

CHEE 363 – ELECTROCHEMICAL ENGINEERING

Course Syllabus – Winter 2021

This is your course syllabus. Please download the file and keep it for future reference.

TEACHING TEAM

COURSE INSTRUCTOR

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Office hours: By appointment



Please check the course website for an up-to-date list of TAs and other course personnel.

CHEE 363 (F 3-0-0.5 3.5)

COURSE DESCRIPTION

This engineering science course covers aspects of technological applications of electrochemistry. It can be considered as overlap between electrical engineering, electrochemistry and chemical engineering. The course addresses the following 6 major topics of electrochemical engineering: 1) Introduction to Electrochemical Engineering: Electrostatics, Electrodynamics, Electrical Circuit Theory, Faradays Law; 2) Elements of Electrochemical Systems I Electrolyte: Transport processes, electrolyte conductivity, pH and buffer solutions; 3) Elements of Electrochemical Systems II Electrodes: Electrochemical Thermodynamics, Nernst Equation, Reference Electrodes, Cell Potential (Electromotive Force), Electrode Kinetics 4) Electrical Double Layers: Theory & Models, Electrokinetic Phenomena; 5) Electrochemical Energy Engineering: Batteries, Fuel Cells, Electrical & Electrochemical Capacitors; 6) Industrial Electrochemical Processes: Fundamentals, Reactor Design & Parameter, Chlor-Alkali Process, Electrochemical Extraction of Metals, Hall Heroult Process.

(0/0/0/30/12)

PRE-REQUISITE KNOWLEDGE

CHEE 210, CHEE 270, CHEE 321, or permission of the department.

COURSE LEARNING OUTCOMES (CLO)

The objective of this course is to acquire fundamental knowledge of electrochemistry/ electrochemical engineering including electrokinetic phenomena. The knowledge is applied to understand general methodologies for analysis and design of electrochemical systems.

After successfully completing this course you should be able to:

CLO	DESCRIPTION	INDICATOR
CLO 1	Define and explain the concepts of Electrical Potential, Electrical Field, Electrostatic Work, Voltage, Current, Electrochemical Potential, Activation Energy, Electrode & Electrochemical Equilibrium.	KB-ES (Applied Chemistry (a)) KB-ES (Applied Chemistry (b)) KB-ES (Thermodynamics (d))
CLO 2	Formulate and calculate relevant transport phenomena such as migration and the characteristics of (diluted) electrolytes. Relate the conversion of matter to the transport of electrical charge.	KB-ES (Applied Chemistry (b)) KB-ES (Process)

CLO	DESCRIPTION	INDICATOR
CLO 3	Evaluate the potential of electrochemical systems based on thermodynamic data and the concept of half-cells. Apply electrical circuit elements to model electrochemical systems in order to calculate energy balances and to estimate efficiencies.	KB-ES (Applied Chemistry (b)) KB-ES (Thermodynamics (b))
CLO 4	Apply knowledge of electrokinetic phenomena to design microfluidic unit operations.	KB-ES (Applied Chemistry (b))
CLO 5	Use of technical measures to characterize properties of galvanic elements and capacitors.	KB-ES (Applied Chemistry (b))
CLO 6	Demonstrate fundamental knowledge of major industrial electrochemical processes and electrochemical reactor design including economic and environmental considerations.	KB-ES (Applied Chemistry (a)) KB-ES (Applied Chemistry (b)) KB-ES (Process (b)) DE-Assess

This course assesses the following program indicators:

Knowledge base for engineering

KB-ES (Chem(a)) Interprets chemical phenomena and relationships through the use of analytical and/or experimental chemical techniques.

KB-ES (Chem(b)) Applies knowledge of electrochemistry and electrochemical engineering to analyze and design electrochemical systems and processes.

KB-ES (Proc(b)) Analyzes kinetic mechanisms, identifies rate limiting steps and develops expressions to describe reaction rates for non-catalytic, catalytic, or electrochemical processes.

KB-ES (Thermo(d)) Determines equilibrium constants and analyzes the influence of thermodynamic equilibrium on reaction and separation systems.

Design

DE-Assess. Evaluate performance of a design, using criteria that incorporates specifications, limitations, assumptions, constraints, and other relevant factors.

RELEVANCE TO THE PROGRAM

This engineering science course covers aspects of technological applications of electrochemistry. It can be considered as overlap between electrical engineering, electrochemistry and chemical engineering. The need for electrochemical engineering arises in society because of multiple important technological applications such as synthesis of chemicals, electrowinning and refining of metals, batteries and fuel cells, sensors, surface modification by electrodeposition and etching, separations, and corrosion, to mention a few. The course assumes knowledge of 2nd year CHEE 210 Thermodynamic Properties of Fluids, 3rd year CHEE 311 Fluid Phase and Reaction Equilibrium and CHEE 321 Chemical Reaction Engineering.

COURSE EVALUATION

Assessment Tool	Due Date (before 23:59 ET)	Weight	Alignment with CLOs
Quizzes	Day 3 of Weeks 5,9	50%	1, 2, 3, 4
Quiz 1	Day 3 of Week 5	25%	1,2
Quiz 2	Day 3 of Week 9	25%	3,4
Assignments	Day 7 of Weeks 2,4,6,10	10%	1, 2, 3, 4, 5
Assignment 1	Day 7 of Week 2	2.5%	1
Assignment 2	Day 7 of Week 4	2.5%	1,2
Assignment 3	Day 7 of Week 6	2.5%	1,2,3
Assignment 4	Day 7 of Week 10	2.5%	1,2,3,4,5
Final Exam	Exam Period	40%	1, 2, 3, 4, 5, 6
		100%	

ASSESSMENT DESCRIPTIONS

Quizzes

There are two quizzes in this course. These quizzes are designed to provide learners with feedback on their knowledge. The duration of the quizzes are 60 minutes. Students must write the quizzes on the day and time scheduled by instructor as indicated above.

Assignments

There are four assignments in this course. Each assignment will require you to solve several complex problems. Some assignments may require you to discuss your findings and extend the concept to wider applications. The assignments can be solved in teams of three students. More details about these assignments can be found on onQ.

Final Exam

The final exam is closed book. Only a Casio 991 non-programmable, non-communicating calculator and a self-written formula sheet will be allowed during tests and exams. Students must write their exam on the day and time scheduled by the University. You should not schedule vacations, travel, etc. during the exam period. The [Term and Session Dates](#) will indicate the final exam period session dates in each term.

Remote Proctoring - Proctortrack

The final exam and some tests/quizzes in this course will use remote proctoring provided by a third-party, cloud-based service that enables the completion of a proctored exam or test from an off-campus location, through onQ or Elentra. This online proctoring solution was chosen as part of the approach to maintaining academic integrity in online assessment. Precise details about how remote proctoring will be used in this course can be found in the “Getting Started with Remote Proctoring” content module in onQ. When writing tests/exams using remote proctoring, you are connecting to the third-party service. Queen’s has conducted a privacy and security review of the service and has entered into a binding agreement with terms that address the appropriate collection, use and disclosure of personal information in accordance with Ontario’s privacy legislation. You should also take measures yourself to protect your information by keeping your NetID password and challenge questions private, closing all applications prior to starting an exam/test, and ensuring your device is updated and safeguarded against malware. For more information about remote proctoring, see the Student FAQs on the VPTL/ITS Resource page for [remote proctoring](#).

GRADING

Students must pass the individual examination component (combined mark on quizzes + final) to pass the course, as stated by [departmental policies](#).

Unless other arrangements have been approved, [departmental policies](#) regarding late and missed assignments, and missed quizzes/exams will be followed.

All assessments in this course will receive numerical percentage marks. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to the established [Grade Point Index](#).

Feedback on Assessments

The teaching team will provide feedback on graded activities. You can expect feedback on your assessments within an adequate time frame.

Accessing Your Final Grade

Your final grades will show on SOLUS. Official transcripts showing final grades will be available on the Official Grade Release Date. Please note that in official transcripts, a mark of IN (incomplete) is considered a grade, and your transcript is released with this grade.

COURSE MATERIALS

Course notes and other course-related material is accessible via OnQ.

The topic is covered comprehensively in the lecture material. That is, no textbook is required for the course. There are several books available in literature concerned with electrochemistry or aspects of

electrochemical engineering. They can be used accompanying to the lecture material if there is a desire to expand and to deepen the knowledge. Suggestions are:

- *Fuller & Harb: Electrochemical Engineering, Wiley.*
- *Hamann, Hamnett, Vielstich: Electrochemistry, Wiley-VCH*

Required Calculator

A Casio 991 is required. **ONLY** this type of non-programmable, non-communicating calculator will be allowed during tests and exams.

Required Hardware/Software

Students must have a reliable [internet connection and hardware](#) that are compatible with online learning and remote proctoring system requirements.

Course Specific Computer-Related Skills

This course requires computer-related technical skills such as accessing the internet and making pdfs.

Suggested Time Commitment

This course represents a study period of one semester spanning 12 weeks. Learners can expect to invest on average 7-9 hours per week in this course. Learners who adhere to a pre-determined study schedule are more likely to successfully complete the course.

COURSE OVERVIEW

CHEE 363	Module overview
Course learning outcomes (CLO): Students will be able to:	
<ol style="list-style-type: none">1. Explain the following abstract concepts: Electrical Potential, Electrical Field, Electrostatic Work, Voltage, Current, Electrochemical Potential, Activation Energy, Electrode & Electrochemical Equilibrium.2. Formulate and calculate relevant transport phenomena such as migration and the characteristics of (diluted) electrolytes. Relate the conversion of matter to the transport of electrical charge.3. Evaluate the potential of electrochemical systems based on thermodynamic data and the concept of half-cells. Apply electrical circuit elements to model electrochemical systems in order to calculate energy balances and to estimate efficiencies.4. Apply knowledge of electrokinetic phenomena to design microfluidic unit operations.5. Use of technical measures to characterize properties of galvanic elements and capacitors.6. Demonstrate fundamental knowledge of major industrial electrochemical processes and electrochemical reactor design including economic and	

environmental considerations.			
Students are expected to augment lecture material through reading of associated sections of the textbook, and to practice execution of course principles by completing posted problem sets			
Module	Lecture approach* and content	Tutorials <i>Tutorial and practice problems are available on OnQ</i>	Assessment (CLO, and % of course grade)
Module 1 (Wks 1-2)	Introduction to Electrochemical Engineering Fundamentals of Electrical Engineering (CLO1) <ul style="list-style-type: none"> • Electrostatics • Electrodynamics • Electrical Circuit Theory Fundamentals of Electrochemical Systems (CLO1, CLO2) <ul style="list-style-type: none"> • Important definitions • Faradays Law 	Tutorials 1 & 2 (CLO1, CLO2)	Material is included on mid-term (CLO1, CLO2) Assignment #1 (2.5% of course grade, CLO1)
Module 2 (Wks 3-4)	Elements of Electrochemical Systems: I. Electrolyte (CLO2) <ul style="list-style-type: none"> • Transport processes within electrolytes • Empirical laws of electrolyte conductivity • The concept of pH and the idea of buffer solutions 	Tutorials 3 & 4 (CLO1, CLO2)	Material is included on Quiz 1 (CLO2) Assignment #2 (2.5% of course grade, CLO1,CLO2)
Module 3 (Wks 5-6)	Elements of Electrochemical Systems: II. Electrode (CLO1, CLO3) <ul style="list-style-type: none"> • Electrochemical Thermodynamics • Nernst Equation • Reference Electrodes • Cell Potential (Electromotive Force) • Electrode Kinetics 	Tutorials 5 - 7 (CLO1-3)	Material is included on Quiz 2 (CL1, CLO3) Assignment #3 (2.5% of course grade, CLO1-3)

Quiz 1 Week 5	Covers Modules 1, 2		<i>Quiz 1: 3-5 multiple choice type questions and 3..5 problems which will target CLO1-3, worth 25% of course grade.</i>
Module 4 (Wk 7)	Electrical Double Layers (CLO4) <ul style="list-style-type: none"> • Theory & Models • Electrokinetic Phenomena 	Tutorial 8 & 9 (CLO1, CLO4)	Material is included on final (CLO4)
Module 5 (Wks 8-11)	Electrochemical Energy Engineering (CLO3, CLO5) <ul style="list-style-type: none"> • Batteries • Fuel Cells • Electrical & Electrochemical Capacitors 	Tutorial 10 & 11 (CLO1-3, CLO5)	Material is included on final (CLO3, CLO5) Assignment #4 (2.5% of course grade, CLO1-5)
Quiz 2 Week 9	Covers Modules 3,4		<i>Quiz 2: 3-5 multiple choice type questions and 3..5 problems which will target CLO3-4, worth 25% of course grade.</i>
Module 6 (Wks 11-12)	Industrial Electrochemical Processes (CLO3, CLO6) <ul style="list-style-type: none"> • Fundamentals • Reactor Design & Parameter • Chlor-Alkali Process • Electrochemical Extraction of Metals • Hall Heroult Process 	Tutorial 12 (CLO1-3, CLO6)	Material is included on final (CLO3,CLO6)
EXAM			<i>Final exam: 3-5 multiple choice type questions and 3-6 problems targeting each CLO, worth 40% of course grade</i>

COURSE COMMUNICATION

NETIQUETTE

In this course, you may be expected to communicate with your peers and the teaching team through electronic communication. You are expected to use the utmost respect in your dealings with your colleagues or when participating in activities, discussions, and online communication.

Following is a list of netiquette guidelines. Please read them carefully and use them to guide your online communication in this course and beyond.

1. Make a personal commitment to learn about, understand, and support your peers.
2. Assume the best of others and expect the best of them.
3. Acknowledge the impact of oppression on the lives of other people and make sure your writing is respectful and inclusive.
4. Recognize and value the experiences, abilities, and knowledge each person brings.
5. Pay close attention to what your peers write before you respond. Think through and re-read your writings before you post or send them to others.
6. It's alright to disagree with ideas, but do not make personal attacks.
7. Be open to be challenged or confronted on your ideas and challenge others with the intent of facilitating growth. Do not demean or embarrass others.
8. Encourage others to develop and share their ideas.

QUESTIONS ABOUT COURSE MATERIAL

Questions or comments regarding the course material that can be of benefit to other students should be posted in the Q&A forum on the class website. The instructor, TAs, and students are committed to answer these questions directly in the discussion forum for the benefit of everyone in the course.

COURSE ANNOUNCEMENTS

The instructor will routinely post course news in the Announcements section on the main course homepage on OnQ. Please sign up to be automatically notified by email when the instructor posts new information in the Announcements section. Instructions on how to modify your notifications are found in the **Begin Here** section of the class website.

OFFICE HOURS

In addition to interaction in the Q&A discussion forums, you will have the opportunity to interact in a synchronous fashion with either a TA or the instructor through office hours. The instructor will provide a schedule of availability at the beginning of the term.

CONFIDENTIAL MATTERS

If you have a confidential matter you would like to discuss with your instructor, their contact details are on the first page of this document. Expect email replies within an adequate time.

COURSE POLICIES

Please review the following policies concerning copyright, academic integrity, absences and academic accommodations:

COPYRIGHT

The material presented in this course is intended for use as part of the course at Queen's University and is the property of the instructor unless otherwise stated. Copying this material for distribution (e.g. uploading material to a commercial third-party website) can lead to a violation of Copyright law and constitutes a violation of Academic Integrity.

ACADEMIC INTEGRITY

As an engineering student, you have made a decision to join us in the profession of engineering, a long-respected profession with high standards of behaviour. As future engineers, we expect you to behave with integrity at all times. Please note that Engineers have a duty to:

- Act at all times with devotion to the high ideals of personal honour and professional integrity.
- Give proper credit for engineering work

The standard of behaviour expected of professional engineers is explained in the [Professional Engineers Ontario Code of Ethics](#). Information on policies concerning academic integrity is available in the [Queen's University Code of Conduct](#), in the [Senate Academic Integrity Policy Statement](#), on the [Faculty of Engineering and Applied Science website](#), and from your instructor.

Departures from academic integrity include plagiarism, use of unauthorized materials or services, facilitation, forgery, falsification, unauthorized use of intellectual property, and collaboration, and are antithetical to the development of an academic community at Queen's. Given the seriousness of these matters, actions which contravene the regulation on academic integrity carry sanctions that can range from a warning or the loss of grades on an assignment to the failure of a course to a requirement to withdraw from the University. In the case of online exams, impersonating another student, copying from another student, making information available to another student about the exam questions or possible answers, communicating with another person during an exam or about an exam during the exam window, or accessing unauthorized materials, including smart devices, are actions in contravention of academic integrity.

LATE POLICY

Students are expected to complete their work in a timely fashion. The course instructor will provide notification (on course Learning Management System) of due dates and any revisions thereof. Submissions after the due date will be penalized at up to 25% per day unless suitable justification is provided. In the event of extenuating circumstances, you may request an extension to an assignment due date without penalty. Requests must be made to your instructor prior to the original due date of the assignment, and some substantiating documentation is often required (see information below on absences). Note that unacceptable reasons include extra-curricular activities, travel plans, generally behind on schoolwork, etc. In the absence of substantiating documentation, the normal late penalty will apply as described in the assignment or departmental policies.

ABSENCES (ACADEMIC CONSIDERATIONS) AND ACADEMIC ACCOMMODATIONS

For absences and academic accommodations please review the information on the [FEAS website](#).

ACADEMIC AND STUDENT SUPPORT

Queen's has a robust set of supports available to you including the [Library](#), [Student Academic Success Services \(Learning Strategies and Writing Centre\)](#), and [Career Services](#). Learners are encouraged to visit the Faculty of Engineering and Applied Science [Current Students](#) web portal for information about various other policies such as academic advisors, registration, student exchanges, awards and scholarships, etc.

INDIVIDUAL NEEDS AND SUPPORT

If you have a disability or health-related condition that may require academic accommodations, please approach the [Queen's Accessibility Services](#). The staff at Accessibility Services are available by appointment to develop individualized accommodation plans, provide referrals, and assist with advocacy. The sooner you let us know your needs, the better we can assist you in achieving your learning goals. For questions or assistance with requesting Academic Consideration or Accommodation, contact the FEAS Academic Accommodation Coordinator at engineering.aac@queensu.ca

Every effort has been made to provide course materials that are accessible. For further information on accessibility compliance of the educational technologies used in this course, please consult the links below.

EDUCATIONAL TECHNOLOGY	ACCESSIBILITY COMPLIANCE INFORMATION
onQ (Brightspace Learning Management System by D2L)	https://www.d2l.com/accessibility/standards/
RocScience	https://www.rocscience.com/
Google Spreadsheets	https://www.google.com/accessibility/products-features/

If you find any element of this course difficult to access, please discuss with your instructor how you can obtain an accommodation.

ACCOMMODATIONS RELATED TO REMOTE ASSESSMENT

To have your accommodations applied to a remote-proctored exam please follow the instructions for submitting your information, as outlined on the QSAS website. Your accommodations will be incorporated into your exam session by the Queen's University exam coordinators, on behalf of your

course instructor. This information is uploaded automatically to [Examity/ Proctortrack](#). Please note that exam accommodations that are uploaded for a specific exam are not visible to students. For example, extra time is calculated and added automatically to the exam duration but is only visible to students once they begin their exam in the Exam Portal.

If you are already registered with QSAS and you require additional accommodations related to remote-proctored exams, please consult with your QSAS advisor to update your Letter of accommodation as appropriate.

RELIGIOUS OBSERVANCE

Students in need of accommodation for religious observance are asked to speak to their professor within a week of receiving their syllabus. Note also that alternative assignments are considered a "reasonable accommodation" under the Ontario Human Rights Code. Students with questions about their rights and responsibilities regarding religious accommodation should contact Chaplain Kate Johnson via Chaplain@queensu.ca.

TECHNICAL SUPPORT

Some basic comfort level with basic hardware and software skills are required for this course. If you require technical assistance, please contact [Technical Support](#).

SUPPORTIVE PERSONAL COUNSELLING

If at any time you find yourself feeling overwhelmed, anxious, sad, lonely, or distressed, consider confidential supportive counselling offered by the [embedded counselors](#) at the Student Wellness Service Faculty of Engineering and Applied Science.

INCLUSIVITY STATEMENT

Queen's students, faculty, and staff come from every imaginable background – small towns and suburbs, urban high rises, Indigenous communities, and from more than 109 countries around the world. You belong here: <https://www.queensu.ca/inclusive/>.