Accessibility statement

Catalysis with Green Technologies - CHE00032H

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- **Department**: Chemistry
- **Module co-ordinator**: Dr. Duncan MacQuarrie
- **Credit value**: 20 credits
- **Credit level**: H
- **Academic year of delivery**: 2020-21
  - See module specification for other years: 2019-20

Module summary

This module is concerned with understanding the importance of catalysis and also how this can be used as a tool for green chemistry. The module begins with introductory lectures on catalysis and green technologies, illustrating the very wide range of interesting and important applications of catalysis. Heterogeneous catalysis is of considerable importance to the chemical industry and combines surface chemistry and the study of important organic and inorganic solid catalysts including the rapidly growing area of shape-selective catalysis. Homogeneous catalysis is also an extremely important subject both in synthesis and industrial chemistry and this subject will be covered in a series of lectures on important metal-catalysed processes. The important and growing areas of catalysis such as enzymatic and asymmetric catalysis will be explored for a range of important chemical reactions. Case studies based on important catalytic processes will be used throughout the module and lectures will be supported by workshops. Hot topics will round off the module with the latest research and challenges in the area

Module will run

Occurrence	Teaching cycle
A	Autumn Term 2020-21

Module aims

This module is concerned with understanding the importance of catalysis and also how this can be used as a tool for green chemistry. The module begins with introductory lectures on catalysis and green technologies, illustrating the very wide range of interesting and important applications of catalysis. Heterogeneous catalysis is of considerable importance to the chemical industry and this subject is discussed by a consideration of surface chemistry, modern techniques for studying surfaces and by the study of important organic and inorganic solid catalysts including the rapidly growing area of shape-selective catalysis. Homogeneous catalysis is also an extremely important subject both in synthesis and industrial chemistry and this subject will be covered in a series of lectures on important metal-catalysed processes. The important and growing areas of catalysis such as enzymatic and asymmetric catalysis will be explored for a range of important chemical reactions. Case studies based on important catalytic processes will be used throughout the module and lectures will be supported by workshops.

Module aims:

- Develop in-depth knowledge of catalytic processes and their relevance to industry
- Train students on the use and application of heterogeneous, homogeneous, asymmetric and enzymatic catalysts
- Develop an understanding of how sustainable catalytic processes are relevant to green chemistry

Module learning outcomes

Subject content

- To understand the importance of catalysis and it application in green chemistry
- To understand how catalysis can occur heterogeneously and homogeneously
- To understand the importance and mechanism of enzymatic and asymmetric catalysis
- To study the use of a range of catalytic processes with the aim of reducing the environmental impact of chemical manufacture
- To study applications of catalysts especially in environmental related areas

Academic and graduate skills

- Develop in-depth knowledge of catalytic processes and their relevance to industry
- Train students on the use and application of heterogeneous, homogeneous, asymmetric and enzymatic catalysts
- Develop an understanding of how sustainable catalytic processes are relevant to green chemistry
- Develop aspects of teamwork and transferable skills in students

Module content

General overview of catalysis (DJM, 2 lectures)

Brief revision of Catalysis including aspects of acid-base catalysis, homogeneous and heterogeneous catalysis. This will provide an introduction to the module and set the scene for detailed discussions throughout the course.

Catalysis for green chemistry (20 lecture equivalents, 2x1h workshops)

Heterogeneous Catalysis (DJM, 5 Lectures)

Chemistry at catalyst surfaces.

Techniques for studying catalysts and catalytic processes.

Zeolites and other porous solids Shape selective catalysis.

Homogeneous Catalysis by Transition Metal Compounds (SBD, 5 lectures)

Important metal-catalysed processes.

Mechanistic aspects of Homogeneous Catalysis by Transition Metal.

Asymmetric catalysis (MN, 5 lectures)

Requirements for asymmetric catalysis and commercial examples.

Survey of important metal catalysed asymmetric reactions.

Asymmetric organocatalysis.

Enzymatic catalysis (GJG, 5 lectures)

Biocatalysis for applications in organic chemistry/pharmaceutical industry.

This will include aspects on general Introduction to enzymatic catalysis, hydrolytic reactions, reductions, oxygenations and carbon-carbon bond formation.

The above lecture courses will be covered by 2 cross course workshops

Sustainable catalysis topics (10 lecture equivalents)

Sustainable catalysis and polymers (GAH, 5 lectures)

Replacing scarce metals with Earth crust abundant ones.

Catalyst recycling (catalytic converters).

Phytomining for catalysts.

Catalysis for polymerisation.

Green catalytic technologies (TJF, 5 lectures)

Catalysis for biomass valorisation.

Combining catalysis with green chemical technologies.

Assessed workshop on "Sustainable catalysis topics" (TJF/GAH, 1x3h workshop)

Hot topics (3 lectures showcasing cutting edge research and challenges in catalysis and Green Technologies, MN, IJSF, DJM)

Assessment

Task	Length	% of module mark
24 hour open exam Catalysis with Green Technologies	N/A	80
Essay/coursework Assessed workshop	N/A	20

Special assessment rules

None

Additional assessment information

The exam will be a 2 hour exam with two compulsory 25 mark questions. This is weighted at 80% of the total module marks. the remaining 20% of the marks come from an assessed workshop, with the deadline for work submission two weeks after the assessed workshop.

Reassessment

Task	Length	% of module mark
24 hour open exam Catalysis with Green Technologies	N/A	80
Essay/coursework Assessed workshop	N/A	20

Module feedback

Closed exam results with per-question breakdown are returned to the students via supervisors within 5 weeks (as per special approval by the University Teaching Committee). Outline answers are made available via the Chemistry web pages when the students receive their marks, so that they can assess their own detailed progress/achievement. The examiners' reports for each question are made available to the students via the Chemistry web pages

Students will receive feedback on their performance in the workshop assessment. They will receive verbal feedback on their progress in the formative workshops, which support lectures.

Indicative reading

Catalytic chemistry B C Gates, Wiley 1992

Handbook of Green Chemistry and Technology, eds. J H Clark, D J Macquarrie Blackwell 2002

Element Recovery and Sustainability ed A J Hunt, RSC 2013

Catalysis without precious metals, ed. R M bullock, wiley 2010

Green Chemistry and Catalysis, eds RA Sheldon, I Arends, U Hanefeld, Wiley-VCH 2007

Fundamentals of Asymmetric Catalysis, P J Walsh, M C Kozlowski, University Science books 2009

Biotransformations in Organic Chemistry K Faber, Springer 2018