1 Course Objectives

Important to researchers in chemistry-allied fields is the behavior of chemical species at equilibrium. Equilibria captures chemical intuition quantitatively to calculate concentrations and predict behaviors as conditions change. This course provides the skills needed to appreciate and parameterize equilibrium behavior. All equilibrium problems can be solved using a few basic ideas:

- Equilibrium reactions
- Equilibrium constants, sometimes as redox
- Analytic concentration expressions - mass balances (conservation of mass)
- Charge balance (conservation of charge)

The course objective is to learn to apply equilibrium constraints to a range of chemically interesting systems. Spreadsheet Tools and Protocols to characterize equilibrium systems are built. Purposes of the Tools include vehicles for homeworks and exams and as means to evaluate chemical systems in your research beyond CHEM:3110. Content is delivered in Modules that are highly reliant on computers and spreadsheets. Please bring laptops/computers to every class. Please notify TAs or instructor immediately of any difficulties.

Tools for visualizing equilibria include Systematic Treatment of Equilibria (STE), fractional concentrations, and titrations for acid base, ligand, precipitation, and redox equilibria. Appropriately parameterized, STE always works. Basics of electrochemistry, voltammetry and potentiometry are presented. Student developed Tools quantify the equilibrium chemical composition of any system.

For the final project, students apply the Tools to a chemical system of their choice. There is no final exam.

2 Prerequisite Skills

Background necessary for success in this course includes:
- freshman chemistry
- a little chemical intuition
- envisioning the problem: “SEE THE BEAKER.”
- expression of problems in algebraic terms
- algebra or algebra solution software
- spreadsheet skills

★ Most important is thinking.
Love of puzzles is useful.

3 Modules and Tools

The course is delivered in Modules. Within the Modules are lectures, activities, homeworks, assessments, and means to Build Your Own (BYO) Tools. Tools include spreadsheets, web links, web searching, and protocols to specify chemical systems. Several additional research tools are presented that may be of use in this course and beyond.

4 Module Topics and the Tools

More details are provided for each Module on ICON under Modules. Links to the various components, additional information, as well as due dates and points are provided.

Introduction 00 - Course Objectives
Tool: Brain (bring to every class)
Tool: Computer (bring to every class)

Module 0 - Introduction; Chemistry-Algebra Review
Tool: Linear Regression, Statistics Spreadsheet
Tool: Online Resources: Data Links, Algebra Widgets

Module 1 - Systematic Treatment of Equilibria (STE)
Tool: Protocol for STE (always works)

Module 2 - Acid Base, Fractional Concentration, Titration
Tool: Fraction Concentration Spreadsheet
Tool: Titration Curves Spreadsheet

Module 3 - Electrochemistry Basics, Redox Titrations
Tool: Protocol $E_{cell}$ Calculations (always works)
Tool: Potential Axis Spreadsheet
Tool: Redox Titration Spreadsheet

Module 4 - Voltammetry
Tool: Steady State Flux, Hydrodynamic Voltammetry
Tool: Transient Flux and Chronoamperometry
Tool: Cyclic Voltammetry (CV): Nernstian Conditions
Tool: Cyclic Voltammetry (CV) Spreadsheet: Kinetics

Module 5 - Activity, Potentiometry, ISEs
Tool: Activity Spreadsheet

Module 6 - Final Project (no final exam)
Use the Tools to model a system of interest to you or write a murder mystery or draft next year’s final...
5 Course Mechanics

Course lectures are taught in person. Office hours are a mix of zoom and in person. Exams are in person. Additional information is available on ICON.

**Class Meetings:** 10:30 to 11:20 am MWF, GILM 106

**Zoom Links:** Leddy Office Hours: https://uiowa.zoom.us/j/93506223375
Perpetual Zoom Room: (Enter 3110 if asked.) https://uiowa.zoom.us/j/92432711775

**Exam Meetings:** Two exams convene at about 6:00 p.m. on Wednesday 6 October (Modules 1 and 2) and 17 November (Modules 3 and 4) in GILH 106 (lecture room). Exams are taken on your computer/laptop. Students have access to all spreadsheets, materials, and online links developed in class. (Open computer, open book, open spreadsheet, open internet,...) During exams, communications are only allowed with the TAs and instructor. The only required dates for attendance are the exams.

**Discussions:** The discussion sections are:
- M 17:30 - 18:20 C139 PC
- T 8:30 - 9:20 C 139 PC

**Office Hours - Leddy:** Leddy’s in person office hours are immediately after class on M from 11:20 to 12:00 (location to TBA) and WF starting at 11:20 after class. Leddy’s virtual office hours are M and Th 20:30 to 21:30 on zoom, https://uiowa.zoom.us/j/93506223375. Additional (derecho) office hours will be posted on the ICON homepage. Send any requests for additional assistance to chem-leddyinstruction@uiowa.edu.

**Leddy’s Class Email:** For class relevant email communications during fall 2021, please use chem-leddyinstruction@uiowa.edu. Response to messages sent elsewhere will likely be delayed.

**TAs and Office Hours:** TAs lead the discussions.

Josh Coduto joshua-coduto@uiowa.edu
Virtual Office Hrs T 9:30-10:30
W 13:30-14:30

Andrés Mora Mata andres-moramata@uiowa.edu
Virtual Office Hrs1 M 9:30-10:30
F 13:30-14:30

**Perpetual Zoom Room:** https://uiowa.zoom.us/j/92432711775

**Homework:** Homework is critical to success in this class. You may work together, but do not copy.

There are 5 homework assignments. Homework are submitted on ICON using a supplied template with Excel sheets. HWs are due at the specified dates and times. For questions about homework, contact the TAs or Leddy; for grading of homeworks, please contact the TAs first; for grading of exams, contact Leddy. Details about HW submissions are available on ICON and within the HW assignment.

**BYOs, OBQ, PB:** Additional assignment types are described below in Section 6.

**Text:** Quantitative Chemical Analysis, by Daniel C. Harris, any edition 6 to 10 suffices. The current 10th edition is not required. There are formats other than hardback. This book is available in earlier editions; editions back at least to 6th edition will be appropriate. (This text is sometimes used in other classes at the University, so consider before purchasing a one semester rental of the electronic version.) Module Links by Chapter in QCA for various editions are posted under the appropriate Modules on ICON.

There will also be handouts posted on ICON. An additional resources is an open source text, Analytical Chemistry Version 2.1 (http://dpauweb.depauw.edu/harvey_web/eTextProject/version_2.1.html). The text is not as advanced as the planned lectures but is a good (and free) resource.

**Laptop and Internet:** This course is computer (internet and spreadsheet) intensive. Access to appropriate hardware, software, and internet is critical. During the first Discussion, TAs will review ICON including assignment submissions and address any questions about computer usage. Please notify the TAs or instructor immediately of any issues.

**Software:** All exams and homework assignments will be undertaken and submitted on ICON using templates under Office 365. Excel is required. Office 365, Zoom, and other programs are available to all students at https://its.uiowa.edu/available-software. Programs that you may find useful for solving algebra problems are below. Additional links will be provided on ICON.
- Mathematica and MatLab free through https://its.uiowa.edu/available-software.
- Wolfram Widgets (http://www.wolframalpha.com/widgets/)

**Links:** Links and content are listed on ICON. One content module contains parts of the book, Chemical Equilibria by A. J. Bard, which clearly presents methods for solving equilibrium problems, a major course objective.

1 Andres’ Office Hrs: https://uiowa.zoom.us/j/91935935279?pwd=aUt4QnVoeckp5VzdYXzjNzlUnZsUT09
ICON WebPage: The class web site on ICON is central to this class. The ICON site includes grades, syllabus, homework assignments, the problems to be covered in upcoming lectures, handouts, useful links, example old exams, and messages to the class. Please check for homework addenda and updates that may contain clarifying information. Most information can be found on the Home Page and under Modules tab. ICON is where you submit assignments. You can access ICON at http://icon.uiowa.edu using HawkID and HawkID password. For CHEM:3110, the link is https://uiowa.instructure.com/courses/167592.

Copyrighted Material: All materials on the ICON site are copyrighted. Information posted on ICON cannot be shared to online sites without the written permission of the instructor(s).

6 Grading and Assignment Types

All materials are submitted through ICON. Each Module may include several different components as follows. Final grade is calculated based on points.

Lectures: Each Module includes Lecture(s). The topics for each lecture are listed in the Module. Lectures are MWF 10:30 in GILH 106. Attendance is not taken for Lectures or Discussions. (The only mandatory attendance is Exam I and II.) There are no points for Lectures.

PRL - Pre-Recorded Lectures: There are a few PRLs for 3110, which are found in the corresponding Modules. Typically, the content is self-explanatory. There are no points for PRLs. There are simple OBQs to assess the PRLs.

OBQ -Online Basic Quiz (5 pts): OBQs are simple, low level and introductory assessment of concepts. OBQs are administered online with links in each Module. OBQs may be taken repeatedly until the due date. The highest score is retained. There are 13 OBQs, each worth 5 pts. Total OBQ points are ~1.6% of the final grade. It is expected that OBQs will generally require less than 20 minutes.

PB - Point Builders (24 pts): PBs are 1 page exercises that focus on a single concept. These are either online ICON quizzes or submitted on templates through ICON. Files can be modified until the deadline. There are 10 PBs, each worth 24 pts. Total PBs points are ~6.0% of the final grade. It is estimated that PBs will generally require 60 to 90 minutes. PBs are graded holistically (A, C, F).

BYO - Build Your Own (50 pts): A major course objective is to provide tools useful in chemical research and course energy is devoted to developing these tools. BYO Tools and Protocols are the basic Tools the student will construct. In several cases, a video is provided that walks through construction of the BYOs. BYOs are the Tools for HWs, Exams, and Final Project. There are 11 BYOs, each worth 50 Points, ~13.7% of the total points. Successful construction of BYOs is critical to successful completion of HWs, Exams, and Final Project.

HW - Homework Set (250 pts): HWs and templates are downloaded from ICON and submitted on ICON. HWs can be modified until the deadline. HW are important to mastery of the Module Objectives. HWs rely on construction of the corresponding BYOs. You may work in groups on HWs, however, you may not copy from one another. There are 5 HWs, each worth 50 pts. HWs are worth ~27.5% of the total points.

During Exams: You may use any tools developed during the semester including online materials. Bring your computer with internet access to exams. Any tools are permitted but communications are restricted to chats with the instructor and TAs.

Final Project (800 pts): The Final Project is an opportunity to demonstrate the skills and Tools acquired during class. This is a written document that incorporates Tools. A detailed rubric will be provided. The Final Project may be the model of a system of interest or related to research, a murder mystery problem, or a cumulative final exam for next year’s class or ..... The Final Project is worth 800 pts and ~20.0% of the total points. There is no final exam.

Grades: Historically, the average grade for this class has been a C+ and B, depending on class performance. This semester, the final grade is based on total points. There are a total of ~4000 points available. Estimating, the A range is ≥ 3600 points; B range is ≥ 3200 points; C range is ≥ 2700 points. and passing ≥ 2000 points. The final points may be set against a curve but the curve will not lower grades. Bonus and extra credit points may occasionally be available. Grades are recorded on ICON.

Submission Due Dates: All submission deadlines are
listed on the home page by Module. All submissions are due by 23:30, unless otherwise noted. There is a 28 minute grace period to allow for technical issues. If technical issues prevail at 23:58, email the assignment to chem-leddyinstruction@uiowa.edu by 00:05 on due date + 1. Include the assignment name in the subject line. Explain in the email body why the assignment is submitted by email. Assignments not submitted in any manner by 00:05 due date + 1 are flagged late.

**Late Submissions:** Penalties for late assignments are 10% of total points for the assignment each 24 hours. For example, if a BYO is submitted 36 hours late, that is a two day penalty of $2 \times 50 \times 0.10 = 10$ point penalty. No assignments are accepted after 72 hours late. (For consideration of extraordinary circumstances, contact Leddy at chem-leddyinstruction@uiowa.edu.)

**Late Submission Chits:** For some leeway given unusual circumstances, each student has 3 late Chits. Each Chit allows a one day (24 hours), no penalty deadline extension. Chits can be used for BYOs and HWs only. Deploy Chits wisely.

To deploy a Chit, submit the homework on ICON within 24 hours after due date and send a message with Chit Deployed for HWx/BYOx in the Subject Line to chem-leddyinstruction@uiowa.edu. Include the number for the BYO or HW for which the Chit redeemed in the Subject Line. The Chit Deployed message must be submitted within 10 minutes of the late assignment submission. In the body of the message restate which assignment, when the assignment was submitted, and when the assignment was due. Only 1 Chit per assignment.

**Summary of Grade Components:** The approximate points for the class are shown below.

<table>
<thead>
<tr>
<th>Assignment Types</th>
<th># in Type</th>
<th>Points per Type</th>
<th>% of Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBQs (Online Basic Quiz)</td>
<td>13</td>
<td>5</td>
<td>65</td>
</tr>
<tr>
<td>PB (Point Builder)</td>
<td>10</td>
<td>24</td>
<td>240</td>
</tr>
<tr>
<td>BYO (Build Your Own)</td>
<td>11</td>
<td>50</td>
<td>550</td>
</tr>
<tr>
<td>HW (Homework)</td>
<td>5</td>
<td>250</td>
<td>1250</td>
</tr>
<tr>
<td>Exams</td>
<td>2</td>
<td>550</td>
<td>1100</td>
</tr>
<tr>
<td>Final Project</td>
<td>1</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Working Total</td>
<td></td>
<td>4005</td>
<td></td>
</tr>
</tbody>
</table>

Time Management Bonus on Final Project: 10% of student’s project score if submitted by close of classes. 5% of score if submitted by Monday of exam week.

### 7 Manners and Administrative Details

**Computer and Internet Access:** Computer and internet access are critical to success in this class. Please note that Chrome Books may not suffice. All assignments are submitted through ICON. Excel is available in Office 365, available free to all students through https://its.uiowa.edu. If you are not familiar with spreadsheets (e.g., Excel), several guides are listed on the class ICON site.

**Attendance:** Except for the two exams, attendance is neither taken nor required for class and discussion.

**Special Requirements for Students with Disabilities:** Please contact me immediately if you have a disability that may require some modification of seating, testing or other class requirements so that appropriate arrangements may be made.

... Absences: For extended absences including COVID-19, please fill out the CLAS Absence form at https://clas.uiowa.edu/sites/default/files/ABSENCE%20EXPLANATION%20FORM.pdf and send a copy of the form to chem-leddyinstruction@uiowa.edu.

**COVID-19:** In the event of COVID exposure or positive COVID test, please submit a self-report at https://apps.its.uiowa.edu/forms/self-report. Please send a brief email to chem-leddyinstruction@uiowa.edu about the period that you will be absent from class and any anticipated challenges with assignments. This is to try to make accommodations for any time disruptions.

**Masks:** The University of Iowa strongly encourages students, faculty, and staff to be vaccinated against COVID-19. The University also encourages students, faculty, and staff to wear a face mask while on campus, and strongly encourages the use of face masks in all classroom settings and during in-person office hours. However, face mask usage is not required except on CAMBUS and in specified research and healthcare settings.

...
Cell Phones, Pagers, and Other Audible Devices:
Please turn off all audible alarms during class.

Cheating: Cheating is not tolerated in this class. If you are found to be cheating, I will pursue the maximum possible penalties for cheating. If you have any questions as to what constitutes cheating, please see me or http://clas.uiowa.edu/students/handbook.

Harassment Harassment will not be tolerated. University policy on sexual harassment is found at http://www.sexualharassment.uiowa.edu/.

Chemistry Department Contact Information: Students in need of additional information may contact staff in the Chemistry Center (E225 CB) during normal business hours.

Additional Constraints of College of Liberal Arts:
This course is given by the College of Liberal Arts (CLAS). Class policies such as requirements, grading, and sanctions for academic dishonesty are governed by CLAS. Students wishing to add or drop this course after the official deadline must receive the approval of the CLAS Dean. Information on cross enrollments is at: http://www.uiowa.edu/~provost/deos/crossenroll.doc.

CLAS Policy Statement: CLAS Policy information is summarized at http://clas.uiowa.edu/faculty/teaching-policies-resources-syllabus-insert and listed in the next section.
ATTENDANCE AND CLASSROOM EXPECTATIONS

Students are responsible for attending class and for knowing an instructor’s attendance policies, which vary by course and content area. All students are expected to attend class and to contribute to its learning environment in part by complying with University policies and directives regarding appropriate classroom behavior or other matters.

ABSENCES

Students are responsible for communicating with instructors as soon they know that an absence might occur or as soon as possible in the case of an illness or an unavoidable circumstance. Students can use the CLAS absence form to help communicate with instructors who will decide if the absence is excused or unexcused; the form is located on ICON within the top banner under “Student Tools.” Delays by students in communication with an instructor could result in a forfeiture of what otherwise might be an excused absence (https://clas.uiowa.edu/students/handbook/attendance-absences).

ABSENCES: ILLNESS, UNAVOIDABLE CIRCUMSTANCES, AND UNIVERSITY SPONSORED ACTIVITIES

Students who are ill, in an unavoidable circumstance affecting academic work, or who miss class because of a University sponsored activity are allowed by UI policy to make up a missed exam. Documentation is required by the instructor except in the case of a brief illness. Students are responsible for communicating with instructors as soon as the absence is known (https://opsmanual.uiowa.edu/students/absences-class#8.1).

ABSENCES: HOLY DAYS

Reasonable accommodations are allowed for students whose religious holy days coincide with their classroom assignments, tests, and attendance if the student notifies the instructor in writing of any such religious Holy Day conflicts within the first days of the semester and no later than the third week. (See the UI Operations Manual, https://opsmanual.uiowa.edu/students/absences-class#8.2).

ABSENCES: MILITARY SERVICE OBLIGATIONS

Students absent from class due to U.S. veteran or U.S. military service obligations (including military service-related medical appointments, military orders, and National Guard Service obligations) must be excused without penalty. Instructors must make reasonable accommodations to allow students to make-up exams or other work. Students must communicate with their instructors about the expected possibility of missing class as soon as possible. (For more information, see https://opsmanual.uiowa.edu/iv-8-absences-class%C2%A0-0).

ACADEMIC MISCONDUCT

All undergraduates enrolled in courses offered by CLAS have in essence agreed to the College’s Code of Academic Honesty. Academic misconduct affects a student’s grade and is reported to the College which applies an additional sanction, such as suspension. Outcomes about misconduct are communicated through UI email (https://clas.uiowa.edu/students/handbook/academic-fraud-honor-code).

ACADEMIC ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES
UI is committed to providing an educational experience that is accessible to all students. A student may request academic accommodations for a disability (such as a mental health, attention, learning, vision, and a physical or health-related condition) through the Student Disability Services (SDS) office. The student is responsible for discussing specific accommodations with the instructor. Note that accommodations are not granted retroactively but from the time of the student’s request to the instructor onward; additionally, accommodations must be requested at least two weeks in advance of the related assignment or exam (https://sds.studentlife.uiowa.edu/).

CLASS RECORDINGS: PRIVACY AND SHARING
Course lectures and discussions are sometimes recorded or live-streamed. These are only available to students registered for the course and the intellectual property of the faculty member. These materials may not be shared or reproduced without the explicit written consent of the instructors. Students may not share these recordings with those who are not enrolled in the course; likewise, students may not upload recordings to any other online environment. Doing so is a breach of the Code of Student Conduct and could be a violation of the Federal Education Rights and Privacy Act (FERPA); also see https://dos.uiowa.edu/policies/code-of-student-life/.

COMMUNICATION: UI EMAIL
Students are responsible for all official correspondences sent to their UI email address (uiowa.edu) and must use this address for any communication with instructors or staff in the UI community (Operations Manual, III.15.2). Emails should be respectful and brief, with complex matters addressed during the instructor’s drop-in hours, for example. Faculty are not expected to answer email after business hours or during the weekends.

COMPLAINTS ABOUT ACADEMIC MATTERS
Students with a complaint about a grade or a related academic issue should first visit with the instructor and then with the course supervisor (if one is assigned), and next with the Chair of the department or program offering the course. If not resolved, students may bring their concerns to the College of Liberal Arts and Sciences: https://clas.uiowa.edu/students/handbook/student-rights-responsibilities.

FINAL EXAMINATION POLICIES
The final exam schedule is published during the fifth week of the fall and spring semesters or on the first day of summer classes; students are responsible for knowing the date, time, and place of their final exams. Students should not make travel plans until knowing this information. A student with exams scheduled on the same day and time or who have more than two final exams on the same day should visit this page for how to resolve these problems by the given deadline: https://registrar.uiowa.edu/makeup-final-examination-policies. No exams may be scheduled the week before finals; some exception, however, have been made for labs, language courses, and off-cycle courses (https://registrar.uiowa.edu/final-examination-scheduling-policies).

FREE SPEECH AND EXPRESSION
The University of Iowa supports and upholds the First Amendment protection of freedom of speech and the principles of academic and artistic freedom. We are committed to open inquiry, vigorous debate, and creative expression inside and outside of the classroom. Visit Free Speech at Iowa for more information on the University’s policies on free speech and academic freedom (https://freespeech.uiowa.edu/).

HOME OF THE COURSE
The College of Liberal Arts and Sciences (CLAS) is the home of this course, and CLAS governs the course’s add and drop deadlines, the “second-grade only” option (SGO), and other undergraduate policies and procedures. Different UI colleges may have other policies or deadlines. See https://clas.uiowa.edu/students/handbook. Questions? Contact CLAS at clasps@uiowa.edu or 319-335-2633.

MENTAL HEALTH
Students are encouraged to seek help as a preventive measure or if feeling stressed or overwhelmed. Students should talk to their instructors for guidance with specific class-related concerns and are encouraged to contact University Counseling Service (UCS) at 319-335-7294 during regular business hours to schedule an appointment. USC offers
group and individual therapy as well as counseling for couples about relationships while making referrals to other resources (https://counseling.uiowa.edu/). Student Health can also address related concerns (https://studenthealth.uiowa.edu/). These visits are free to students. After hours, students are encouraged to call the Johnson County Community Crisis Line at (319) 351-0140 or dial 911 in an emergency.

**NONDISCRIMINATION IN THE CLASSROOM**

The University of Iowa is committed to making the classroom a respectful and inclusive space for people of all gender, sexual, racial, religious, and other identities. Toward this goal, students are invited in MyUI to optionally share the names and pronouns they would like their instructors and advisors to use to address them. The University of Iowa prohibits discrimination and harassment against individuals based on race, class, gender, sexual orientation, national origin, and other identity categories indicated by the University’s Human Rights policy. Contact the Office of Equal Opportunity and Diversity at https://diversity.uiowa.edu/division/office-equal-opportunity-and-diversity-eod.

**SEXUAL HARASSMENT**

Sexual harassment subverts the mission of the University and threatens the well-being of students, faculty, and staff; all members of the UI community are expected to conduct themselves in a manner that maintains an environment free from sexual harassment and sexual misconduct. Those experiencing sexual harassment are strongly encouraged to report the incidents and to seek help (https://osmrc.uiowa.edu/).