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:	*Electrochemical Systems, 3rd Edition*, John Newman and Karen E. Thomas-Alyea, Wiley, ISBN: 978-0-471-47756-3, (2004)
Supplemental Texts:	*Electrochemical Methods: Fundamentals and Applications, 2nd Edition*, Allen J. Bard and Larry R. Faulkner, Wiley, ISBN: 978-0-471-04372-0, (2000)

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

Topics	Reading materials
Part 1: Introduction to Electrochemical Engineering	
Historical perspective and industrial applications	Newman – Chapter 1 and supplemental readings
The chemical engineering connection: definitions, thermodynamics, kinetics, and transport; introduction to electrochemical cell overpotentials; Faraday's law of electrolysis, conservation of charge/electroneutrality	Newman – Chapter 1 and supplemental readings
Part 2: Thermodynamics of Electrochemical Systems	
Thermodynamics in terms of electrochemical potential, phase equilibrium, equilibrium potential	Newman – Chapter 2 and supplemental readings
Electric potential	Newman – Chapter 3 and supplemental readings
Electrochemical double layer	Newman – Chapter 7 and Supplemental readings
Pourbaix Diagrams	Supplemental readings
Determining activity coefficients	Newman – Chapter 4 and supplemental readings
Reference electrodes	Newman – Chapter 5 and supplemental readings
Potentials of cells with junctions; Nernst potential	Newman – Chapter 6 and supplemental readings
Part 3: Reaction Kinetics in Electrochemical Systems	
Electrode kinetics: Butler-Volmer kinetics, Tafel slope, activation/surface overpotentials; exchange current density	Newman – Chapter 8 and supplemental readings
Part 4: Transport Phenomena in Electrochemical Systems	
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	Newman – Chapter 11 and supplemental readings
Transport in concentrated solutions: reference velocities and multi-component species transport	Newman – Chapter 12 and supplemental readings
Thermal transfer in electrochemical systems: thermal galvanic cells	Newman – Chapter 13 and supplemental readings
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,	Newman – Chapters 9, 10,15, 17 and supplemental readings

Part 5: Current Distribution in Electrochemical Systems	
Application of potential theory	Newman – Chapter 18 and supplemental readings
Effect of migration on limiting currents and currents below the limiting current density	Newman – Chapters 19, 21 and supplemental readings
Concentration overpotential	Newman – Chapter 20 and supplemental readings
Porous electrodes	Newman – Chapter 22 and supplemental readings
Part 6: Industrial Applications	
Electroplating	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.
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.	
Part 7: Introduction to electroanalytical methods	
Voltammetry	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
Chronoamperometry	
Electrochemical impedance spectroscopy and electric circuit equivalent modeling	