GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Heterogeneous Catalysis (COO4151)

Course size *(nominal values; actual values may depend on programme)*

Credits 4.0 **Study time 120 h**

Course offerings and teaching methods in academic year 2024-2025

A (semester 2)	English	Gent	lecture
			seminar

Lecturers in academic year 2024-2025

Van Der Voort, Pascal	WE06	lecturer-in-charge

Offered in the following programmes in 2024-2025	crdts	offering
Master of Science in Teaching in Science and Technology(main subject Chemistry)	4	A
Master of Science in Chemistry(main subject Materials and Nano Chemistry)	4	A
Master of Science in Bioscience Engineering: Chemistry and Bioprocess Technology	4	A
Exchange Programme in Chemistry (master's level)	4	A

Teaching languages

English

Keywords

Heterogeneous Catalysis, photocatalysis, electrocatalysis, adsorption, kinetics, diffusion, surface, catalytic cycle, industrial applications, kinetics.

Position of the course

This is an basis course in heterogeneous Catalysis that can be followed by any student in the first or second year master. The course can be followed independent from other courses in the master. Sutdents who wish a further in depth understanding of the materials in the course heterogeneous catalysis can also follow 'nanomaterials chemistry'. Homogeneous catalysis is studied in a separate course 'organometallics and homogeneous catalysis' The course 'industrial chemistry' in the third bachelor has already discussed some industrial processes in which heterogeneous catalysts are used, however without discussing the catalysts and the catalytic cycles in any depth or detail. The course heterogeneous catalysis has its own focus and is intended for students in the masters of sciences, it attempts to build bridges to the chemical engineers.
The bio-engineering students can also take the course. Specifically for them, 2 separate sessions will be built in around FTIR spectroscopy and nitrogen adsorption for the determination of specific surface area and pore size distributions. The bio-engineering students will not attend the session on chemical reactors as they have already covered this
Next to the "classical" heterogeneous catalysis, with an in depth study of the kinetics and the diffusion phenomena in heterogeneous catalysis, also photocatalysis and electrocatalysis will be discussed. These techniques are emerging as sustainable processes. We also pay attention to the typical characterization methods in heterogeneous catalysis.
This course is taught yearly.
The theory courses are complemented by theoretical exercises to furhter practice the concepts by solving typical problems.

Contents

Chapter 1. Introduction and definitions.
- Introduction.
- Types of catalysis.

- Towards Green and Sustainable Industrial Chemistry.
- Atom efficiency, E factors and environmental friendliness.
- Definitions and units.

Chapter 2. Kinetics and Diffusion.

- The 5 steps determining the kinetics of a heterogeneous reaction.
- Langmuir model of adsorption/desorption of 1 component
- Multiple adsorbents and dissociative adsorption.
- Kinetics of Surface Catalyzed Reactions.
- Monomolecular surface reactions.
- Langmuir – Hinshelwood kinetics (bimolecular reactions)
- The LHHW model with examples
- The Eley - Rideal Mechanism
- Diffusion Phenomena
- Thiele Modulus
- Effectiveness factor.
- Weisz Prater criterion.

Chapter 3 Photo- en Electrocatalysis

- Principles of Photocatalysis
- Principle of Electrocatalysis
- Examples

Chapter 4 - Catalyst Characterization

- XPS
- TPD - acid/base titration
- TPO/TPR - active metal sites
- FTIR / Raman / XRD / XRF

Chapter 5 - Chemical Reactors (chemistry students)

- Convervation of mass - mass balance
- Batch Reactors - Ideal reactor
- Continuous Stirred Tank Reactor
- Flow Reactor
- Fixed Bed Reactor
- Fluidized Bed Reactor

Chapter 5 - FTIR, BET and BJH (bio-ir students)

- Fourier Transform Infrared, Michelson interferometer
- Jacquinot, Connes and Felgett advantages
- FTIR-DRIFTS, ATR
- BET equation
- BJH pore size distrubutions
- Excell exercise

Chapter 6 - Examples of Recent Catalysis

- Guest lectures, varying every year

Initial competences

Bachelor degree in chemistry

Final competences

1 Student is able to discuss with chemical engineers on reactors, mass transport, mass balance, heterogeneous reaction kinetics, surface processes, diffusion.
2 Student is able to solve questions/exercises on reaction kinetics, reactors and diffusion.
3 Student is able to interprete journal papers about heterogenous catalysis and to understand the spectra / characterizations shown.
4 Student is aware of societal challenges and the solutions that can be created by heterogeneous catalysis and green chemistry.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Seminar, Lecture

Extra information on the teaching methods

Lectures, practical exercices, guest speakers

Study material

Type: Handbook

Name: Pascal Van Der Voort, Els De Canck and Karen Leus, “An introduction to Porous Materials”, Inorganic Chemistry Series, Wiley, New York, London, 2019. (448 p.)'
Indicative price: € 100
Optional: no
Additional information: ISBN: Hardback: 978-1-119-42660-8; ePDF: 978-1-119-42658-5; epub: 978-1-119-42670-7 (same book also for courses for NanoMaterials Chemistry and partly for Materials Chemistry)

References

Several English handbooks on heterogeneous catalysis are available in the departments library.

Course content-related study coaching

- Interactive support by means of Ufora.
- Possibility for questions and discussions after every lecture or seminar.
- Private discussions with lecturer(s) upon request.

Assessment moments

end-of-term assessment

Examination methods in case of periodic assessment during the first examination period

Written assessment with open-ended questions

Examination methods in case of periodic assessment during the second examination period

Written assessment with open-ended questions

Examination methods in case of permanent assessment

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible

Extra information on the examination methods

The focus of the exam is on the problems that have been solved in the theoretical exercises (kinetics, LHHW, diffusion, reactors, characterization), together with some theory questions.

Calculation of the examination mark

Periodic: 100%