ChE-407

Electrochemical engineering

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Cursus	Sem.	Type
Energy Science and Technology	MA1, MA3	Obl.
Energy minor	H	Opt.
Ing.-chim.	MA1, MA3	Obl.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Courses	2 weekly
Exercises	1 weekly
Number of positions	

Summary

This course builds upon the underlying theory in thermodynamics, reaction kinetics, and transport and applies these methods to electrosynthesis, fuel cell, and battery applications. Special focus is placed on addressing current challenges in state-of-the-art energy storage and conversion devices.

Content

Thermodynamics:

- Spontaneous vs. non-spontaneous reactions for different fuels.
- Maximum and minumum voltages for galvanic and electrolytic devices.
- Variation of device efficiency with temperature and pressure.
- Comparison of electrochemical vs. Carnot efficiency.

Kinetics:

- Derivation of Butler-Volmer model with and without transport limitations.
- Tafel plot derivation and analysis.
- Derivation and application of charge transfer theory.

Transport:

- Diffusion, migration, and convection of electroactive species in different systems.

At the end of the course, students are expected to provide an in-depth analysis of electrochemical device operation and critical analysis of the literature.

Keywords

Butler-Volmer model; Marcus model; Gerischer theory; rotating disk electrode; fuel cells; water-splitting (artificial photosynthesis); electrosynthesis; rechargeable battery

Learning Prerequisites

Required courses

chemical thermodynamics (CH-241 or similar), transport phenomena (ChE-301 or similar), chemical kinetics (CH-342 or similar)

Learning Outcomes

By the end of the course, the student must be able to:
- Differentiate between galvanic and electrolytic reactions.
- Work out / Determine limiting electrochemical thermodynamic efficiency and voltage of a device.
- Derive key kinetic models used to characterize electrochemical devices.
- Identify limiting bottleneck(s) of a technology based on its current-potential behavior.
- Compare activation, concentration, and ohmic overpotential losses of a device.
- Propose approaches to improving device performance.
- Design electrodes and operating conditions with favorable performance for specific applications.
- Critique performance of new electrochemical technologies.

Transversal skills

- Make an oral presentation.
- Summarize an article or a technical report.
- Access and evaluate appropriate sources of information.
- Communicate effectively with professionals from other disciplines.
- Demonstrate the capacity for critical thinking
- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.
- Give feedback (critique) in an appropriate fashion.
- Evaluate one's own performance in the team, receive and respond appropriately to feedback.

Expected student activities

Specific activities include:
- Completion of exercises before each exercise session.
- Participation in in-class exercises and discussions.
- Completion of feedback forms for student presentations..

Assessment methods

Mid-term Exam: 30%
Final Exam: 50%
Group Project: 15%
Participation: 5%

Exercises are assigned on a weekly basis. Exercises are not graded, though they form the basis of the exams. Group projects are graded based on a team presentation given towards the end of the term. Students are expected to participate in exercise problems and discussion during lecture, as well as discussions during student presentations.