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 2022

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

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

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 (Carbohydrates)
End of year Exam: Three hours, with questions from Topics 2 and 3 (Pericyclic Reactions and Transition Metal Catalysis)

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 or CHEM322 or CHEM362

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.

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.

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.

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.

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

- *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).*
- *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.*
- *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.*

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:

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

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

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

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: It is the policy for this course that late work is not accepted.

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
February 2022