CHEM ENG 4EC3/6EC3 — Electrochemistry and Electrochemical Engineering
Winter 2026 — TENTATIVE Course Outline

INSTRUCTOR:

Drew Higgins (he/him), ABB 428, higgid2@mcmaster.ca

Preferred name: Drew

Office hours: I do not set office hours, because they are restrictive. I am eager to get to know you and to help. I will stick around during breaks and after lectures for discussion, or please feel free to reach out by email to set something up. I will do my best to respond in a timely fashion, but I do not generally check emails on evenings and weekends as I am spending time with my family. If you don't hear back in 2 business days, please send me a gentle reminder — I will appreciate it 😊

TEACHING ASSISTANTS AND OFFICE HOURS:

Matthew Gibson (he/him), gibsot3@mcmaster.ca

Jahnavi Upreti (she/her), upretij@mcmaster.ca

Samuel Fahrngruber (he/him), fahrngrs@mcmaster.ca

- Teaching assistants available for office hours by appointment. Please feel free to reach out to them.
- Matt and Sam will be taking care of the laboratory and Jahnavi will be taking care of assignments.
- Jahnavi will be available for support with assignments in the days leading up to the assignment due date, so please feel free to reach out to her.

SCHEDULE:

Fridays from 2:30pm-5:20pm. First class Jan 9th, last class Apr 3rd. Please refer to Mosaic for class location.

COURSE DESCRIPTION:

This course covers fundamental concepts of electrochemistry and electrochemical engineering, with a particular focus on sustainable energy conversion and storage technologies. In the first half of the course there will be lectures to cover electrochemistry and electrochemical technology fundamentals. In the second half of the course, students will develop expertise (and teaching skills!) with the opportunity to deliver a pedagogical lesson focused on one particular electrochemical technology. This course will also involve a laboratory component where students will gain first-hand experience conducting electrochemical experiments working in groups, and preparing a written laboratory report where they will analyze and interpret their results drawing on the concepts taught throughout the term. It is not expected students will have a background in electrochemistry or electrochemical engineering. However, it is expected students have a basic knowledge of chemistry and chemical engineering, including reaction kinetics, thermodynamics, mass transport and basic scientific/engineering principles.

IMPORTANT DISCLAIMERS

- Elements of this course including topics and schedule will likely be modified throughout the term. Students will be given reasonable notification of any changes or deadlines via the course website (Avenue to Learn). Important communications will also be discussed in class.

- This course in its current format is relatively new. It may not be perfect, but we promise we will do our best.
    - Your input is also encouraged! We have flexibility over how this course is offered, so please feel free to candidly share your thoughts and feedback.
- This is an in-person course and **attendance is expected**. We will be doing group activities and problem solving that will help solidify understanding of course content. Class hours will also be the best opportunity to ask questions, seek clarity on course content and get to know your peers.
- All lectures will be recorded and uploaded for later viewing, but the recording technology (Echo360) commonly has issues so no guarantees can be made about the recording quality or reliability.
- For every class, you will need the slides (I will post them in advance), as well as a calculator and a pen/paper (or other writing means) for doing problem solving.
    - Please feel free to interrupt at any time to ask questions, seek clarity or share your thoughts!

COMMUNICATIONS:

All course announcements and information will be **posted on Avenue**. You are responsible for checking regularly. If you want to reach Drew, please correspond by **email**: higgid2@mcmaster.ca

There is an **anonymous feedback form** available throughout the term that Drew will check weekly. Please share any thoughts/comments/feedback (even compliments 😊) that may be helpful for improving the course offering. The survey is available at: https://forms.gle/CpbzmzJXiNQL8ACGA

RESOURCES:

This is a technical elective/graduate course and, like real-world engineering and research, will involve a lot of self-directed learning that includes pulling information from different resources. Some resources that may be helpful are listed below, but please don't constrain yourself to these.

- Pletcher, *A First Course in Electrode Processes*, 2nd Edition, RSC Publishing (2009).
- Newman, Thomas-Alyea, *Electrochemical Systems, 3rd Edition*, John Wiley & Sons, Ltd. (2004)
- Bard, Faulker, *Electrochemical Methods – Fundamentals and Applications*, 2nd Edition, John Wiley & Sons, Ltd. (2001)
- https://knowledge.electrochem.org/encycl/
- https://www.newworldencyclopedia.org/entry/electrochemistry

COURSE STRUCTURE

The following content will be covered through lectures in this course:

- Applications of electrochemistry
- Electrode reaction principles
- Electrode reaction thermodynamics
- Mass transport in electrochemistry
- Electrochemical cell principles
- Electrochemical cell thermodynamics

- Electrochemical kinetics and transport phenomena in electrochemical systems
- Electrochemical engineering
- Fuel cells
- Experimental electrochemistry
- Deep dive into different electrochemical technologies (via student led pedagogical lessons)

The following is the **TENTATIVE** schedule:

Lecture #	Date	Topic
1	Jan 9	Introduction to teaching team + course syllabus, Applications of electrochemistry
2	Jan 16	Electrochemical reaction principles pt. 1 Thermodynamics
3	Jan 23	Electrochemical reaction principles pt. 2 Reaction kinetics
4	Jan 30	Electrochemical reaction principles pt. 3 Mass transport
5	Feb 6	Electrochemical cell principles; Fuel cells; Batteries
6	Feb 13	Experimental and analytical electrochemical techniques
--	Feb 20	**Winter break!**
7	Feb 27	Hands on experimental electrochemistry laboratory
8	Mar 6	Hands on experimental electrochemistry laboratory
9	Mar 13	Hands on experimental electrochemistry laboratory
10	Mar 20	Student pedagogical lessons
11	Mar 27	Student pedagogical lessons
12	Apr 3	Student pedagogical lessons

COURSE EVALUATION:

Undergraduate students

Assignments — 45%

Experimental electrochemistry laboratory — 30%

Pedagogical lessons — 25%

Graduate students

Assignments — 40%

Experimental electrochemistry laboratory — 25%

Pedagogical lessons — 20%

Research proposal — 15%

Assignments (3)

There will be three assignments each equally weighted towards your final mark. Assignment will be submitted on Avenue. Jahnavi Upreti will be responsible for facilitating assignments and can be contacted for assistance. Late submissions will receive a 15% penalty per day that they are late.

Experimental electrochemistry laboratory

Students will gain first-hand experience applying electrochemistry principles in an experimental laboratory setting. Working with a teaching assistant, groups of students will help set up and perform electrochemical measurements. Groups will then be required to analyze, interpret and discuss their laboratory results, drawing on the concepts and topics taught throughout the term to prepare a laboratory report. Sam Fahrngruber and Matt Gibson will be responsible for the laboratories and can be contacted for any questions or assistance. The groups and schedule for the experimental laboratory will be set closer to the date. **You will be required to do online safety training in advance of the laboratory.**

Pedagogical lessons

Groups of 3-4 students will give a 15min "talking time" pedagogical lesson on an electrochemical technology/application of their choice. This presentation should introduce the topic, highlight the application(s)/real world implications of the topic, and discuss the operating principles, ensuring to relate the lesson subject matter to the fundamental concepts covered in this course. An evaluation rubric will be provided. The groups and schedule for the pedagogical lessons will be set closer to the date.

- I should be able to use the slides and content you prepare while teaching future offerings of this course!

Possible Topics for Pedagogical Lesson

- Chloro-alkali process
- PEM water electrolysis
- Alkaline water electrolysis
- Electrochemical CO_2 conversion
- Electro-organic syntheses
- Batteries
    - Lithium-ion batteries
    - Zn-ion batteries
    - Other battery chemistries?
- Supercapacitors
- Electrochemical sensors
- Corrosion (and it's prevention!)
- Metallurgical processes (you are encouraged to pick one type of metal and process to focus on, i.e., aluminum production)
- Any other topics you may be interested in?

Research Proposal

Graduate students will be individually responsible for preparing a 2-3 page research proposal at the end of the term on a topic related to electrochemistry. More details will be provided leading up to the due date, which will be during the examination period. A marking rubric and guidelines will also be provided.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK:

In the event of an absence for medical or other reasons, students should review and follow the Policy on Requests for Relief for Missed Academic Term Work.

All MSAFs will receive an automatic 72 hour extension. When submitting an MSAF, please also send an email to Drew (higgid2@mcmaster.ca) to ensure it is not missed.

The P.R.O.C.E.S.S.

As some of you may already be aware, the department of Chemical Engineering has a storied history of education. In addition to teaching and learning, the department is proud of our graduates not only for their academic success, but their more intrinsic traits that make them respected members of the engineering community.

Recently, several high-ranking graduates from the McMaster Chemical Engineering Program employed in various industries (oil/gas, financials, *etc*.) were interviewed to ask what traits they look for when hiring for engineering positions. Using this information, the department would like to present to you the **PROCESS**: a code of conduct that we hope will guide our students throughout this program and their careers to come.

- **P**rofessionalism
- **R**esponsibility
- **O**wnership
- **C**uriosity
- **E**mpathy
- **S**elflessness
- **S**ervice

It is up to YOU to interpret these traits and apply them to your time at McMaster and your career as you see fit. These traits will not be assessed for grades but will be strongly encouraged throughout your time at McMaster. We hope that you identify with these character traits and what they mean to you, and that you **trust the process**.

ACADEMIC INTEGRITY:

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-proceduresguidelines/

The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

Academic credentials you earn are rooted in principles of honesty and academic integrity. Please remember that copying, cloning, or "borrowing" other people's solutions and assignments is cheating – academic dishonesty. Many engineering problems involve working in groups, so you are encouraged to work with others on assignments. However, you must each hand in your own assignments having solved the problems on your own. The best way to learn the material is to go through the problems and understand what you are doing. Since this course forms the basis of so much of what you will do in Chemical Engineering, it is particularly important to understand the material presented and be able to solve the problems from this course.

AVENUE TO LEARN (A2L):

This course uses A2L and email for communications. Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

CONDUCT EXPECTATIONS:

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online.**

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMODATION FOR RELGIOUS, INDIGENEOUS, OR SPIRITUAL (RISO):

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING:

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES:

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, Avenue to Learn and/or McMaster email.

CLOSING THOUGHTS:

I look forward to the term, including learning alongside you and discussing topics relating to electrochemistry and electrochemical engineering. I am particularly excited about this field of science and engineering because I see electrochemistry as a crucial component of a future society built on sustainability. I hope you enjoy this course and that the content helps you out in your future endeavours!

Please also remember that myself (Drew) and the teaching team are here to support you in your learning. Please do not hesitate to reach out to me if there is any way that I can help and support. Our goal is to offer a course that is effective at achieving all of our learning objectives and that is hopefully also enjoyable 😊