MSE 466, Spring 2024

Electrochemical Energy Conversion

Time: M/W/F, 11:00–11:50 am

Location: 204 Transportation Building

Website: Canvas

Instructor: Prof. Yingjie Zhang, yjz@illinois.edu, 256 MRL

Office hour: Wednesday 10–10:50 am (256 MRL)

Credit: 3 undergraduate or graduate hours

Course description: Fundamental mechanism, materials, and device design of electrochemical energy conversion systems such as batteries, fuel cells, electrolyzers, and supercapacitors. Emphasis is placed on the thermodynamics and kinetics of electrode processes, as well as design principles and materials specific issues for renewable energy. This course is intended for both undergraduate and graduate students.

Learning objectives: students will be able to

(a) explain the fundamental thermodynamic and kinetic principles of electrode processes;

(b) connect the fundamental electrochemical principles to real-world renewable energy applications;

(c) critically review scientific literature on electrochemical energy conversion systems.

Prerequisite: MSE 304 or any other courses that introduce the electronic structure of materials.

Textbook:

Allen J. Bard and Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition, Wiley & Sons, 2001. (ebook uploaded to Canvas – for this course only, avoid distribution outside this course)

Course Topics:

This course will integrate two aspects of electrochemistry. The first part is the basic electrochemical principles. The second will be electrochemical systems for renewable energy. The two will be integrated wherever appropriate.

1. Fundamentals of Electrochemistry

Basics of electrochemical cells; redox processes
Nonfaradaic processes
Electrode reaction processes; electrodeposition

Mass transfer
Thermodynamics of electrochemical cells
Electrochemical potential
Kinetics of electrochemical reactions
Electrocatalysis; Sabatier principle
Kinetics of water splitting reactions
Marcus theory of charge transfer

2. Electrochemical Energy Conversion Systems

Zinc-copper battery
Supercapacitors
Lithium-ion batteries
Redox flow batteries
Design of electrocatalysts
Water electrolyzers
Fuel cells
CO_2 electroreduction to chemicals and fuels

Grading:

Homework assignments	40%
Literature review	20%
Final exam (take home)	40%
Bonus points from in-class quizzes	up to 5%

Late policy:

Homework, literature review slides, and completed final exams turned in within 24 hours after the deadline will be given 50% score. After 24 hours past the deadline, 0% score will be given.

Policy on conflicts or emergencies:

(1) For time conflicts with other events (e.g. another scheduled exam), or an official UIUC activity (e.g. varsity athletics, band concert), please show official documentation about the conflict at least **one week** before the homework/report/exam due date. The due date will be extended if the excuses are legitimate.

(2) If you will not be able to make it to the exam or submit HW on time due to serious illness or other emergent personal crisis (e.g. car accident) that are not described in (1), you must send an email to the instructor (yjz@illinois.edu) at your earliest convenience, and submit a statement from the professionals that are authorized to evaluate your situation (e.g. doctors, police officers). The statement needs to clearly explain that you are not physically capable of submitting the HW/report/exam on time. The due date will be extended if the excuses are legitimate.