

UNIVERSITY OF CALGARY
DEPARTMENT OF CHEMISTRY
COURSE SYLLABUS
FALL 2021

COURSE: CHEM 311, ANALYTICAL CHEMISTRY: QUANTITATIVE ANALYSIS

CONTACT INFORMATION

LEC	DAY & TIME	ROOM	INSTRUCTOR	OFFICE	EMAIL
LO1	MWF 1 - 1:50 PM	ST 140	Dr. Amanda Musgrove	SA 144F	amanda.musgrove@ucalgary.ca

Office hours are by appointment – request online via:

<https://outlook.office365.com/owa/calendar/AmandaMusgrove@uofc.onmicrosoft.com/bookings/>

To help me reply faster, please put “CHEM 311” in the subject line of any email correspondence.

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 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, 2020, W.H Freeman and Company.

A copy of this text has been requested for 2-hour reserve in the library. (Availability pending library reserves reopening)

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

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

Students will need to supplement readings from Analytical Chem 2.1 with material from Harris (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:

- Lab coat
- 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.
- Non-medical masks or approved face covering

Required for lecture/class:

- 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 15: Electrodes and Potentiometry

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 laboratory or in the assigned readings and homework.

IN-PERSON LABORATORY EXPERIMENTS (10 SESSIONS)

① "TRAINING CAMP"

3 sessions of hands-on skill development.

② ANALYSIS FOR SODIUM CARBONATE

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

③ 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.

⑤ ANALYSIS FOR COPPER IN BRASS

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

⑥ DETERMINATION OF ETHYLENE GLYCOL BY FUNCTIONAL-GROUP ANALYSIS

Skills: Redox titration, primary standards.

⑦ DETERMINATION OF NTA IN DETERGENT BY POTENTIOMETRIC TITRATION

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

⑧ 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 AND OUT OF SPEC (OOS) REPORTS

Full details are given in the Chem 311 lab manual (available on D2L).

For the 7 analysis labs, you will hand in a numerical **report of analysis**, which will be graded /5 based on accuracy. If you receive a grade of 1.9 or lower, you should complete an *Out of Spec (OOS) Report* (form available on D2L). You are encouraged to meet with your TA to discuss your performance while completing the form. Your TA will 'sign off' on completion of the form.

"CASE STUDY" ACTIVITIES

Case Study group assignments will be completed **every Friday during scheduled class time**. These activities will be completed collaboratively during class time, with a short, individually-completed followup D2L "quiz" afterwards (24h availability window). Each week's Case Study will focus on the topics that have been covered in class up to that point, focusing on the material in the videos assigned for that Monday.

EXAMS

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

The two **midterms are not cumulative** – a detailed outline of content included in each exam will be 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. Details on the content and format of these sheets will be on the course D2L.

TENTATIVE LECTURE & LABORATORY SCHEDULE

Week Starting:	Schedule for Lecture Topics (Approximate)	Lab Schedule
Sept 6 <i>Labour Day: Sept 6</i>	Introduction The Analytical Process	M, T, W, F sections: <i>No labs</i> *Thurs. sections: Check-in & TC1
Sept 13	Theory of Titrations I Uncertainty in Measurements	Check-in and Training Camp 1 *Thurs. sections: TC2
Sept 20	Uncertainty in Measurements Statistics	Training Camp 2 *Thurs. sections: TC3
Sept 27 <i>Sept 30: No classes/labs</i>	Statistics Hypothesis Testing	Training Camp 3 *Thurs. sections: No Lab
Oct 4	Solubility Equilibria Activity	Analysis of Carbonate
Oct 11 <i>Thanksgiving: Oct 11</i>	Systems of Equilibria Potentiometry Midterm 1: Fri Oct 15 (in class)	No labs
Oct 18	Potentiometry Theory of Titrations II	Analysis of a Mixture of Acids
Oct 25	Solubility Titrations	Analysis of Chloride (Volhard)
Nov 1	Acid-base Equilibria Polyprotic Acids and Bases	Analysis of Cu in Brass
Nov 8	No Classes	No labs
Nov 15	Acid-Base Titrations Midterm 2: Fri Nov 19 (in class)	Analysis of NTA in detergent
Nov 22	Acid-Base Titrations EDTA Titrations	Analysis of Glycol
Nov 29	EDTA Titrations	Analysis of Ca in Limestone & Check-out
Dec 6	Redox Titrations	No labs
<i>Classes End: Dec 9</i>		<i>Final Exam Period: Dec. 11-22</i>