CHMC21H3 F

Topics in Biophysical Chemistry

Fall 2023 Syllabus

Course Meetings

CHMC21H3 F

Section	Day & Time	Delivery Mode & Location
LEC01	Wednesday, 12:00 PM - 2:00 PM	In Person: HL B108

Refer to ACORN for the most up-to-date information about the delivery and location of the course meetings.

Course Contacts

Instructor: Dr. Kagan Kerman
Email: kagan.kerman@utoronto.ca
Office Hours and Location: Tuesdays, 3-5 pm, EV548

Course Overview

Advanced topics in Physical Chemistry with emphasis on biochemical systems. Spectroscopic methods for (bio) molecular structure determination, including IR, NMR, UV/VIS; colloid chemistry; polymers and bio-polymers, bonding structure and statistical mechanics; physical chemistry of membranes, active transport and diffusion; oscillatory (bio)chemical reactions.

In this year, CHMC21 will provide an overview of electroanalytical chemistry with a focus on the development of sensors and biosensors in the field of biophysical chemistry. It covers the principles, technologies, methods and applications of electrochemical sensors and biosensors.

Course Learning Outcomes

By the end of the course, the students will have acquired knowledge about the following topics: Activity, Nernst Equation, Diffusion, Solid electrodes (Glassy carbon, carbon paste, metal electrodes), mercury electrodes, microelectrodes, screen-printed electrodes, reference electrodes, cyclic voltammetry, differential pulse voltammetry, square wave voltammetry, stripping voltammetry, amperometry, AC voltammetry, Nyquist plot, Bode plot, Equivalent circuits, pH electrodes, membrane electrodes, chronopotentiometric stripping analysis, ITO electrodes, approach curves, single molecule analysis, electrochemical quartz crystal microbalance, electrochemical surface plasmon resonance, metalloproteins, oxidation of nucleic

acids and proteins, electroanalysis of neurotransmission and exocytosis, electrogenerated chemiluminescence (ECL), biosensors based on ECL.

Prerequisites: CHMB21H3
Corequisites: None
Exclusions: None
Recommended Preparation: None
Credit Value: 0.5

Course Materials

There is no individual textbook assigned for the course and students should rely on course notes, literature articles, and lectures for the material covered. The following is a list of suggested textbooks you may use for extra reading on covered topics:

1. **Electrochemical Methods: Fundamentals and Applications, 2nd Edition, by Allen J. Bard and Larry Faulkner, Wiley-VCH.**
2. **Analytical Electrochemistry, by Joseph Wang, 3rd Edition, Wiley-VCH.**
3. **Understanding Voltammetry, Richard G. Compton and Craig Banks, World Scientific Books.**

All texts are available in the UTSC Library and Gerstein Science Library.

Marking Scheme

Assessment	Percent	Details	Due Date
Quiz	20%	10-minute open-book quizzes reviewing material from the previous week's lecture. There will be no make-up test of the missed quizzes.	2023-09-19,2023-09-26,2023-10-03,2023-10-31,2023-11-07,2023-11-14,2023-11-21
Mid-term	30%	The mid-term test will take place in class on October 18th for 90 minutes. Mid-term will be closed-book and on the course topics, including quiz questions covered until the date of the exam. There will be no make-up test of the mid-term	2023-10-18

Assessment	Percent	Details	Due Date
Participation	10%	Each lecture participation will be worth 1% on the marked dates. There will be no make-up participation mark of the missed lectures.	2023-09-12,2023-09-19,2023-09-26,2023-10-03,2023-10-24,2023-10-31,2023-11-07,2023-11-14,2023-11-21,2023-11-28
Final Exam	40%	Final exam will be in take-home format. Final exam will be on the whole course work, including quiz questions with reading and summarizing a selected number of papers followed by critically reviewing them. The students will have one week to complete and submit their final exams through Quercus Assignments page.	Final Exam Period

N/A

Late Assessment Submissions Policy

Mid-term 30% (In-class, Mid-term will be closed-book and on the course topics, including quiz questions covered until the date of the exam. There will be no make-up test of the mid-term**)**

Final Exam 40% (Take-home, Final exam will be on the whole course work, including quiz questions with reading and summarizing a selected number of papers followed by critically reviewing them**)**

Participation 10% (Each lecture participation will be worth 1%. There will be no make-up of the missed lectures**)**

Quiz 20% (10-minute open-book quizzes reviewing material from the previous week's lecture. There will be no make-up test of the missed quizzes**)**

Total 100%

Course Schedule

Week	Description
Week 1 Sept. 06	**Introduction to Course Syllabus with Q&A session**

Week 2 Sept. 13	**Introduction to Electroanalytical Chemistry (Participation-1%)** **Learning objectives: Activity, Nernst Equation, Diffusion** **Recommended Reading: Understanding the Nernst equation and other electrochemical concepts: An easy experimental approach for students,** F. J. Vidal-Iglesias, J. Solla-Gullon, A. Rodes, E. Herrero, A. Aldaz, *J. Chem. Ed.* **2012**, *89*, 936-939.
Week 3 Sept. 20	**Electrodes and Voltammetry-1 (Quiz-1-4%) (Participation-1%)** **Learning objectives: Solid electrodes (Glassy carbon, carbon paste, metal electrodes), mercury electrodes, microelectrodes, screen-printed electrodes, reference electrodes, cyclic voltammetry-1** **Electrochemical study and determination of electroactive species with screen-printed electrodes,** D. Martin-Yerga, E. C. Rama, A. C. Garcia, *J. Chem. Ed.* **2016**, *93*, 1270-1276. **Electrically transduced sensors based on nanomaterials**, G. T. Chandran, X. Li, A. Ogata, R. M. Penner, *Anal. Chem.* **2017**, *89*, 249-275.
Week 4 Sept. 27	**Voltammetry-2 (Quiz-2-3%)(Participation-1%)** **Learning objectives: Cyclic voltammetry-2, differential pulse voltammetry, square wave voltammetry, stripping voltammetry, amperometry** **Recommended Readings: Development and use of a cyclic voltammetry simulator to introduce undergraduate students to electrochemical simulations,** Jay H. Brown, *J. Chem. Ed.* **2015**, *92*, 1490-1496.
Week 5 Oct. 04	**Electrochemical Impedance Spectroscopy-1 (Quiz-3-3%)(Participation-1%)** **Learning objectives: AC voltammetry, Nyquist plot, Bode plot, Equivalent circuits.** **Recommended Reading: Electrochemical impedance spectroscopy: an overview of bioanalytical applications,** Edward P. Randviir and Craig E. Banks, *Anal. Methods* **2013**, *5*, 1098-1115.
Week 6 Oct. 11	Reading Week
Week 7 Oct. 18	Mid-term test **(In-class open-book exam for 90 min)**
Week 8 Oct. 25	**Electrochemical Impedance Spectroscopy-2 and Potentiometry (Participation-1%)** **Learning objectives: Nyquist plot, Bode plot, Equivalent circuits, AC**

	voltammetry, pH electrodes, membrane electrodes, chronopotentiometric stripping analysis. **Recommended Reading: Electroanalysis with membrane electrodes and liquid-liquid interfaces**, Eric Bakker, *Anal. Chem.* **2016**, *88*, 395-413.
Week 9 Nov. 01	**Spectroelectrochemistry, SECM, EQCM and ESPR (Quiz-4-2%) (Participation-1%)** **Learning objectives: ITO electrodes, approach curves, single molecule analysis, electrochemical quartz crystal microbalance, electrochemical surface plasmon resonance.** **Recommended Readings: Scanning probe microscopy for nanoscale electrochemical imaging,** Y. Takahashi, A. Kumatani, H. Shiku, T. Matsue, *Anal. Chem.* **2017**, *89*, 342-357. **Electrochemical quartz crystal microbalance with dissipation real-time hydrodynamic spectroscopy of porous solids in contact with liquids**, Sergey Shilov *et al*., *Anal. Chem.* **2016**, *88*, 10151-10157.
Week 10 Nov. 08	**Bioelectrochemistry (Quiz-5-3%) (Participation-1%)** **Learning objectives: Metalloproteins, oxidation of nucleic acids and proteins** **Recommended Reading: Recent advances in electrochemical immunosensors,** W. Wen, X. Yan, C. Zhu, D. Du, Y. Lin, *Anal. Chem.* **2017**, *89*, 138-156. **Artificial cell membrane systems for biosensing applications**, T. Osaki, S. Takeuchi, *Anal. Chem.* **2017**, *89*, 216-231. **Analytical techniques in Neuroscience: Recent advances in imaging, separation, and electrochemical methods.** M. Ganesana, S. T. Lee, Y. Wang, B. J. Venton, *Anal. Chem.* **2017**, *89*, 314-341.
Week 11 Nov. 15	**In vivo electrochemistry and Photoelectrochemistry (Quiz-6-3%) (Participation-1%)** **Learning objectives: Electroanalysis of neurotransmission and exocytosis, electrogenerated chemiluminescence (ECL), biosensors based on ECL.** **Recommended Readings: In vivo analysis with electrochemical sensors and biosensors**, T. Xiao, F. Wu, J. Hao, M. Zhang, P. Yu, L. Mao, *Anal. Chem.* **2017**, *89*, 300-313. **Recent advances in electrochemiluminescence analysis**, L. Li, Y. Chen, J.-J. Zhu, *Anal. Chem.* **2017**, *89*, 358-371.
Week 12 Nov.	**Future directions of electrochemical sensors and biosensors (Quiz-7-3%) (Participation-1%)**

22	
Week 13 Nov. 29	**REVIEW GAME (2% Bonus mark opportunity, more details will be given in the course) (Participation-1%)**

Policies & Statements

Plagiarism Detection Tool

Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (https://uoft.me/pdt-faq).

Academic Integrity

The University treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters (http://www.governingcouncil.utoronto.ca/policies/behaveac.htm) outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences.

Potential offences in papers and assignments include using someone else's ideas or words without appropriate acknowledgement, submitting your own work in more than one course without the permission of the instructor, making up sources or facts, obtaining or providing unauthorized assistance on any assignment.

On tests and exams, cheating includes using or possessing unauthorized aids, looking at someone else's answers during an exam or test, misrepresenting your identity, or falsifying or altering any documentation required by the University.

Equity, Diversity and Inclusion

The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. U of T does not condone discrimination or harassment against any persons or communities.

The University of Toronto is a richly diverse community and as such is committed to providing

an environment free of any form of harassment, misconduct, or discrimination. In this course, I seek to foster a civil, respectful, and open-minded climate in which we can all work together to develop a better understanding of key questions and debates through meaningful dialogue. As such, I expect all involved with this course to refrain from actions or behaviours that intimidate, humiliate, or demean persons or groups or that undermine their security or self-esteem based on traits related to race, religion, ancestry, place of origin, colour, ethnic origin, citizenship, creed, sex, sexual orientation, gender identity, gender expression, age, marital status, family status, disability, receipt of public assistance or record of offences.

University Land Acknowledgement

I wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca, and the Mississaugas of the Credit. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Accommodations

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the AccessAbility Services Office as soon as possible.

AccessAbility Services staff (located in Rm AA142, Arts and Administration Building) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations 416-287-7560 or email ability.utsc@utoronto.ca. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

Use of Generative Artificial Intelligence Tools

Students may use artificial intelligence tools, including generative AI, in this course as learning aids or to help produce assignments. However, students are ultimately accountable for the work they submit.

Students may not use artificial intelligence tools for taking tests, writing research papers, creating computer code, or completing major course assignments. However, these tools may be useful when gathering information from across sources and assimilating it for understanding.

The knowing use of generative artificial intelligence tools, including ChatGPT and other AI writing and coding assistants, for the completion of, or to support the completion of, an examination, term test, assignment, or any other form of academic assessment, may be considered an academic offense in this course.

Recording of Classroom Material by Students

Recording or photographing any aspect of a university course - lecture, tutorial, seminar, lab, studio, practice session, field trip etc. – without prior approval of all involved and with written approval from the instructor is not permitted.