

ChE-407

Electrochemical engineering

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Cursus	Sem.	Type
Energy minor	H	Opt.
Ing.-chim.	MA1, MA3	Opt.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	During the semester
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 minimum 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 Marcus charge transfer theory.

Transport:

- Modeling diffusion, migration, and convection of electroactive species.
- Application of Navier-Stokes equation for modeling rotating disc electrode (RDE).

At the end of the course, students are expected to provide an in-depth analysis of electrochemical device operation, including a thermodynamic assessment of efficiencies as well as quantitative characterization of kinetic and transport limitations.

Keywords

Butler-Volmer model; Marcus model; 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

Final Exam: 60%

Project: 40%

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 discussions during lectures, as well as discussions during student presentations.

Supervision

Assistants Yes

Resources

Moodle Link

- <http://moodle.epfl.ch/enrol/index.php?id=14984>