School of Physical and Chemical Sciences

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

General Course Information

CHEM 436
Sustainable Chemistry: Catalysis, Energy and Green Materials

0.125 EFTS 15 Points
First Semester 2022

Description
Sustainable chemistry is basically doing more with less: reducing the environmental impact of products and processes, optimising or rather completely avoiding the use of limited raw materials and minimising waste. This course will introduce the importance of catalysis, energy and green materials in the context of reducing the impact that synthetic chemistry has on our planet.

This course is presented in the first semester only. It counts 15 points towards a Bachelor of Science with Honours / Masters of Science / Postgraduate Diploma of Science degree and should be taken in conjunction with other 400-level courses as advised by the postgraduate coordinator.

Timetable
Lectures: Two hours of lectures per week. Details to be confirmed on 'My Timetable' and the Web.
Tutorials: One hour every second week. Details to be confirmed on 'My Timetable' and the Web.

Students should note that in the Science Faculty that the average student is responsible for approximately 4.5 hours of additional study for each hour of lecture at 400-level.

Course Coordinator
A/Professor Vladimir Golovko, School of Physical and Chemical Sciences,
Room *Beatrice Tinsley* 427, ext 95942 email: vladimir.golovko@canterbury.ac.nz

Assessment

Assignment (1st block of lectures)	10%
Assignment (2nd block of lectures)	10%
Assignment (3rd block of lectures)	10%
End of course exam:	70%

Examination and Formal Tests
End of Semester Exam: Three hours, with questions from all lecturers.

Textbooks
Each lecturer will provide library references and information handouts as appropriate.

Prerequisites
P: CHEM335 or CHEM343 (can be waived on the case by case basis by the Director of Postgraduate Studies, Associate Professor Sarah Masters)

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.

Goal of the Course
This course will introduce or expand upon the fundamental concepts of catalysis, energy and green materials in the context of sustainable chemistry. Specifically:

Students will learn the fundamental physical chemistry and relevant aspects of nanotechnology behind existing and emerging industrial chemical, environmental remediation and selected modern fuel production technologies, and will be able to critically assess strategies for producing improved catalysts for minimisation of the environmental impact of chemical industry.

Students will learn the fundamental physical chemistry behind a selection of sustainable energy production and storage technologies, they will understand their advantages and limitations and will gain knowledge of the current challenges and future promise.

Students will gain a sound and detailed understanding of the unique properties of ionic liquids and these impact on their physical and chemical properties.

Learning Outcomes (see also detailed Learning Objectives after Course Content, below)
- Develop the ability to apply scientific principles and concepts.
- Develop problem-solving and numeracy skills.
- Understand, evaluate, access and critically review new chemical information.
- Demonstrate the ability to think independently about chemical concepts.
- Develop a more in-depth knowledge of sustainable chemistry.
- Know the concepts of catalysis, energy storage and ionic liquids.
- Know how the concepts above can be applied in the real world.
- Communicate effectively in written English and chemical diagrams.

Transferable Skill Register
As a student in this course I will develop the following skills:
- Problem solving. This is a key skill that is transferable to most careers.
- Pattern spotting and logical analysis. A key feature to applied chemistry is the ability to understand similarities between processes and use this pattern recognition to address complex issues in a logical fashion.
- Critical analysis of data. This is a key skill that is transferable to most careers
- Three-dimensional spatial awareness. The ability to think about molecules and chemical reactions in three dimensions is highly useful transferable skill.
- Science communication. A particularly important skill is being able to communicate scientific principles.

Summary of the Course Content

The topics coved by this course are:

MODERN ASPECTS OF CATALYSIS (8 LECTURES)
This section of the course will focus on building and expanding upon the foundations set in CHEM335. Lectures will cover modern advances in several classes of catalysts. Firstly, discussion of several examples of several catalytic processes relevant to New Zealand and globally will start the lectures, with highlights of recent developments for each process. Catalysts defined with atomic precision will be covered with focus on the cutting edge research and selected examples of breakthroughs. Secondly, photo- and electro-catalysts will be discussed with focus on the applications of these in renewable chemicals, energy production and pollution remediation. An invited lecture by a colleague from chemical and process engineering (if possible to arrange) will complement this course by providing an engineering perspective on the modern research and development in catalytic processes.
Lecturer: A/Professor Vladimir Golovko,
Room Beatrice Tinsley 427, ext. 95942. vladimir.golovko@canterbury.ac.nz

IONIC LIQUIDS AND THEIR APPLICATIONS (8 LECTURES)
This section of the course will focus on ionic liquids. These have grown immensely over the past two decades, from virtual obscurity to thousands of publications and hundreds of patents a year and a wide variety of applications, from their uses as non-volatile and tuneable solvents on multi-ton scales to uses in wood/cellulose processing, catalysis, gas separation and storage, as battery and solar cell electrolytes, electrowinning of precious metals, as lubricants and so on. This course will extend the fundamental properties of liquids

discussed in CHEM255 (but not rely on it) to the special properties of ionic liquids such as heterogeneity, conductivity, ionicity and ion-pair/cluster formation. A selection of topical applications will then be discussed.
Lecturer: A/Professor Owen Curnow,
Room Beatrice Tinsley 420, ext. 94239. owen.curnow@canterbury.ac.nz

MODERN ASPECTS OF ENERGY CAPTURE AND STORAGE (8 LECTURES)
This section of the course will start with an introduction covering aspects that include definition and examples of sustainable and renewable energy sources, contributions to present day energy consumption, contribution of renewables to energy generation and the New Zealand situation. The principles, application and strengths and limitations of solar photovoltaics, and energy storage technologies be discussed.
Lecturer: A/Professor Vladimir Golovko,
Room Beatrice Tinsley 427, ext. 95942. vladimir.golovko@canterbury.ac.nz

Specific Learning Objectives

Catalysis:
At the end of this lecture block you should be able to:
- Understand issues underpinning modern R&D in catalytic industrial processes
- Understand and be able to list the factors that affect performance of the catalysts and issues with respect to use of catalysts in industry
- Suggest suitable avenues of studies aimed at improving performance of the catalysts
- Know several major global catalytic processes and how these compare to other industrial processes in terms of the global energy and materials usage profiles
- Understand in detail two major catalytic processes used in NZ as well as recent developments of these catalytic processes.

Ionic Liquids and Applications:
At the end of this lecture block you 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 rationalise the liquid properties of a previously unknown compound
- Critically evaluate new information concerning the properties of ionic liquids
- Explain solvation processes and how these relate to the molecular structure of the solvent and solute

Energy Capture and Storage:
At the end of this lecture block you should be able to:
- Differentiate between sustainable and renewable energy sources and give examples, understand current patterns of energy usage and renewable energy production, both world-wide and in New Zealand
- Describe, in detail, the types, functioning and performance of solar photovoltaics based on silicon and non-traditional materials, and dye-sensitised solar calls
- Describe the science behind selected energy storage technologies, their advantages and limitations
- Communicate in-depth knowledge on a selected topic related to sustainable energy production and storage

GENERAL INFORMATION 2022

Chemistry Department Policy on 'Dishonest Practice'
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 ('Academic Integrity and Breach of Instruction Regulations').

The Department of Chemistry upholds this policy. It considers plagiarism, collusion, copying, and ghost writing to be unacceptable and dishonest practices:

- ***Plagiarism*** 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.
- ***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) (with, or without payment) to prepare all or part of an item of work submitted for assessment.

Additional Information
Special consideration of assessment*:** If you feel that illness, injury, bereavement or any other critical extenuating circumstance beyond your control has prevented you from completing an item of assessment or affected your performance in that assessment, you may apply for special consideration. Special consideration is not available for items worth less than 10% of the course. Applications for special consideration should be made **within five days** of the due date for the work or examination. In the case of illness or injury, medical consultation should normally have taken place shortly before, or within 24 hours after, the due date for the required work or the date of the test or examination. For details on special consideration, or to make an application, refer to the Examinations Office website http://www.canterbury.ac.nz/exams/. ***You have the right to appeal any decision.

Extensions of deadlines: Where an extension may be granted for an assessment item, this will be decided by application to the course co-ordinator.

Late withdrawal from the 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*:** 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.**

***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 will be at the discretion of the course coordinator. Please contact the coordinator if your assessment is likely to be late.

Marks and Grades: The following numbers should be considered as a guide to the expected grades under normal circumstances. The School reserves the right to adjust mark/grade conversions, if necessary.

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, and a C- at 300 level.

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**

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 Coordinator of 400-level studies, Dr Sarah Masters (Room 422, Beatrice Tinsley Building, phone 369 4229). 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.

Students with Disabilities: Students with disabilities should speak with someone at Equity and Disability Service, phone: 369 3334 (or ext. 93334), email: eds@canterbury.ac.nz).

***Academic Advice*:** Dr Dan Foley is the coordinator of postgraduate 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 postgraduate studies should get in contact with Dan.

Dan Foley
Coordinator of Postgraduate Studies
School of Physical and Chemical Sciences
2022