ESENG 505/ChE 696: Energy Generation & Storage Using Modern Materials

Instructors: Prof. Suljo Linic, TBD
GSI: TBD
Lecture: TBD

Course objectives/outcomes

At the end of this course, you should be able to:
- demonstrate fundamental knowledge about various electrochemical energy systems
- apply charge, energy, and material balances in the analysis of energy systems
- describe interfacial absorption, double-layer, insertion, and kinetic phenomena
- analyze processes that lead to internal resistance in electrochemical devices
- analyze experimental energy-system diagnostic and characterization data

Office hours

TBD.

Course work

Problem sheets will account for 40% of the course grade. There will be a total of 4 problem sheets, which will be physically collected at the beginning of the class period (or communicated via e-mail before that time).

Course projects will account for 20% of the course grade. The class will be broken into groups of 4 or 5 students (the exact number being determined by the final enrollment). Each group will write a short (10-page) paper about a particular electrochemical energy generation or storage system. Class periods will be dedicated to oral presentations, wherein each group will provide a 10-20 minute discussion (the exact duration will also be adjusted when the number of groups is determined). Project topics will be selected from a list provided to the class, at which time group selections will also be made.

The final examination will account for 40% of the course grade. It will take the form of an in-class written test.

Tentative course outline (by week)

Week 1) Electrochemical energy systems overview

Energy consumption trends; alternative energy options
Operating principles for electrochemical systems
Electrochemistry review
Device terminology

Week 2) Electricity and magnetism/circuits

Capacitance and resistance; impedance
Equivalent-circuit models of electrochemical systems

Week 3) Electrochemical thermodynamics

Fundamentals (electrochemical potentials; Nernst equations; colligative properties)
Applications (redox reaction thermodynamics, corrosion; open-circuit potentials)

Week 4) Transport 1. Response of electrolyte solutions at constant voltage

Ohmic drops, diffusion potentials
Identification of limiting currents
Transient concentration profiles in button-cell separators
Cottrell equation

Week 5) Interfacial processes and kinetics 1

Double layers
Surface overpotential (Butler-Volmer kinetics)

Week 6) Interfacial processes and kinetics 2

Multistep reactions
Surface reactions (reactions involving adsorption steps)

Week 7) Transport 2. Response of electrochemical cells at constant potential

Week 8) Experimental characterization methods

Materials characterization
Linear-sweep voltammetry (Koutecky-Levich theory)
Cyclic voltammetry (Randles-Sevcik theory)
Impedance spectroscopy

Week 9) Porous electrodes

Week 10) Fuel Cells

Week 11) Batteries and supercapacitors

Weeks 12/13) Course project presentations

Final examination **TBD**