School of Physical and Chemical Sciences

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

General Course Information

CHEM343
Materials Science and Nanotechnology

0.125 EFTS 15 Points
First Semester 2024

Description
This course applies the fundamental physical and chemical principles learnt in CHEM111 and CHEM251 to predict, explain and understand the properties of materials, both at the nano-scale and in bulk.

The topics covered by this course are:
1. Polymers
2. Materials Fabrication and Characterisation
3. Liquids: Their Diversity and Their Applications

This course is presented in the first semester only. It counts 15 points towards a Bachelor of Science degree and preferably should be taken in conjunction with other 300-level chemistry courses.

Timetable
Refer to the online course information system or MyTimetable.
Lectures will be given in the following order:

Associate Professor Greg Russell (4 weeks) Phone 369 5129, JvH 635
Email: *greg.russell@canterbury.ac.nz*

Associate Professor Vladimir Golovko (4 weeks) Phone 369 5942, JvH 632
Email: *vladimir.golovko@canterbury.ac.nz*

Associate Professor Owen Curnow (4 weeks) Phone 369 4239, JvH 634
Email: *owen.curnow@canterbury.ac.nz*

Lectures and tutorials*:* This course has *4 teaching slots per week* for lectures and tutorials, although *lecturers may opt not to use all of these* – they will advise. On average there will be *one tutorial per week* – again, lecturers will advise when these are being held. Tutorial attendance will be monitored. Failure to attend tutorials will lead to diminished performance and may result in failure of the course.

Assignments*:* Each lecturer will set an assignment for this course. The timing and nature of each assignment will be at the discretion of each lecturer and the assignment may take a non-traditional form, e.g. an essay, a data-analysis exercise, a quiz during a tutorial, use of a computational package, and so on.

NOTE: If you do not submit an assignment for assessment you will be allotted zero marks, which will affect your final result. You should ensure that you pick up marked assignments and keep them until the end of the course as evidence that the work was completed and marked in the event that either is disputed. To guard against accidental loss, it would be prudent to keep photocopies or electronic copies of anything submitted. If you submit work electronically, please cc a copy to yourself in lieu of keeping a physical copy.

Please note that in the Faculty of Science, *students are responsible for about* ***three hours of additional study or work*** *on assignments for each hour of lectures or tutorials at the 300-level*.

Course Co-ordinator
Associate Professor Greg Russell, School of Physical and Chemical Sciences
Room JvH 635, phone 369 5129, email: *greg.russell@canterbury.ac.nz*
Email, phone or arrange to see me ***at any time*** *if you have* ***any*** *questions about the course.*

Assessment

Assignments:	25% total (8.33% for each of the three topics)
Test:	25% (Topic 1 only)
Exam:	50% (Topics 2 and 3)

Examination and Formal Tests

Test:	Will be held in week 6 of semester – precise time and date to be advised on MyTimetable; 1.5 hours in length.
Test Format:	Questions on lecture topic 1 only.
Exam:	Time and date to be advised on MyTimetable; 3 hours in length.
Exam Format:	Questions on lecture topics 2 and 3 only.

Textbook

P W Atkins & J de Paula, *Physical Chemistry* (8th or 9th edition). This text covers some of the material of this course, and should be used to supplement the lecture material prepared by each lecturer. The book also contains many helpful worked examples and tutorial problems.
Copies are available on short term loan from the Engineering and Physical Sciences Library.

Additionally, each lecturer will provide library references and information handouts.

Prerequisites

CHEM251

Web-based resources

Various learning resources (lecture material, reference links, quizzes, discussion forums etc.) for this course are available via the University of Canterbury's *Learn* web site – http://learn.canterbury.ac.nz/. This site will also be used regularly as a means of communication and information distribution for all of your Canterbury courses. **You should familiarise yourself with *Learn* as soon as possible**.

GOALS OF THE COURSE

To learn how to apply theory to real-world problems, providing both qualitative and quantitative explanations of observed properties of nano- and bulk materials.

More specifically, the goals of each component of the course are:

Polymers

- To understand the key concepts of polymer synthesis.
- To describe how material properties (of polymers) are dictated by chemical structure.
- To apply elementary aspects of chemical kinetics and thermodynamics to polymer reactions in order to explain real-world properties of the products.
- To appreciate basic principles of polymer characterization.
- To illustrate how statistical concepts may be used to describe macromolecular properties.

Materials Fabrication and Characterisation

- To introduce the concepts of materials fabrication and give examples of both classical and cutting edge materials fabrication methods.
- To examine case studies in materials fabrication and characterisation.

Liquids: Their Diversity and Their Applications

- To introduce the classes of liquids and the important properties that chemically characterise them.
- To look at how these chemical properties relate to their uses as solvents.
- To consider uses of liquids in chemical processes, in particular "green reaction media" and ionic liquids.

SUMMARY OF THE COURSE CONTENT
The topics coved by this course are:

POLYMERS **(4 weeks)**
Topics will include:

- The two major paradigms for synthesizing polymers: step- and chain-growth polymerization
- Other important polymerization chemistry: a brief survey
- The most important concepts associated with polymer molar mass: distributions and averages
- The most common methods for measuring polymer molar mass
- Number-average degree of polymerization: the Mayo and Carothers equations
- Kinetics of radical polymerization and of step-growth polymerization
- Copolymer composition and microstructure
- Application of thermodynamics: ceiling temperature
- The size and shape of polymer molecules

Lecturer: Associate Professor Greg Russell, Room JvH 635, tel. 369 5129
greg.russell@canterbury.ac.nz

MATERIALS FABRICATION AND CHARACTERIZATION **(4 weeks)**
This block of lectures will start with brief overview of the history of development of materials and the effect new materials and associated technologies on humanity. The introduction to materials block of lectures will cover materials fabrication processes starting from classical processes employed in industry, such as steel *etc*., to solid-state, solution-based and modern cutting-edge methods relying on delivery of building blocks *via* gas phase (atomic layer deposition, chemical vapour deposition, molecular beam epitaxy and pulsed laser deposition). Case studies of industrially important processes will highlight advances in control of composition and feature size (Moore's law *etc.*). Importance of characterization techniques in development of materials will be highlighted throughout this block of lectures, with in depth coverage of selected aspects of electron microscopy, scanning probe microscopy and advanced elemental analysis methods (energy-dispersive X-ray spectroscopy, electron energy loss spectroscopy, X-ray photoelectron spectroscopy and Auger electron spectroscopy). When possible, examples of NZ-relevant materials-related technologies (NZ Steel, aluminium smelting at Tiwai Point and Methanex) will be highlighted with reference to the world-wide technological progress.
Lecturer: Associate Professor Vladimir Golovko, Room JvH 632, tel. 369 5942
vladimir.golovko@canterbury.ac.nz

LIQUIDS: THEIR DIVERSITY AND THEIR APPLICATIONS **(4 weeks)**
Understanding the variety of physical and chemical properties of liquids is essential to understanding their potential impact on a system or application. This module will start with a consideration of the various classes of liquids and their properties (e.g. viscosity, conductivity, dielectric constant, donor and acceptor numbers, cohesive pressure, melting points and boiling points) that characterise them. We will then look at how these properties relate to their uses as solvents.
Many chemical processes are carried out in solution or use a liquid material, and one highly-active area of chemical innovation is the development of new generations of liquids. The second part of this module will include "Green Reaction Media" such as fluorous liquids, ionic liquids and supercritical carbon dioxide. The rest of the course will focus on ionic liquids. These have grown immensely in importance over the past two decades, from virtual obscurity to thousands of publications and hundreds of patents per year and a vast array of applications, from their uses as non-volatile and tunable solvents on multi-ton scales to uses in wood/cellulose processing, catalysis, gas separation and storage, as battery and solar cell electrolytes, for electrowinning of precious metals, as lubricants, and so on.
Lecturer: Associate Professor Owen Curnow, Room JvH 634, tel. 369 4239
owen.curnow@canterbury.ac.nz

LEARNING OUTCOMES

At the end of the polymers topic, students should be able to:

- Understand how the great variety of synthetic polymers stems from just two basic chemical paradigms, and give specific examples of each of these in operation.
- Illustrate how macromolecular complexity can arise even though the underlying chemistry is simple.
- Define the most common terms associated with molar mass distributions, and be able to derive results for these for the (so-called) most-probable distribution.
- Describe the underlying principles of the most important methods for characterizing molar mass of polymers.
- Derive the Mayo and Carothers equations for number-average degree of polymerization, and be able to use these equations to evaluate the (average) size of polymers from knowledge of polymerization conditions.

- Apply basic principles of chemical kinetics to radical and step-growth polymerizations in order to acquire an understanding of the rates of these processes.
- Know what is meant by the terms copolymer, copolymer composition, reactivity ratio and copolymer microstructure; quantitatively describe copolymer composition for chain-growth polymerization; explain how microstructure is linked to reactivity ratios.
- Describe in both physical and mathematical terms the shape adopted by polymer molecules, and understand the factors that determine spatial dimensions.
- Understand how the principles of classical thermodynamics may be equally applied to polymers, and give an example of an important result from doing this.

At the end of the materials fabrication and characterization topic, students should be able to:

- Describe the wide range of materials fabrication methods that can be applied to make materials with control over composition and structure determine molecular structure.
- Understand the key process which enable control over composition and product structure for each of the material fabrication methods.
- Give NZ-relevant examples of the use of cutting-edge fabrication of industrially-important materials.
- Develop understanding of the advantages and limitations of a wide range of materials characterization methods.
- Describe and explain appropriate approaches towards characterization of a material, suggesting approaches towards the characterization of a specific material using the most appropriate set of techniques.
- Discuss in detail electron microscopy, including its variations, advantages and limitations.
- Discuss in detail scanning probe microscopy, including its variations, advantages and limitations.
- Discuss in detail a range of advanced characterization methods capable of providing information on the elemental composition of a given sample.

At the end of the liquids topic, students should be able to:

- Explain the properties of liquids in general in terms of intermolecular forces and how this relates in particular to the properties of ionic liquids.
- Rationally classify compounds into various liquid classes.
- Predict or rationalize the liquid properties of a previously unknown compound.
- Critically evaluate new information concerning the properties of liquids.
- Explain solvation processes and how these relate to the molecular structure of the solvent and solute.
- Describe the essential differences between ionic liquids and other classes of liquids.
- Describe the essential and typical characterization techniques of an ionic liquid.
- Display knowledge of applications that utilize ionic liquids.

GENERAL INFORMATION | TE KIMI MŌHIOHIO 2024

Policy on 'Dishonest Practice'| Ngā Takahitanga me ngā Tinihanga

The University has strict guidelines regarding 'dishonest practice' and 'breach of instructions' in relation to the completion and submission of examinable material. In cases where dishonest practice is involved in tests or other work submitted for credit, a department may choose to not mark such work – see the online guidelines in relation to 'Academic Integrity'.

The School of Physical and Chemical Sciences upholds this policy. It considers plagiarism, collusion, copying and ghost writing – all detailed below – to be unacceptable and dishonest practices:

- ***Plagiarism | Tārua Whānako*** is the presentation of any material (text, data or figures, on any medium including computer files) from any other source without clear and adequate acknowledgement of the source. Note that the use of **AI generative tools such as ChatGPT** for assessment work is *strictly forbidden*, except where the lecturer concerned has specifically granted approval.
- ***Collusion*** is the presentation of work performed in whole, or in part, in conjunction with another person or persons, but submitted as if it has been completed by the named author alone. This interpretation is not intended to discourage students from having discussions about how to approach an assigned task and incorporating general ideas that come from those discussions into their own individual submissions, but acknowledgement is necessary.
- ***Copying*** is the use of material (in any medium, including computer files) produced by another person or persons with or without their knowledge and approval. **This includes copying of the lab reports (raw data may be shared within the group if permitted or required by the experiment) – data analysis and interpretation of obtained results MUST be performed individually.**

- ***Ghost writing*** is the use of other person(s) (whether with or without payment) to prepare all or part of an item of work submitted for assessment.

Special consideration of assessment | Ngā Pairuri Motuhake
'Special Consideration' for an item of assessment is for students who have covered the work involved but have been prevented from demonstrating their knowledge or skills at the time of the assessment due to unforeseen circumstances, whether illness, injury, bereavement, car crash or any other extenuating circumstance *beyond one's control*. Special Consideration for a test/exam may be because a student has not sat it or has done so with impaired performance. Applications can be submitted via the above link and must be made **no later than five working days after the assessment due date**. Note that special consideration is **not available for items worth less than 10% of the overall course mark**. In the case of illness or injury, medical consultation should normally have taken place either shortly before or within 24 hours after the due date for the required work or test/examination.

Note that you may be required to sit a special exam or your grade may not be changed if there is insufficient evidence of your performance from other invigilated assessment items in the course. ***You have the right to appeal any decision.***

It is important to understand that Special Consideration is only available *where course work has been covered*, and the inability to demonstrate this fully is both *no longer possible* AND is due to *unexpected circumstances beyond one's control*. Thus Special Consideration **is NOT available for:**

- essays, assignments or quizzes where an extension of time is available to complete the assessment item (see below for the process to involved);
- missed lectures during the semester;
- experiencing examination anxiety;
- having several examinations or assessments close together;
- known impairment, such as chronic illness (medical or psychological), injury or disability unless medical evidence confirms that the circumstances were exacerbated, despite appropriate management, at the time of assessment;
- mistaking the date or time of an examination (this is a circumstance one can control!);
- failing to turn up to an examination or test because of sleeping in (a circumstance as above!);
- where applications are repeatedly made for the same or similar reason, then the application may be declined on the grounds that the reason is not unexpected;
- where the application is made at the time of the assessment but the supporting documentation is received significantly after this date or after the date results are released; or
- the application is made following the release of results (unless under exceptional circumstances).

Extensions of deadlines | Tononga Wā Āpiti
Where an extension may be granted for an assessment item, this will be decided by application to the course co-ordinator and/or the lecturer concerned.

Late withdrawal from a course
If you are prevented by extenuating circumstances from completing the course after the final date for withdrawing from the course, you may apply for special consideration for late discontinuation. For details on special consideration, or to make an application, refer to the Examinations Office website http://www.canterbury.ac.nz/exams/. Applications must be submitted ***within five days*** of the end of the main examination period for the semester.

Missing of tests | Te Matangaro i ngā Whakamātautau
In rare cases a student will not be able to sit a test. In such cases, the student should consult with the course co-ordinator to arrange alternative procedures. **This must be done well in advance of the set date for the test.**

Past tests and exams
Past tests can be found on our Chemistry Undergraduate website. Past exams can be found on the Library website.

Submission of reports and assignments
Reports (including lab reports) and assignments should be handed in on time. Extensions will be granted only in exceptional circumstances (such as illness or bereavement). If an extension is required, as early as possible you should request it from the lecturer concerned.
Note: If you do not submit an assignment for assessment, you will be allotted zero marks, which will affect your final result. You should ensure that you pick up marked assignments and keep them until the end of the course

as evidence that the work was completed and marked in the case that either is disputed. To guard against accidental loss, it would be prudent to keep photocopies or electronic copies of anything submitted.

Late Work
Acceptance of late work for assessment will be at the discretion of the course coordinator and/or the lecturer concerned. If your assessment is likely to be late, please contact the relevant of these people ***before the assessment is due***. Never assume that an extension will be automatically granted – some courses have the policy of no late work being accepted. A commonly exercised policy is to deduct 10% of the total marks for each day that the work is late, where weekends and public holidays also count as such days.

Marks and Grades | Taumata Ako
The following numbers should be considered as a guide to the expected grades under normal circumstances.

Please note that for all invigilated assessments (tests and exams) worth 33% and above, failure to obtain a mark of at least 40% will result in a final grade no higher than an R at 100 and 200 level; in general this requirement will not be applied at 300 level, but if it is then the course coordinator will inform the class and it will result in a final grade no higher than a C–.

Grade:	**A+**	**A**	**A−**	**B+**	**B**	**B−**	**C+**	**C**	**C-**	**D**	**E**
Minimum mark %:	**90**	**85**	**80**	**75**	**70**	**65**	**60**	**55**	**50**	**40**	**0**

The School reserves the right to adjust this mark/grade conversion, up or down, to achieve consistency of assessments standards.

Reconsideration of Grades
Students should, in the first instance, speak to the course co-ordinator about their marks. If they cannot reach an agreeable solution, or have questions about their grade in a course, students should then speak to the Director of Undergraduate Studies, Assoc Prof Greg Russell. Students can appeal any decision made on their final grade. You can apply at the Registry for reconsideration of the final grade within four weeks of the date of publication of final results. Be aware that there are time limits for each step of the appeals process.

Student Accessibility Services | Te Whaikaha
Students can speak with someone at Student Accessibility Service, phone: 369 3334 (or ext. 93334), email: sas@canterbury.ac.nz).

Academic Advice
Assoc Prof Greg Russell is the coordinator of undergraduate chemistry courses. His interest is in the academic performance and well-being of all such students. Anyone experiencing problems with their chemistry courses or requiring guidance about their B.Sc. in Chemistry should get in contact with Greg.

Staff-Class Rep Liaison
Assoc Prof Greg Russell is in charge of liaison with students in chemistry courses. Your class will appoint a student representative to the liaison committee at the start of the semester. Please feel free to talk to the Academic Liaison or the student rep about any problems or concerns that you might have.

Greg Russell (greg.russell@canterbury.ac.nz, tel. 369 5129)
Director of Undergraduate Studies
School of Physical and Chemical Sciences
2024