CHE 4275 – ELECTROCHEMICAL ENGINEERING  
SPRING 2020  
LOUISIANA STATE UNIVERSITY

Instructor:  
Assistant Professor Christopher G. Arges  
Room 3315S – Patrick F. Taylor Hall (PFT)  
Phone #: 225-578-3060  
E-mail: carges@lsu.edu  
Office Hours: 1:00 to 1:50 PM Friday or by appointment

Class:  
1253 Patrick F. Taylor Hall (PFT)  
1:30 PM to 2:50 PM Monday and Wednesday

Course Objectives:  
Develop a strong foundation in understanding, analyzing, and communicating electrochemical phenomena and applying electrochemical engineering principles.  
Note: This is a communication-intensive (CI) course

Prerequisites:  
ChE 3102 (Heat and Mass Transfer) or consent by the instructor

On-line:  
Additional class materials will be posted on Moodle

Textbook:  

Supplemental Texts:  

Grading:  
Homework: 0% - for your own practice  
Paper analysis: 15% - Individual assignment. Analysis, in the context of electrochemical phenomena, of a peer-reviewed publication.  
Experimental Project: 25% - Group assignment. Grade will be 50% on report and 50% on oral presentation (20 minutes). Groups of 3 people. Experimental project will occur in Professor Arges’ lab.  
Exams: 60% (2 exams) – One Midterm Exam and one Final Exam. The highest score will count 45% and the lower score will count 15%. 
Project/paper due dates:

- Analysis of paper: Wednesday, February 26th, 2020 at the start of class
- Oral presentations: Monday and Wednesday, April 13th and 15th, 2020
- Experimental report: Monday, April 27th, 2020 at the start of class

Exam schedule:

- Midterm: Monday, March 2nd, 2020 in class
- Final Exam: Friday, May 8th, 2020 at 10:00 AM to 12:00 PM

Exam format:

- Closed book, equation sheet provided, calculator allowed. Phones and computers are prohibited during exam.

Course policies:

- Homework will not be graded and credit will not be given. The intent of the Homework is to help you learn the material so you can do well on the exam. I encourage you to work together on the homework.

Students are expected to take each examination on the pre-arranged dates. Excused absences from exams will follow LSU Policy Statement 22 (PS-22).

Students with Accommodation Letter: Submit your letter in person to me during office hours or at a scheduled appointment. I will not take the letter after class.

Regrade requests for exams, presentation, and reports must be made in writing. Please specify which part that you want regraded and please justify your request. The regrades will be due at the start of the next class period after returning exams or reports. Late regrade requests will not be accepted. You can earn or lose points from a regrade request.

Violation of academic integrity will be immediately reported to Student Advocacy and Accountability (SAA). I will recommend to SAA that the student fail the course for any integrity violation.

This is a certified Communication-Intensive (C-I) course which meets all of the requirements set forth by LSU’s Communication across the Curriculum program, including:

- Instruction and assignments emphasizing informal and formal [mode 1] and [mode 2];
- Teaching of discipline-specific communication techniques;
- Use of feedback loops for learning;
- 40% of the course grade rooted in communication-based work; and
- Practice of ethical and professional work standards
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<th>Topics</th>
<th>Reading materials</th>
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<tr>
<td><strong>Part 1: Introduction to Electrochemical Engineering</strong></td>
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<td>Historical perspective and industrial applications</td>
<td>Newman – Chapter 1 and supplemental readings</td>
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<td>The chemical engineering connection: definitions, thermodynamics, kinetics, and transport; introduction to electrochemical cell overpotentials; Faraday’s law of electrolysis, conservation of charge/electroneutrality</td>
<td>Newman – Chapter 1 and supplemental readings</td>
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<td><strong>Part 2: Thermodynamics of Electrochemical Systems</strong></td>
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<td>Thermodynamics in terms of electrochemical potential, phase equilibrium, equilibrium potential</td>
<td>Newman – Chapter 2 and supplemental readings</td>
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<td>Electric potential</td>
<td>Newman – Chapter 3 and supplemental readings</td>
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<td>Electrochemical double layer</td>
<td>Newman – Chapter 7 and Supplemental readings</td>
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<td>Pourbaix Diagrams</td>
<td>Supplemental readings</td>
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<td>Determining activity coefficients</td>
<td>Newman – Chapter 4 and supplemental readings</td>
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<td>Reference electrodes</td>
<td>Newman – Chapter 5 and supplemental readings</td>
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<td>Potentials of cells with junctions; Nernst potential</td>
<td>Newman – Chapter 6 and supplemental readings</td>
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<td><strong>Part 3: Reaction Kinetics in Electrochemical Systems</strong></td>
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<td>Electrode kinetics: Butler-Volmer kinetics, Tafel slope, activation/surface overpotentials; exchange current density</td>
<td>Newman – Chapter 8 and supplemental readings</td>
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<td><strong>Part 4: Transport Phenomena in Electrochemical Systems</strong></td>
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<td>Transport in infinitely/moderately dilute solutions: electric field driven migration, conductivity, diffuse potentials, transference number, ionic mobility and diffusion coefficients, introduction to limiting current densities</td>
<td>Newman – Chapter 11 and supplemental readings</td>
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<td>Transport in concentrated solutions: reference velocities and multi-component species transport</td>
<td>Newman – Chapter 12 and supplemental readings</td>
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<td>Thermal transfer in electrochemical systems: thermal galvanic cells</td>
<td>Newman – Chapter 13 and supplemental readings</td>
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<td>Convective-transport problems and fluid mechanics in electrochemical systems, electrokinetic phenomena, and electrocapillary phenomena; streaming potential, fluid flow in a rotating disk and an annulus,</td>
<td>Newman – Chapters 9, 10, 15, 17 and supplemental readings</td>
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### Part 5: Current Distribution in Electrochemical Systems

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<th>Application of potential theory</th>
<th>Newman – Chapter 18 and supplemental readings</th>
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<td>Effect of migration on limiting currents and currents below the limiting current density</td>
<td>Newman – Chapters 19, 21 and supplemental readings</td>
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<td>Concentration overpotential</td>
<td>Newman – Chapter 20 and supplemental readings</td>
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<tr>
<td>Porous electrodes</td>
<td>Newman – Chapter 22 and supplemental readings</td>
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### Part 6: Industrial Applications

- **Electroplating**
- **Corrosion**
- **Semiconductor applications:** semiconductor electrodes, electroplating, chemical mechanical polishing, nanoionics (non-volatile memory)
- **Electrosynthesis of chemicals:** chloro-alkali process, water electrolysis, carbon dioxide electrolysis, photoelectrochemical cells, ammonia synthesis
- **Energy storage and conversion:** fuel cells, batteries, supercapacitors, reverse electrodialysis, thermalgalvanics
- **Electrochemical separations:** electrodialysis, electrodeionization, capacitive deionization, electro-swing adsorption
- **Sensors:** gas detectors, biologics
- **Bio-electrochemical systems:** microbial fuel cells, microbial desalination, etc.

You will select a paper for your analysis on one of these topics. We will cover (maybe not all) these topics in class. Readings to be assigned later on.

### Part 7: Introduction to electroanalytical methods

- **Voltammetry**
- **Chronoamperometry**
- **Electrochemical impedance spectroscopy** and electric circuit equivalent modeling

Note: This part is not the intent of this course. LSU offers a course dedicated to this topic: Chem 4559. We will briefly cover this topic in real-time as necessary to help explain other topics.

See Bard and Faulkner Textbook