

UNIVERSITY OF CALGARY
DEPARTMENT OF CHEMISTRY
COURSE SYLLABUS
FALL 2022

COURSE: CHEM 311, ANALYTICAL CHEMISTRY: QUANTITATIVE ANALYSIS

CONTACT INFORMATION

LEC	DAY & TIME	ROOM	INSTRUCTOR	OFFICE	EMAIL
L07	MWF 1:00 – 1:50 PM	ENA 201	Dr. Hans Osthoff	SB 205	hosthoff@ucalgary.ca

The preferred method of contact is by email. Please put “**CHEM 311**” in the subject line of any email correspondence.

Office hours are online, by drop-in during scheduled office hours (Thursday 12-1 pm, Friday 2 - 3 pm), or by appointment. A zoom link will be posted on D2L.

For registration or course planning assistance, email science.advising@ucalgary.ca or call 403-220-8600.

Departmental Office: Room SB 605, e-mail: chem.info@ucalgary.ca.

Course web site: <https://d2l.ucalgary.ca/d2l/home/472344>.

COURSE DESCRIPTION

Lectures: Principles and practice of precision measurement in chemistry. Statistical treatment of data. Acid-base and oxidation-reduction equilibria. Complexometric analysis.

Laboratory: Quantitative analysis of organic and inorganic materials.

TEXTBOOK

The following text is recommended for study in CHEM 311. **Older editions are acceptable**; however, it is the students' sole responsibility to ensure that s/he can identify the appropriate chapter readings and practice problems in alternate texts.

Quantitative Chemical Analysis, 10th Ed.; Daniel C. Harris and Charles A. Lucy, 2020, W.H. Freeman and Company.

This text is available for purchase in e-book, loose-leaf, or hardcover format at the [U Calgary bookstore](#), [via the publisher web site](#), and other retailers. The e-book of this text is accessible in the [TFDL](#) - see <https://sites.google.com/macmillan.com/Chem311f22/home> or the instructions posted on D2L.

A physical copy of the 9th edition of this text has been requested to be put on 2-hour reserve in the library.

Supplemental resource: **Analytical Chemistry 2.1: David Harvey, 2016, published online:**

http://dpuadweb.depauw.edu/harvey_web/eTextProject/version_2.1.html

[https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Analytical_Chemistry_2.1_\(Harvey\)](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Analytical_Chemistry_2.1_(Harvey))

Students will need to supplement readings from Analytical Chem 2.1 with material from Harris & Lucy (above) for some course topics – see D2L for detailed course readings. This text does not cover all required course material.

OTHER REQUIRED SUPPLIES

To access the course and complete the required assignments, you will need:

Required for lab:

- Personal protective equipment (PPE): Lab coat and safety glasses / goggles.
- Lab notebook – *recommended*: blue or black “lab notebook” from the bookstore (can be used for 311+315+515 until you run out of space) –see requirements in the lab manual for type of book.

Required for lecture/class (in the unlikely event that the class will switch to an online format):

- A **computer**, laptop or tablet that has installed / can run:
 - A modern **web browser** – for accessing D2L and viewing course videos
 - If you will participate in lecture activities virtually: **Zoom** (with a functioning microphone)
 - **PDF viewer** (e.g., Acrobat Reader, Nitro Reader). *Preview* or in-browser reader is not sufficient.
 - **Excel 365** – (full version, not iOS or web version – or equivalent software). Also free for students.
 - **Word processor** (e.g., Word 365)
 - **PDF printer** (or ability to export / save documents to PDF from OneNote, Word, and Excel)
- A **scanner** or phone app that can save documents/photos as PDF (e.g., OneDrive app)

TOPICS INCLUDED AND SUGGESTED TEXTBOOK READINGS

Chapter references are from the Harris 10th ed. textbook.

TOPIC 1: INTRODUCTION TO ANALYTICAL CHEMISTRY

Chapter 0: The Analytical Process

Chapter 1: Measurements

Chapter 2: Tools of the Trade

AFTER STUDYING THIS TOPIC, YOU SHOULD BE ABLE TO:

- Explain the general principles of quantitative analysis.
- Identify common analytical methods and equipment and describe their correct usage.

TOPIC 2: UNCERTAINTY AND ERROR ANALYSIS

Chapter 3: Experimental Error

Chapter 4: Statistics (4.1-4.6)

AFTER STUDYING THIS TOPIC, YOU SHOULD BE ABLE TO:

- Identify sources of uncertainty in chemical measurements.
- Use appropriate statistical techniques to describe and quantify the uncertainty in chemical measurements.

TOPIC 3: QUANTITATIVE ANALYSIS: EQUILIBRIUM AND TITRATIONS

Chapter 6: Chemical Equilibrium

Chapter 7: Let the Titrations Begin

Chapter 8: Activity and the Systematic Treatment of Equilibrium

Chapter 9: Monoprotic Acid-base Equilibria

Chapter 10: Polyprotic Acid-base Equilibria

Chapter 11: Acid-base Titrations

Chapter 12: EDTA Titrations

Chapter 14: Electrochemistry fundamentals (review)

Chapter 15: Electrodes and Potentiometry (15-1 - 15-7; time permitting)

Chapter 16: Redox titrations (time permitting)

AFTER STUDYING THIS TOPIC, YOU SHOULD BE ABLE TO:

- Use equilibrium principles to quantitatively describe the composition of solutions:
 - Monoprotic and polyprotic acids and bases.
 - Metal ions with chelating reagents.
 - Sparingly soluble compounds.
- Describe (qualitatively and quantitatively) the changes that occur in these solutions during a titration.
- Explain and apply important titration techniques, including endpoint detection, back titration, masking interferants.
- Describe the effect of analyte concentration on electrochemical potential and how potentiometry is used in endpoint detection.

Students are responsible for all material included in [lecture and laboratory components](#). Some examinable course material may not be addressed directly in lecture but will be discussed in the laboratory or in the assigned readings and homework.

IN-PERSON LABORATORY EXPERIMENTS (10 SESSIONS)

④ "TRAINING CAMP"

3 sessions of hands-on skill development.

④ ANALYSIS FOR SODIUM CARBONATE

Skills: Standardization, primary standards, acid-base titrations.

④ ANALYSIS OF AN ACID MIXTURE

Skills: Potentiometric (pH) titrations, acid-base titrations, correcting for non-removable impurities.

④ DETERMINATION OF SOLUBLE CHLORIDE

Skills: Volhard titration, Back titration, precipitation, filtration, argentometric titration.

④ ANALYSIS FOR COPPER IN BRASS

Skills: Iodometric titration, sample preparation, alternation of analyses.

④ DETERMINATION OF ETHYLENE GLYCOL BY FUNCTIONAL-GROUP ANALYSIS

Skills: Redox titration, primary standards.

④ DETERMINATION OF NTA IN DETERGENT BY POTENTIOMETRIC TITRATION

Skills: Potentiometric titration, ion-selective electrodes, Gran plots, surfactant analysis.

④ ANALYSIS OF CALCIUM IN LIMESTONE BY COMPLEXIMETRIC TITRATION

Skills: EDTA titration, complexation reactions.

WHILE COMPLETING THE LABORATORY COMPONENT, YOU WILL:

- Develop hands-on lab skills and perform chemical manipulations with high precision and accuracy.
- Determine the most relevant sources of uncertainty/error in analytical techniques.
- Demonstrate appropriate record-keeping by keeping a lab notebook that conforms to professional and ethical standards.

LABORATORY GRADING

Full details are given in the lab manual posted on the course's web site at <https://d2l.ucalgary.ca/d2l/home/472344>.

For the 7 analysis labs, you will hand in a numerical **report of analysis**, which will be graded out of 5 based on accuracy. If you receive a grade of 1.9 or lower, you are encouraged to meet with your TA to discuss your performance while completing the form.

EXAMS

There are **three exams** in this course: two midterms and a final exam.

The two **midterms are not cumulative** – a outline of content included in each exam will be communicated in class and posted to D2L approximately one week before the exam.

The **final exam is cumulative** and will include all lecture and laboratory content of the course (including readings, suggested text questions, case study activities, etc.).

Exams are **closed book** and written **in-person**. As part of your exam preparation, you will bring a **data/formula sheet** to the exam and hand it in along with your exam paper as part of your grade (make sure to put your name on it). Details on the content and format of these sheets will be on the course D2L.

TENTATIVE LECTURE & LABORATORY SCHEDULE (FALL 2022)

Week	Schedule for Lecture Topics (Subject to change)	Lab Schedule
Sept 5 - 9 <i>Labour Day: Sept 5</i>	Introduction The Analytical Process	M, T, W sections: <i>No labs</i> *Thurs. and Fri sections: Check-in & TC1
Sept 12 - 16	Chemical measurements I-II Tools of the trade I	Check-in and Training Camp 1 *Thurs. and Fri sections: TC2
Sept 19 - 23	Tools of the trade II + Graphing with Excel™ Let the titrations begin I-II	Training Camp 2 *Thurs. and Fri sections: TC3
Sept 26 - 30 <i>Sept 30: No classes/labs</i>	Experimental error I-II National Day for Truth and Reconciliation	Training Camp 3 *Thurs. and Fri sections: No Lab
Oct 3 - 7	Experimental error III Statistics I-II	Analysis of Carbonate
Oct 10 - 14 <i>Oct 10: No classes/labs</i>	Thanksgiving Day Statistics III Review	No labs
Oct 17-21	Midterm 1: Mo Oct 17 (in class) Equilibrium I+II	Analysis of a Mixture of Acids
Oct 24-28	Activity Systematic treatment of equilibrium Monoprotic acids and bases	Analysis of Chloride (Volhard)
Oct 31 - Nov 4	Polyprotic acid-base equilibria I Acid-base titrations I Polyprotic acid-base equilibria II	Analysis of Cu in Brass
Nov 7-11	No Classes	No labs
Nov 14-18	Acid-base titrations II Review Midterm 2: Fri Nov 18 (in class)	Analysis of Glycol
Nov 21-25	Kjeldahl and titration curves with spreadsheets EDTA titrations I+II	Analysis of NTA in detergent
Nov 28 - Dec 2	Electrochemistry fundamentals I Electrochemistry fundamentals II Electrodes and Potentiometry I	Analysis of Ca in Limestone & Check-out
Dec 5-7	Electrodes and Potentiometry II Review	No labs
<i>Classes End: Dec 7</i>	<i>Final Exam Period: Dec. 10 (Sat) - Dec. 21 (Wd)</i>	