School of Physical and Chemical Sciences

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

General Course Information

CHEM 432
Organic Chemistry

0.125 EFTS 15 Points
First Semester 2023

Description
This course is about the organic chemistry at a higher level. The topics covered by this course are:

- applications of transition metal catalysis in synthesis
- pericyclic reactions, and their applications in synthesis
- carbohydrate chemistry

Timetable
Lectures: Two hours of lectures per week. Details to be confirmed on 'My Timetable' and the Web.
Tutorials: One hour of tutorials 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
Professor Antony Fairbanks, Department of Chemistry, Room West 801, ext 95217
e-mail: antony.fairbanks@canterbury.ac.nz

Assessment
Test: 33%
End of course exam: 67%

Examination and Formal Tests
Test: Ninety minutes, with questions from Topic 1 (Transition Metal Catalysis)
End of year Exam: Three hours, with questions from Topics 2 and 3 (Pericyclic Reactions and Carbohydrate Chemistry)

Textbooks
Organic Chemistry, Clayden, Greeves, Wothers and Warren, Oxford University Press, 2001 is the preferred general organic chemistry textbook for the course. Copies are available on reserve in the Engineering and Physical Sciences Library

Other more specialised textbooks that will also be useful for the course are as follows:

Carbohydrate Chemistry
B.G Davis and A.J. Fairbanks, 'Carbohydrate Chemistry' Oxford Chemistry Primer No 99, Oxford University Press, 2002, Chapters 1-7.

Prerequisites
P: CHEM337

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 aims to develop a higher-level understanding of organic chemistry as applied to more complex molecules and processes. The complex nature of modern organic synthesis routinely requires control of chemio-, regio- and stereoselectivity in reactions. This course will focus on highly selective synthetic processes, both with respect to substrate and reaction outcome.

Transition metal catalysis allows complex organic systems to be synthesised with control and economy of reagents. This part of the course will introduce you to synthesis of organic molecules using transition metal catalysed processes. Several systems will be introduced, and their broad-ranging application emphasised using relevant literature examples.

Pericyclic reactions can allow control of many aspects of selectivity in both conventional synthetic and enzyme catalysed chemistry, and an understanding of how their mechanistic detail relies on orbital symmetry illustrates their fundamental importance. This course will extend and generalise the limited number of basic pericyclic reactions that you have already encountered. Several new reactions will also be introduced, the symmetry basis for these processes will be investigated, and their broad-range of use emphasised with relevant literature examples.

Carbohydrates are the most abundant and structurally complex of the biomolecules, and play vitally important roles in a myriad of biological process. This part of the course will develop a mechanistic understanding of the synthetic organic chemistry of carbohydrates / sugars. The course will focus on selective transformations of these molecules, which contain multiple functional groups and stereogenic centers, including their linking together to form oligosaccharides.

Learning Outcomes
As a student in this course, I will develop the ability to:

- *Discuss the basic mechanisms of organometallic reactions as they pertain to organic synthesis.*
- *Understand how transition metals such as palladium are able to catalyse reactions, and apply this knowledge to literature examples of synthetic schemes.*
- *Demonstrate how reaction conditions (additives, solvent, substrate, etc) can be used to control chemio-, regio- and stereoselectivity in transition metal catalysed reactions.*
- *Discuss how transition metal complexes are able to alter the reactivity of organic systems, and how this can be applied to the synthesis of complex organic systems.*
- *Illustrate how domino reactions involving transition metals are able to be applied to organic synthesis.*
- *Be able to use the basic mechanism of cycloaddition reactions to explain their reaction chemistry, including selectivity.*
- *Be able to use both the Woodward-Hoffman rules and a frontier molecular orbital approach to rationalise cycloaddition reactions and apply this knowledge to predict and explain reaction chemistry.*
- *Be able to use both the Woodward-Hoffman rules and a frontier molecular orbital approach to rationalise other classes of pericyclic reactions and rearrangements, including sigmatropic rearrangements, electrocyclic ring opening and closing processes, and ene and cheleotropic reactions.*
- *Apply this understanding to explain pericyclic reaction processes in detail and to predict reaction products.*
- *Explain the structures of carbohydrates*
- *Develop a precise mechanistic understanding of processes that interconvert different forms of carbohydrates; hemiacetal formation, mutarotation and furanose / pyranose equilibration.*
- *Explain the Anomeric Effect and its wide-reaching importance.*

- *Discuss the range of chemical reactions that can be undergone by the hydroxyl groups of carbohydrates including; the formation of cyclic acetals, other protecting group chemistry, nucleophilic substitution reactions, oxidation and reduction reactions, rearrangement reactions.*
- *Exemplify the range of chemical reactions that can be undergone by the anomeric centre of carbohydrates including; acetal formation, Fischer glycosylation, reactions as an aldehyde, oxidation and reduction reactions, rearrangement reactions.*
- *Understand the vital importance of nucleophilic substitution at the anomeric centre and its use for the synthesis of di- and oligosaccharides.*
- *Exemplify the synthesis and use a variety of commonly used glycosyl donors including; glycosyl bromides, thioglycosides, trichloroacetimidates, pentenyl glycosides and glycals.*
- *Explain the strategies employed for oligosaccharide synthesis, including methods that can be employed to control stereochemistry of the newly formed glycosidic bond.*
- *Demonstrate the roles of glycosidase enzymes in the processing of carbohydrates in biological systems.*
- *Explain how one can synthesize glycosidase inhibitors that are used, for example, for the treatment of influenza (e.g. Relenza, Tamiflu).*

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. The key to Organic Chemistry it the ability to understand similarities between processes which allows enormous simplification / rationalisation. *This is a highly useful skill that allows the rationalisation of huge numbers of different reactions into a manageable and quite limited number of distinct processes.*
- Three-dimensional spatial awareness. The ability to think about molecules and chemical reactions in three dimensions is highly useful transferable skill.
- Presentation. A particularly important skill is being able to represent three dimensional situations in a two-dimensional format (i.e., on paper).

Summary of the Course Content

The topics coved by this course are:

TRANSISTION METAL CATALYSIS IN SYNTHESIS **(8 lectures, plus ~2/3 tutorials)**

Transition metals have allowed complex organic systems to be synthesised with control and economy of reagents. This course will introduce students to synthesis of organic molecules using transition metals. Several systems will be introduced, and their broad-ranging applications emphasised using relevant literature examples.

Lecturer: Dr Daniel Foley, BT 323, ext 90479, daniel.foley@canterbury.ac.nz

PERICYCLIC REACTIONS **(8 lectures, plus ~2/3 tutorials)**

Pericyclic reactions can allow control of many aspects of selectivity in both conventional synthetic and enzyme catalysed chemistry, and an understanding of how their mechanistic detail relies on orbital symmetry considerations and illustrates their fundamental importance. This course will extend and generalise the pericyclic reactions that you have already encountered. Several new reactions will also be introduced, and their broad-range of use emphasised with relevant literature examples.

Lecturer: Associate Professor Chris Fitchett, Room BT 424/West818, ext 95344
chris.fitchett@canterbury.ac.nz

CARBOHYDRATE CHEMISTRY **(8 lectures, plus ~2/3 tutorials)**

Sugars/carbohydrates, the most structurally diverse of the biomolecules, and play extremely importance roles throughout biology. Their structural complexity – including multiple hydroxyl groups at stereogenic centres and a carbonyl group – makes their chemistry appear complicated. This part of the course will demystify the synthetic organic chemistry of sugars, and allow you to develop a precise mechanistic understanding of their reactivity and chemical transformations. The course will also cover strategies that may be used to link sugars

together to make oligosaccharides, focusing on important considerations of regio- and stereochemical control. The course will also briefly consider how Chemists can make mimics of carbohydrates to interfere with undesirable processes, which can for example be used as treatments for diseases (e.g. the anti-influenza drugs Tamiflu and Relenza).

Lecturer: Professor Antony Fairbanks, Room West 801, ext 95217,
antony.fairbanks@canterbury.ac.nz

GENERAL INFORMATION | TE KIMI MŌHIOHIO 2023

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' (previously termed 'Aegrotat Application') 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. The School reserves the right to adjust mark/grade conversions, if necessary.

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, Professor Sarah Masters (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*:** Professor Sarah Masters is the coordinator of 400-level chemistry courses. Her 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 400-level courses should get in contact with Sarah.

Sarah Masters
Coordinator of 400-level Chemistry Courses
School of Physical and Chemical Sciences
February 2023