerical cut-offs for each descriptive grade are then determined. The numerical grade that you will be issued with (the Standardised Numerical Grade, SNG) is determined to match your descriptive grade by standardising the weighted sums of raw marks to match standard scores out of 100. The SNG gives you an indication of how you have performed within the band for your descriptive grade. As the SNG is the result of scaling the weighted sum of your raw marks, you won't be able to:

(a) work out your exam mark based on the assignment marks you already know and the SNG;

(b) determine that you were "one mark away" from a different grade.

It is our professional responsibility as your teachers to assign you a descriptive grade that accurately reflects your performance and capabilities in a unit. Our grading decisions are subject to scrutiny from our academic colleagues within the Department, as well as within the Faculty and University Senate.

The Grades range from High Distinction to Fail, and are defined in the Handbook as follows:

Grade	SNG	Description
HD High Distinction	85-100	Work of outstanding quality. This may be demonstrated in areas such as criticism, logical argument, interpretation of materials or use of methodology. This grade may also be awarded to recognise a high order of originality or creativity in student performance
D Distinction	75-84	Work of superior quality in the same areas of performance as above. This grade may also be awarded to recognise particular originality or creativity in student performance
Cr Credit	65-74	Work of predominantly good quality, demonstrating a sound grasp of content together with efficient organisation, selectivity and use of techniques
P Pass	50-64	Satisfactory achievement of unit objectives
F Fail	0-49	Failure to achieve unit objectives.

Your final grades will be based primarily on the aggregate mark, but the **minimum requirement** to achieve a passing grade is **satisfactory completion of both** the **coursework** component and the **laboratory** component.

Levels of Achievement: The lowest passing level is to be able to identify and use correctly the appropriate formulae from those supplied, in familiar circumstances (i.e., problems similar to those practised in tutorial questions or from past exams). In this case you would expect to obtain a low Pass grade.

A creditable level of achievement is to display knowledge of the meaning and significance of the topics in relation to molecular parameters, and to correctly use formulae in unfamiliar situations.

The highest level of achievement is to display a deep knowledge of the models being used, its uses and limitations, and to apply knowledge from beyond that which is taught in the unit, and even to challenge the material presented.

The assignments and in-semester tests are designed to help you learn the material during the

semester, rather than trying to cram on the day before the examination. They are relatively low risk (a small component of the aggregate score) but they are very valuable for you as measures of your understanding of the topics.

The laboratories and workshops will allow you to put the material that you have been exposed to in the lectures into practice. They will provide concrete expositions of theory. They also provide the opportunity for you to continue your development of bench, data collection and data analysis skills. Writing up the experiments will give you skills in communicating in the chemistry context.

Examinations: The final examination will cover all sections of the unit (lectures, tutorials, assignments and laboratory exercises).

The date of the final examination will be posted by the University during the semester. You are expected to present yourself for examination at the time and place designated in the University Examination Timetable. The timetable will be available in Draft form approximately eight weeks before the commencement of the examinations and in Final form approximately four weeks before the commencement of the examinations.

www.timetables.mq.edu.au/exam

The only exception to sitting an examination at the designated time is because of documented illness or unavoidable disruption. In these circumstances you may wish to consider applying for Special Consideration. The special consideration process is available at:

www.student.mq.edu.au/ses/Special%20Consideration.html

If a Supplementary Examination is granted as a result of the Special Consideration process the examination will be scheduled after the conclusion of the official examination period. The offer of a supplementary examination is at the discretion of the academic staff and you should not assume that it will be provided. Supplementary Examinations are **not make-up exams**, i.e., a poor result in the final examination is not reason to request a supplementary examination.

It is Macquarie University policy to **not set early examinations** for individuals or groups of students. All students are expected to ensure that they are available until the end of the teaching semester, that is, the final day of the official examination period.