


# CHEM 2302

Fall 2023



**Instructor:**

Professor Jeff Smith  
Office: Steacie 225  
Phone: (613) 520-2600 ext.2408  
E-mail: [jeff.smith@carleton.ca](mailto:jeff.smith@carleton.ca)  
 @profjeffsmith

**Lectures:**

Tuesdays and Thursdays, 11:35am-12:55pm  
In person in Nideyinàn (former UC) 180

**Textbook:**

Quantitative Chemical Analysis by Daniel C. Harris, 10<sup>th</sup> Ed., Freeman, 2020. Hard copies available for purchase at Haven Books ([havenbooks.ca](http://havenbooks.ca)) or you get a one term access to the e-book when you purchase Achieve.

**Course website:**

Brightspace will be used. Please visit <https://brightspace.carleton.ca> for course-related materials.

**Office hours:**

See slide 4.

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**Course description:** Analytical measurement process. Sampling and sample preparation techniques. Instrumental methods of analysis including absorption spectrophotometry (UV-visible, IR), molecular fluorimetry, atomic spectrometry, inductively coupled plasma atomic emission and ion chromatography. Experimental methodologies for various organic, inorganic, geological and industrial analyses.

**Preclusion:**

Additional credit for CHEM 2300

**Prerequisites:**

CHEM 1000 or CHEM 1101, MATH 1007 and MATH 1107

**Lectures three hours a week, laboratory three hours a week**

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## **Homework Management System:**

This year a homework management platform will be bundled with the QCA10e textbook called Achieve. It will allow you to work through problems related to the material we are learning to solidify concepts in your mind and help you understand how to relate the theoretical knowledge you are learning to practical situations. The material on Achieve will resemble the types of questions that you will see on Midterms and the Final Exam.

There will be a component of your final grade attributed to your interactions with the Achieve system.

You can access Achieve through this course in Brightspace.

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**Homework Management System:**

Please note that Achieve is a 3<sup>rd</sup> party tool that is integrated into Brightspace and has been vetted by Carleton University for privacy and security. It is not directly licensed or supported by the University. However, I have determined that it is the best tool to meet the learning outcomes in this course. If you have questions or need support with this tool, please contact me. If you have accessibility issues using this tool, please let me know and I will work with the Paul Menton Centre to find solutions for you.

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## Office hours:

This year CHEM 2302 will be co-taught by myself (Jeff) and Christian Rosales. Christian taught this course in 2021 and has been a TA in the course for many years. To better benefit your experience in CHEM 2302, Christian will be handling all administrative and office hours aspects of the course this year. Christian will be in charge of office hours, answering questions about the syllabus or course content, issues or questions relating to Achieve, or any homework or course notes. If you wish to see a midterm exam after it is marked, please reach out to Christian.

[ChristianRosales@cmail.carleton.ca](mailto:ChristianRosales@cmail.carleton.ca)



**Clickers:**

Poll Everywhere will be used for class polling every week for interactive and educational purposes. Cell phones, smart phones and WiFi connected laptops may be used to interact with these polls via text messaging and online answering. The use of Poll Everywhere is free, except if your cellular service provider charges for text messages; due to this, and the technological nature of Poll Everywhere, class participation is encouraged, but not mandatory.

**Laboratory:**

Section A1 – Thursday 1:35-4:25pm – SC 305

Section A3 – Tuesday 1:35-4:25pm – SC 305

Section A4 – Tuesday 8:35-11:25am – SC 305

Section A5 – Thursday 8:35-11:25am – SC 305

**WHMIS:**

All students registered in this course must successfully complete online training in the **Workplace Hazardous Materials Information System** (WHMIS) before being allowed to enter the laboratory. The training course takes about 2 hours to complete. If you have done the training before, there is no need to repeat it. If you have not completed the training, email the CHEM 2302 Laboratory Coordinator Graham Galway at [grahamgalway@cunet.carleton.ca](mailto:grahamgalway@cunet.carleton.ca).

## Laboratory Coordinator:

Graham Galway – [grahamgalway@cunet.carleton.ca](mailto:grahamgalway@cunet.carleton.ca)

## Teaching assistants:

Keri Malanchuk - [KeriMalanchuk@cmail.carleton.ca](mailto:KeriMalanchuk@cmail.carleton.ca)

Sarah Larose - [SarahLarose3@cmail.carleton.ca](mailto:SarahLarose3@cmail.carleton.ca)

Tianqi Li - [TianqiLi@cmail.carleton.ca](mailto:TianqiLi@cmail.carleton.ca)

Hieu Le - [MinhLe@cmail.carleton.ca](mailto:MinhLe@cmail.carleton.ca)

## Laboratory details:

(a) Laboratories are scheduled to begin in the week of September 11<sup>th</sup>. The first lab will be an introductory session that is **mandatory to attend** to learn about the format of labs in CHEM 2302 as well as be trained on basic lab skills that will pertain to the rest of the labs in this course – please make sure you attend!

(b) The lab timetable is printed on p. 5 in the lab manual; students should prepare for each lab accordingly. The new lab manual will be available electronically (via Brightspace) and careful notes on each lab should be made by each student.



## Laboratory details (cont.):

(c) The wearing of safety glasses and lab coat is MANDATORY at all times. They can be purchased from the Science Stores. Contact lenses should NOT be worn in the lab. Prescription glasses with safety lenses are permissible; if the glasses are small, goggles will have to be used. **See the safety rules on page 6 of the lab manual.**

(d) Due to the timing and equipment limitations, it is impossible to coordinate the labs and lectures. The lab manual contains some general information in the Introduction section of each experiment. Students may refer to the textbook for more theory of the technique and method.

(e) Satisfactory completion of the lab is required to pass the course. This includes performing all the experiments as scheduled, recording the output signals in the lab, analysing the data at home, and submitting your results on time in either an analysis report form (pages 16-18 in the lab manual), a short report (page 19 in the lab manual) or a formal report (pages 20-21 of lab manual).

Late deductions: **10% per business day.**



## Laboratory details (cont.):

### NEW FOR THIS YEAR: CHEM 2302 Laboratory Primer Videos!

These short (2-3 min) videos will give you an overview of what to expect in the labs for CHEM 2302 to help you prepare and manage your expectations going into each lab. **They are not a substitute for reading the lab manual!** They are to complement the lab manual and help you understand what you will be doing as you read through the lab manual (and do the pre-lab) prior to every lab. The goal of these videos is to help you hit the ground running for each lab to ensure success and efficient time management.

Experiment 1 – Ion Chromatography of Anions in Drinking Water with Conductivity Detection

Experiment 2 – Determination of Fluoride in Drinking Water by Ion Selective Electrode Potentiometry

Experiment 3 – Determination of Lead, Cadmium and Copper in Drinking Water by Differential Pulse Anodic Stripping Voltammetry

Experiment 4 – Determination of Copper in Drinking Water by Atomic Absorption Spectroscopy

Experiment 5 – Gas Chromatography of Polycyclic Aromatic Hydrocarbons with Flame Ionization Detection

Experiment 6 – Monitoring Carbonyls by 2,4-Dinitrophenylhydrazine Derivatization and Reversed-Phase High-Performance Liquid Chromatography

Experiment 7 – Determination of Vitamin C using Oxidation-Reduction Titrimetry

<https://www.youtube.com/watch?v=er0xs2834I8&list=PLABFzZMgnynH1oojzoxCL72sMJvJ1qU5g&pp=gAQBIAQB>

Assignments: Questions and problems will be assigned through the Achieve Homework Platform to help solidify your understanding of the class material. **Interaction with Achieve will be graded.**

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### Grading:

The final grade for Chemistry 2302 will be based on the following:

Laboratory component:

1) Formal reports (2 @ 7%)	14.0%
2) Short report (1 @ 2.1%)	2.1%
3) Analysis reports (4 @ 1.4%)	5.6%
4) Lab notebook (post-lab)	2.8%
5) Lab assignment	5.25%
6) Teaching assistant's evaluation of correct laboratory techniques, manipulative skills, and pre-lab preparation	3.5%
7) Online pre-lab quizzes on Brightspace	1.75%
<b>Laboratory subtotal:</b>	<b>35.0%</b>

<b>Achieve:</b>	<b>5.0%</b>
<b>Midterm #1:</b>	<b>12.5%</b>
<b>Midterm #2:</b>	<b>12.5%</b>
<b>Final Exam:</b>	<b>35.0%</b>
<b>Total:</b>	<b>100.0%</b>

(Bell curving will not be used on laboratory, midterm, exam or final marks)

## Fine print:

### **Academic Accommodation for Students with Disabilities:**

Carleton University is strongly committed to providing access and accommodation for all individuals with identified and duly assessed disabilities. The University has a Senate-approved policy on Academic Accommodation that forms part of its Human Rights Policy. This policy should be consulted for further information and is available at the front of this Calendar and online at: [www.carleton.ca/equity](http://www.carleton.ca/equity). The policy promotes efforts to accommodate students with disabilities so that they will have the opportunity to meet learning objectives and be fairly evaluated in their performance. In no case, however, does academic accommodation negotiate away, lower, or remove the academic standards and learning objectives of any course or program, rule, regulation, or policy at the University.

The Paul Menton Centre for Students with Disabilities ([www.carleton.ca/pmc/](http://www.carleton.ca/pmc/)) is the designated unit at the University for assisting the Carleton community in integrating persons with disabilities into all aspects of Carleton's academic and community life. The Paul Menton Centre provides assessment of academic accommodation, advises students on strategies to open a dialogue with instructors and acts as consultant, facilitator, coordinator and advocate in this area for all members of the University community.

The Paul Menton Centre provides individualized support services, based on appropriate and up to date documentation, to persons who are deaf or hard of hearing, with learning disabilities, attention deficit disorder (ADD), visual impairments, head injuries, physical disabilities including mobility impairments, or who have psychiatric, other medical or non-visible disabilities. Students are responsible for applying for special services by making an appointment with the appropriate coordinator at the Paul Menton Centre. All requests will be considered on the basis of individual need. Students are advised to come to the Centre early in the term to discuss service requests.

Examination accommodations for all tests and examinations (in-class, CUTV, or formally scheduled) must be arranged by specific deadline dates. Please consult the Paul Menton Centre for a list of deadlines for all examinations. Accommodation requests not made prior to the specified deadlines will not be fulfilled. Students with disabilities requiring academic accommodations in this course must register with the Paul Menton Centre for Students with Disabilities for a formal evaluation of disability-related needs. Registered PMC students are required to contact the PMC, 613-520-6608, every term to ensure that I receive your Letter of Accommodation, no later than two weeks before the first assignment is due or the first in-class test/midterm requiring accommodations. If you only require accommodations for your formally scheduled exam(s) in this course, please submit your request for accommodations to PMC by the deadlines published on the PMC website: <http://www2.carleton.ca/pmc/new-and-current-students/dates-and-deadlines/>

### **Academic Accommodation for Students with Religious Obligations:**

Carleton University accommodates students who, due to religious obligation, must miss an examination, test, assignment deadline, laboratory, or other compulsory event. The University has a Senate-approved policy on religious accommodation that forms part of its Human Rights Policy, available at: [www.carleton.ca/equity](http://www.carleton.ca/equity). Students requesting academic accommodation on the basis of religious observance should make a formal, written request to their instructors for alternate dates and/or means of satisfying academic requirements. Such requests should be made during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist, but no later than two weeks before the compulsory academic event. Accommodation is to be worked out directly and on an individual basis between the student and the instructor(s) involved. Instructors will make accommodations in a way that avoids academic disadvantage to the student. Students or instructors who have questions or want to confirm accommodation eligibility of a religious event or practice may refer to the Equity Services website for a list of holy days and Carleton's Academic Accommodation policies, or may contact an Equity Services Advisor in the Equity Services Department for assistance. Students unable to reach a satisfactory arrangement with their instructor(s) should contact the Director of Equity Services. Instructors who have questions or wish to verify the nature of the religious event or practice involved should also contact this officer. For more details visit the Equity Services website [http://www.carleton.ca/equity/accommodation/student\\_guide.htm](http://www.carleton.ca/equity/accommodation/student_guide.htm)

## Fine print (cont):

### **Academic Accommodation for Pregnant Students:**

Pregnant students requiring academic accommodations are encouraged to contact an Equity Advisor in Equity Services to complete a letter of accommodation. The student must then make an appointment to discuss her needs with the instructor at least two weeks prior to the first academic event in which it is anticipated the accommodation will be required. For more details visit the Equity Services website

[http://www.carleton.ca/equity/accommodation/student\\_guide.htm](http://www.carleton.ca/equity/accommodation/student_guide.htm)

### **Student Conduct:**

The University has adopted a policy to deal with allegations of academic misconduct. This policy is expressed in the document Carleton University Academic Integrity Policy, effective July 1, 2006. The policy describes in detail its scope of application, principles, definitions, rights and responsibilities, academic integrity standards, procedures, sanctions, transcript notations, appeal process, and records implications.

The complete policy is available at: [www.carleton.ca/studentssupport](http://www.carleton.ca/studentssupport) or [www.carleton.ca/studentaffairs](http://www.carleton.ca/studentaffairs)

### **Plagiarism:**

Plagiarism is presenting, whether intentional or not, the ideas, expression of ideas or work of others as one's own. Plagiarism includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to: books, articles, papers, literary compositions and phrases, performance compositions, chemical compounds, art works, laboratory reports, research results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, and material on the Internet.

Examples of plagiarism include, but are not limited to:

- submitting a take-home examination, essay, laboratory report or other assignment written, in whole or in part, by someone else;
- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another's data or research findings;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own;
- failing to acknowledge sources through the use of proper citations when using another's works and/or failing to use quotation marks.

For more information, see: [http://www.carleton.ca/studentaffairs/academic\\_integrity/index.html](http://www.carleton.ca/studentaffairs/academic_integrity/index.html)

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

**Pregnancy obligation:** write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: <http://www2.carleton.ca/equity/>

**Religious obligation:** write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: <http://www2.carleton.ca/equity/>

**Academic Accommodations for Students with Disabilities:** The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or [pmc@carleton.ca](mailto:pmc@carleton.ca) for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable) at <http://www2.carleton.ca/pmc/new-and-current-students/dates-and-deadlines/>

You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at <http://www2.carleton.ca/equity/>

# CHEM 2302 Midterm and Final Exam Details

Here is how the midterm and final exam component of CHEM 2302 is going to work:

- There will be 2 midterm exams, one on October 19<sup>th</sup> and one on November 16<sup>th</sup>
  - *These midterms will be designed to take 60 minutes to complete but you will have the whole class time (80 minutes) to finish*
  - *The midterms will be held in person during normal class time (or in the MEC if you have approved accommodation(s) through the PMC)*
  - *Make up midterms will not be offered, if a midterm is missed, the weight of the other midterm and final exam will be adjusted to compensate for the removal of the midterm. If both midterms are missed, your final exam will be worth 65% (not recommended!!)*
- There will be a 3 hour final exam that will take place in December 2023
  - *The exam will be designed to take 120 minutes to complete but you will have 180 minutes to finish*
  - *The exam will be in person and administered by exam services (e.g. in the field house, or in the MEC if you have approved accommodation(s) through the PMC)*

# CHEM 2302 Learning outcomes

- Understand and use analytical terminology
- Conduct quantitative analysis using a calibration curve
- Understand the quality assurance process
- Understand and know how to use chromatographic separation techniques
- Appreciate chemical equilibrium as it relates to analytical chemistry
- Understand how electrochemistry may be used for quantitative analysis
- Understand how buffered solutions are used in analytical chemistry
- Appreciate the many ways analytical chemistry may be used in the world
- Gain practical experience in the use of analytical instrumentation
- Be able to collect and analyze data and report results
- Enhance scientific communication skills in written form
- Improve good laboratory practice (GLP) skills



# Tentative Lecture Schedule\*\*

#	<u>Lecture</u>	<u>Topics</u>	<u>Chapters</u> (N = notes)
1	Sept 7 <sup>th</sup> , 2023	<ul style="list-style-type: none"><li>• Presentation / discussion of syllabus</li><li>• Tips for success</li><li>• Introduction to the analytical process</li><li>• Sample preparation, liquid and solid-phase extraction</li></ul>	N/A N/A Ch. 0 Ch. 28-2, 28-3
2	Sept 12 <sup>th</sup> , 2023	<ul style="list-style-type: none"><li>• Brief tutorial on measurements</li><li>• Brief tutorial on analytical chemistry laboratory tools</li><li>• Brief tutorial on experimental error</li><li>• Brief tutorial on statistics</li><li>• Error calculations</li></ul>	Ch. 1 Ch. 2 Ch. 3 Ch. 4-1, 4-3 Ch. 4-8
3	Sept 14 <sup>th</sup> , 2023	<ul style="list-style-type: none"><li>• Quality assurance and calibration methods</li></ul>	Ch. 5
4	Sept 19 <sup>th</sup> , 2023	<ul style="list-style-type: none"><li>• Introduction to gas chromatography</li></ul>	Ch. 24
5	Sept 21 <sup>st</sup> , 2023	<ul style="list-style-type: none"><li>• Introduction to liquid chromatography</li></ul>	Ch. 23-2
6	Sept 26 <sup>th</sup> , 2023	<ul style="list-style-type: none"><li>• Introduction to atomic spectroscopy</li></ul>	Ch. 21

\*\* – Lecture and test / Midterm schedule is subject to change at the discretion of Professor Smith

# Tentative Lecture Schedule\*\*

#	<u>Lecture</u>	<u>Topics</u>	<u>Chapters</u> (N = notes)
7	Sept 28 <sup>th</sup> , 2023	<ul style="list-style-type: none"> <li>• Chemical equilibrium constant and thermodynamics</li> <li>• Solubility product</li> </ul>	Ch. 6-1, 6-2 Ch. 6-3
8	Oct 3 <sup>th</sup> , 2023	<ul style="list-style-type: none"> <li>• Acids and bases and pH</li> </ul>	Ch. 6-5, 6-6, 6-7
9	Oct 5 <sup>th</sup> , 2023	<ul style="list-style-type: none"> <li>• Titrations</li> </ul>	Ch. 7
10	Oct 10 <sup>th</sup> , 2023	<ul style="list-style-type: none"> <li>• Ionic strength, activity coefficients and true pH</li> </ul>	Ch. 8-1, 8-2, 8-3
11	Oct 12 <sup>th</sup> , 2023	<ul style="list-style-type: none"> <li>• Fundamentals of electrochemistry</li> <li>• Galvanic cells</li> <li>• Standard potentials</li> </ul>	Ch. 14-1 Ch. 14-2 Ch. 14-3
	Oct 17 <sup>th</sup> , 2023	<ul style="list-style-type: none"> <li>• <i>Buffer time to review material for Midterm #1</i></li> </ul>	N/A
	<u>Oct 19<sup>th</sup>, 2023</u>	<ul style="list-style-type: none"> <li>• <b>Midterm #1 on material covered until Oct 10<sup>th</sup></b>  <i>(Test will be designed to take 60 minutes to complete;  however, 80 minutes will be allocated)</i></li> </ul>	<b>Ch. 0, 28-2, 28-3, 5, 6, 7, 8, 21, 23-2, 24, <u>N</u></b>

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# Tentative Lecture Schedule\*\*

#	<u>Lecture</u>	<u>Topics</u>	<u>Chapters</u> (N = notes)
	Oct 23 <sup>rd</sup> – 27 <sup>th</sup> , 2023	• <i>READING WEEK</i>	N/A
12	Oct 31 <sup>st</sup> , 2023	• Nernst Equation • $E^{\circ}$ and the Equilibrium Constant	Ch. 14-4 Ch. 14-5
13	Nov 2 <sup>nd</sup> , 2023	• Electrodes and potentiometry • Reference electrodes • Indicator electrodes • pH measurement • Ion-selective electrodes	Ch. 15 Ch. 15-1 Ch. 15-2 Ch. 15-5 Ch. 15-4, -6, -7
14	Nov 7 <sup>th</sup> , 2023	• Redox titrations	Ch. 16
15	Nov 9 <sup>th</sup> , 2023	• Fundamentals of electrolysis	Ch. 17-1

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# Tentative Lecture Schedule\*\*

<u>#</u>	<u>Lecture</u>	<u>Topics</u>	<u>Chapters</u> (N = notes)
	<i>Nov 14<sup>th</sup>, 2023</i>	• <i>Buffer time / optional review session for Midterm #2</i>	<i>N/A</i>
	<b><u>Nov 16<sup>th</sup>, 2023</u></b>	• <b>Midterm #2 on material from Oct 12<sup>th</sup> to Nov 7<sup>th</sup></b> <i>(Test will be designed to take 60 minutes to complete, however 80 minutes will be allocated)</i>	<b>Ch. 14, 15, 16 and N</b>
<b>16</b>	<b>Nov 21<sup>st</sup>, 2023</b>	• Electrogravimetric analysis • Coulometry • Amperometry	Ch. 17-2 Ch. 17-3 Ch. 17-4
<b>17</b>	<b>Nov 23<sup>rd</sup>, 2023</b>	• Voltammetry	Ch. 17-5
<b>18</b>	<b>Nov 28<sup>th</sup>, 2023</b>	• Buffers • Diprotic Buffers • Isoelectric and isoionic pH	Ch. 9-5 Ch. 10-2 Ch. 10-6
	<i>Nov 30<sup>th</sup>, 2023</i>	• <i>NO CLASS</i>	<i>N/A</i>

\*\* – Lecture and test / Midterm schedule is subject to change at the discretion of Professor Smith

# Tentative Lecture Schedule\*\*

#	<u>Lecture</u>	<u>Topics</u>	<u>Chapters</u> (N = notes)
19	Dec 5 <sup>th</sup> , 2023	• EDTA Titrations	Ch. 12
	<i>Dec 7<sup>th</sup>, 2023</i>	• <i>Buffer time / optional review session for Final Exam</i>	<i>N/A</i>
	<b><u>December</u></b> <b><u>2023</u></b> <b><u>Time: TBD</u></b>	• <b><u>FINAL EXAM</u></b> • The in-person exam will cover all of the material covered in this course and will be 3 hours in duration	<b>Ch. 0, 28-2, 28-3, 23-2, 21, 24, 5, 6, 7, 8, 9-5, 10-2, 10-6, 12, 14, 15, 16, 17 and <u>N</u></b>

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