Syllabus for Instrumental Methods of Chemical Analysis

Course Number	**SC/CHEM 3080 4.0; Section M**
Term	**Winter (W)**
Session	**2023-2024**
Description	**The theory and application of a variety of common modern quantitative instrumental methods. Topics include calibrations; basic electronics; signal processing; optical systems; atomic and molecular absorption and emission spectroscopies; gas, liquid, and ion chromatography; and electroanalytical techniques. This course covers applications to modern chemical analysis of samples relevant to industry, medicine, environment, and others. Three lecture hours, three laboratory hours. One term. Four credits.**
Prerequisites	**SC/CHEM 2080 4.0; SC/PHYS 1010 or SC/PHYS 1410 or SC/PHYS 1420 (or a strong skillset in linear algebra that can be applied to electronics and optics). Permission from the Course Director is required if prerequisites are not met.**
Aim and Purpose of this Course	**The course will cover a variety of topics pertaining to instrumental chemical analysis. You will be provided the opportunity to learn about a wide variety of modern analytical instrumentation starting from their basic components, their theoretical principles of operation, the organization and workflow of instruments, and practical aspects of performing quantitative analysis with instrumentation.**

Purpose of this course:

- **To provide the opportunity to learn the principles of a wide variety of analytical instruments.**
- **To create awareness of the operational components that are used in concert to generate an analytical instrument.**
- **To familiarize you with practical aspects of instrumental methods for quantitative analysis.**
- **To realize the fundamental tool set that any analytical lab requires of its instrumental analysis personnel.**

Course Director	**Dr. Trevor VandenBoer** **(may be addressed as: Dr. Trevor, or Professor VandenBoer)** **Office: CB 344** **Email: profvdb@yorku.ca** **NOTE: I strive to answer emails in a timely manner, typically between 09:00-17:00 on weekdays. It may take up to 3 days to get a response.** **The purpose of email communications should be to obtain brief answers to questions about course materials. In depth questions should be reserved for office hours.** **Dr. VandenBoer will respond ONLY to emails which include:** • **The Course Code (CHEM3080) in the *Subject Line*** • **A professional salutation (e.g. 'Dear Dr. VandenBoer')** • **Your full name and student number as the inquiring student**
Lab Technicians	**Ha B. Au (Wednesday) and Delwar Hossain (Tuesday/Thursday)** **Office: CB240-244** **Email: nebula@yorku.ca, dhossain@yorku.ca**
Lecture Times	**T, R; 10:00 AM; 90 minutes;** **Location: CB121** **NOTE: Lectures will be delivered live and I will strive to have audio will be recorded. These recordings will only be available to students enrolled in the course. However, audio quality and availability could be affected by technical difficulties. Students are strongly encouraged to attend the lectures in-person and be prepared to participate in iClicker discussion questions.**
Office Hours (Hybrid)	**W; 1:00-2:00; CB344 and Zoom Room: https://yorku.zoom.us/j/5024903027** **Office hours can be used to discuss detailed questions about practice problems or course concepts. Office hours can also be used to revisit challenging course concepts. If no other students are present with questions related to the course, office hours are also a time when Prof. VandenBoer is available to provide guidance on developing or improving concepts from pre-requisite courses.**

Laboratory **Room CB 343**

The lab component of CHEM3080 must be passed in order to pass the overall course.

Duration is a 3-hour experiment *every other week* with day and timing based on lab group. All laboratory concerns and conflicts must be addressed with your day's Lab Technician (see above) and Prof. VandenBoer.

The labs will start on the week of January 15, 2024 for orientation on the space and expected practices. The printed lab manual and finalized schedules will be available by January 15 at the Main Chemistry Office (CB124), during their normal business hours. Any changes will be announced on eClass.

Labs are performed with the entire group in your lab section. A list of students for each lab section will be made available on eClass.

Any lab grading issues must be submitted in writing (a brief paragraph) and referring to the grading rubric with a justification for the request. These must be sent to your TA and the Course Director within 1 week of having a lab report returned. Your lab grade may go up, down, or stay the same should such requests be granted.

NOTE 1: You are strongly encouraged to <u>wear a face mask at all times</u> while in the Chemistry Building and CHEM3080 laboratory. Students are expected to use their own mask, but one can be provided if yours is forgotten. We strongly encourage you to wear a well-fitting N95-rated mask to protect yourself and your peers in addition to standard lab personal protective equipment (lab coat, goggles, gloves). Hand sanitizer is provided throughout the building and at the entry to the laboratory. Adhering to proper hygiene protocols is necessary to create a safe lab environment during the ongoing SARS-CoV-2 pandemic.

NOTE 2: The laboratory portion of the course represents a significant fraction of your final grade. To complete the experiments and reports to a satisfactory level, you must prepare for the experiment in the lab manual and the background information in the course textbook *before* coming to the lab:

1. **Read the experiment (theory through discussion questions) in detail at least a day in advance.**

2. Identify any skills and training you have already received related to this lab from CHEM2080 or other courses and ensure you can implement these as required.
3. Review the theory again before coming to the lab on the day of your experiment and, if needed, review the concepts from the textbook and your lecture notes.
4. When conducting the lab, remember to review the discussion questions and start collecting ideas and information on how to address them.

It is possible that could need to perform an instrumental technique before it has been fully covered in the lectures. You are expected to be comfortable with basic analytical techniques (e.g. accurate dilutions) and performing linear regressions, as learned in CHEM 2080. Expect a number of labs to be analyzed using TurnItIn to ensure that the Academic Honesty guidelines of York University are being respected. Any breaches of Academic Honesty will be fully enforced.

Course Texts

Principles of Instrumental Analysis 7th Edition by Skoog, Holler, and Crouch

This is available in the York bookstore and as an eBook. Most analytical chemistry textbooks include sections on instrumentation and can be readily substituted. We will not be comprehensively covering the materials in Skoog, Holler, and Crouch, but many relevant practice problems to prepare for quizzes and the exam are found within. You will be responsible ONLY for topics/concepts covered in class and the assigned problems.

Further supporting materials are held on reserve specifically for students in this course at Steacie Science Library:
Principles of Instrumental Analysis 7th, 6th, and 5th Editions by Skoog, Holler, and Crouch

Student Tools

All students will require the following to participate in the online portions of this course:

- Access to CrowdMark, eClass, and iClicker

Evaluation

<u>NOTE: Both the theory and laboratory components must be passed in order to pass this course.</u>

There are two grading structures for this course to help stay on top of course materials. These are also offered to provide you with flexibility, choices, and autonomy. The two options follow (all dates are tentative):

Option 1 (Default Grading Scheme): Quizzes with Exam

Quizzes (best 5 of 6 x 4% = 20%)
Dates: Jan 25, Feb 13, Feb 27, Mar 12, Mar 26, Apr 4

iClicker Participation (10%) **Throughout the term**
Must be fully completed. Can be done either during lecture or online afterward. Participation only, not for correctness.

Final Exam (30%) **Date set by registrar's office**

Laboratory (4 x 10% = 40%) **Throughout the term**

Option 2: Best 5 of 6 Quizzes and No Exam

Quizzes (best 5 of 6 x 4% = 20%)
Dates: Jan 25, Feb 13, Feb 27, Mar 12, Mar 26, Apr 4

iClicker Participation (10%) **Throughout the term**
Must be fully completed. Can be done either during lecture or online afterward. Participation only, not for correctness.

Laboratory (4 x 10% = 40%) **Throughout the term**

1. **Quizzes (Open Book)**

All course quizzes will be conducted in-person and will be 'open book'. This means that course and study notes, as well as worked practice problems may be used to complete the quiz. These may be hard copy or electronic. If using electronic notes, you will be expected to disconnect from the internet during the quiz. As this is an advanced chemistry course, the use of the internet is more likely to result in erroneous information in addition to being a breach of academic honesty expectations.

Quizzes will be held in CB121 during the lecture timeslot. Question sets with practice problems to aid in preparations for each quiz will be provided alongside the in-lecture example calculations, as well as concepts based on theory from each unit. If a student has accommodations, the Quizzes may be written at the AltExam Centre.

Quizzes are ~45 minutes and consist of ~45 marks. They will take place approximately every other week, beginning on the third week of class (January 24). Quizzes will consist of calculations, short answers, and schematic questions similar to those assigned in the practice problems during the prior week. Quiz questions can also draw on any calculations

and concepts found in the associated lecture materials. The top 5 quizzes will be used to tabulate your total quiz mark in the course. This means that if you miss a quiz, there is no need to worry, as only the top 5 will be used for your total quiz mark. If you miss 2 or more quizzes, the missed portion of your final grade will be transferred to the mandatory final exam.

EXAM EXEMPTION: If you complete 5 out of 6 quizzes during the semester, you will be eligible for exemption from writing the final exam (Option 2). If you complete all 6 quizzes, your lowest quiz score will be dropped when your final grade is calculated. If this 5 out of 6 condition is NOT met, you must write the final exam.

NOTE: All students are expected to be available for the complete final exam period. Conflict with previously made travel arrangements is not an acceptable reason for missed exams.

2. iClicker Participation will be evaluated by:
    - Completion of all of the iClicker assignments to obtain full participation marks.
    - These can be completed during the live lecture or while viewing the lecture on demand.
    - Participation questions are not graded for correctness.
    - The iClicker assignments will be available for a week following the corresponding lectures (or until the end of classes, whichever comes first) to ensure they can be completed.
    - The app 'iClicker REEF' can be downloaded for free on your mobile devices and tablets and is also available at app.reef-education.com for laptops.
    - York has a free subscription to this app, so do NOT make any purchase (even if prompted).
    - Ensure your correct student number is associated with your iClicker account. Failure to do so may mean that your participation is not counted.
    - To find iClicker questions, search for 'CHEM3080 W24' on the iClicker website. They can be found under the 'Assignments' section.

3. Final Exam (Open Book)

The final exam will be 3 hours in duration (180 minutes), consist of ~180 marks, and be conducted in a classroom in-person. The final exam follows the same format and expectations of demonstrating knowledge as the quizzes, including the open book resources allowed. If a student has accommodations, the Exam may be written at the AltExam Centre.

If the final exam is missed, you will need to submit a Deferred Standing Agreement form to Dr. VandenBoer within one week of the missed exam.

4. Laboratory

The lab component of this course consists of an orientation lab that is pass/fail to demonstrate your ability to work safely and demonstrate competence before working with expensive analytical instrumentation. This is also a free opportunity to gain feedback on core components of all lab reports (e.g. regression statistics, uncertainty, etc.) that are essential to your success in the course.

You will complete four (4) lab reports over the course of the term that are worth 20 marks each, for a total of 10% each of your final grade in this course. Lab reports will be submitted through CrowdMark and TurnItIn on eClass. Feedback will be provided by your TAs on each report before the next one is due. Reviewing and implementing this feedback prior to each subsequent report submission is critical to your improvement in the labs and success in this course.

If you miss a lab due to illness, contact your respective Lab Technician and Dr. VandenBoer in order to schedule a make-up date for your experiment.

Final Grade The Faculty of Science approved letter grades

NOTE: The numerical grades used throughout the course are only guides for assigning final approved letter grades. Students must keep track of their own numeric grades as values returned through eClass are not guaranteed. The course director retains the prerogative on how to use numerical grades to assign letter grades. Quiz and laboratory marks are made available to students. However, a final numerical mark for the course is not disclosed to the student.

NOTE 2: Grades are not negotiable. A regrade request for course components can be made using a clear written statement of less than half a page to Prof. VandenBoer outlining the concerns. Regrading may cause your marks to increase, decrease, or stay the same as the entire assessment may be re-evaluated. The resulting grade will be final.

Course Content

The course will cover topics pertaining to instrumental chemical analysis. You will be provided the opportunity to learn about a wide variety of modern analytical instrumentation starting from their basic components, their theoretical principles of operation, the organization and workflow of instruments, and practical aspects of performing quantitative analysis with instrumentation.

Learning Objectives

Successful completion of the theory in this course should enable you to:

- Relate concepts from CHEM 2080 to those in CHEM 3080. Review and cross-reference concepts as necessary.
- Explain the theoretical principles underpinning quantitative instrumental techniques and their applications.
- Calculate voltages, currents, resistances, and other quantities relevant to generating detector signals converting them into numbers with chemical meaning.
- Assess the appropriateness of instrumental methods for the quantitative analysis of samples in various formats using theoretical and practical principles of instrumental operation.
- Describe the components of each of the analytical instruments studied utilizing a box-schematic.
- Describe the operational parameters and utility of each component of an instrument.
- Compare a variety of instruments for a particular use, including the ability to identify limitations and capabilities.
- Solve multi-step problems dealing with the quantitative analysis of samples from instrument data through sample concentrations and their associated uncertainties.

Successful completion of the lab in this course should enable you to:

- Carry out high precision and accuracy chemical analysis laboratory activities, in-person, with safety and reliability in a laboratory setting.
- Operate instruments as chemical analysis techniques and perform basic troubleshooting of common technical issues.
- Conduct calculations used in quantitative instrumental analysis.
- Set and appropriately adjust the operating parameters of different instruments as necessary for their use.
- Perform calibration and quantitative analysis on samples with known and unknown composition.
- Interpret and interpolate conclusions from experimental data correctly.
- Account for sources of error and noise in instrumental analyses in order to evaluate the reliability of data produced by your work.

- Use chemical analysis terminology appropriately in the context of scientific writing.
- Write, recognize, and successfully identify and implement scientific citations.
- Predict experimental results.

Course Units

1. Calibrations and Method Selection
   - External Calibration
   - Standard Addition
   - Internal Standards

2. Analytical Separations I
   - Separation Theory
   - Gas Chromatography

3. Electrical Components and Circuits
   - Basic Components
   - Operational Amplifiers
   - Digital Electronics
   - Signals and Noise

4. Analytical Spectrophotometry
   - Optical Components
   - Atomic Absorption
   - Atomic Emission
   - Molecular Spectroscopy (UV-Vis)
   - Luminescence Spectroscopy

5. Analytical Separations II
   - Ion Chromatography
   - Liquid Chromatography

6. Electroanalytical Techniques (time permitting)

Awareness

Students must make themselves aware of York University policies on Academic Honesty/Integrity, Access/Disability, Student Conduct, Religious Observance and other matters. A periodically updated Information Sheet summarizing this information can be downloaded* and printed, and the Registrar's Office issues a list of Religious Observance Days.‡

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http://secretariat.info.yorku.ca/files/CourseInformationForStudentsAugust20121.pdf
‡ http://registrar.yorku.ca/enrol/dates/religious-accommodation-guidelines-2018-2019

https://www.yorku.ca/secretariat/policies/policies/academic-accommodation-for-students-religious-observances-policy-guidelines-and-procedures/

Accessibility and religious accommodations

- Students already registered with Accessibility Services must submit accommodation letters to via email to Dr. VandenBoer by January 31, 2024. If obtained after this date, please provide as soon as possible to ensure these are enacted.
- Any religious observance conflicts occurring at any point during the term should be communicated by email to Dr. VandenBoer at least three weeks prior to the course component.
- Note: "Senate policy states that students are expected to monitor their progress in courses, taking into account their personal and academic circumstances, and to make the necessary adjustments to their workload to meet the requirements and deadlines." (from Senate Policy of Students' Responsibilities in the Petition/Appeal Processes).
- The drop deadline is March 11, 2024.

Academic honesty

- Any student who breaches York's Academic Honesty Policy will be reported. Some examples of offences include:
  - Plagiarism.
  - Students who misrepresent themselves during iClicker activity, a quiz, or examination or provide documentation for absence from any of these that is not legitimate.
  - Students who submit any material for remarking that has been modified in any manner to misrepresent the original assessment.
- Ignorance of the policies is not an acceptable defense. https://spark.library.yorku.ca/academic-integrity-what-is-academic-integrity/

I hope you enjoy this course, and please feel free to reach out if you have any questions or concerns at any time. I am here for you. It is my hope that our class will support diversity of experience, thought, and perspective.