

**Quantitative Chemical Analysis (CHEM 3000), 3 credits**

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**Professor:** Yi Rao

**Class meeting place & time:** Face-to face, ESCL046, MWF 12:30 - 1:20 pm

**Contact Information:** Phone: 435-797-0640; e-mail: yi.rao@usu.edu

**Office Hours:** Zoom, Thursday (4:00 -5:00 pm) and Friday (4:00 - 5:00 pm)

**Help session (UTF):** Ayzia Johnson; email: ayzia.johnson@usu.edu

**Help session time & place:** Zoom, Wednesday 2:00 - 5:00 pm

**Office hours (zoom)**

Thursday (4:00 -5:00 pm). Meeting ID: 847 6704 2410. Passcode: chem3000

Friday (4:00 - 5:00 pm). Meeting ID: 889 7372 3575. Passcode: chem3000

**Help sessions (zoom)**

Wednesday (2:00 -5:00 pm). Meeting ID: 865 7801 9714. Passcode: 110442

**Covid Precautions:**

- USU is encouraging everyone to wear a mask in class.
- A COVID vaccine is the most powerful tool we currently have against infection. If you haven't yet been vaccinated, I urge you to consider getting the vaccine.
- If you are sick (even mild symptoms), don't come to class. Let me know and I will make sure that you will get to participate.
- If you think you have COVID, get tested. USU has free testing: <https://www.usu.edu/covid-19/testing/index>.
- If you stay home sick, test positive for COVID or are exposed to someone who has COVID, fill out the questionnaire on the top right of the page <https://www.usu.edu/covid-19/testing/index>. You will be sent instructions on what to do.

**Course Description:** The goal of this course emphasizes on the quantitative aspects of the basic analytical chemistry. The topics of the course include statistical treatment of data, error analysis, quality assurance, gravimetric and volumetric methods, titration analysis, chemical equilibria (solubility, acid-base, complexation, and oxidation/reduction), introductory electrochemical analysis, introductory spectroscopic analysis, and introductory chemical separations.

**Course Objectives:**

- To understand the goals of analytical chemistry, i.e., the questions analytical chemists seek to answer, and the steps required to perform quantitative analysis.
- To understand the importance of stoichiometry and chemical equilibrium in chemical analysis. Be able to apply these concepts to analytical problem solving.
- To understand how chemical reactions may be utilized for the quantitative measurement of one or more compounds (analytes) in a sample.
- To develop critical reasoning skills so that a student can calculate the concentration of analyte in an unknown sample, given an appropriate set of data.

- To develop a greater understanding of relevant chemical equilibria (solubility, acid-base, complexation, and oxidation/reduction), and to apply this knowledge in solving different types of equilibrium-based problems (pH, principal species, fractional composition, etc.).
- To understand how selected forms of instrumental analysis (i.e., potentiometry, spectrophotometry, and chromatography) may be utilized for quantitative measurements in each.
- To understand the difference between accuracy and precision and the figures of merit used to quantify them (relative error and relative standard deviation).
- To be able to perform basic statistical tests such as the Grubbs-test and the t-test on one or more sets of data.
- To understand the sources for error in chemical measurements and account for errors in data analysis
- To be able to evaluate and employ proper analytical standards and be able to formulate suitable standardization strategies
- To be able to apply basic spectrophotometric methods for various chemical analyses.
- To understand how chemical separations simplify otherwise very complex chemical analyses.

**Required textbooks and other materials:**

- Quantitative Chemical Analysis 9th Edition by Daniel C. Harris. W.H. Freeman and Company. ISBN 1-4292-1815-0.
- Scientific Calculator
- Igor 8.0 will be provided.

**Course Fees:** No.

**Preview lecture notes** are usually posted in advance on the Canvas.

**Lecture notes** are updated after the lecture based on student feedback.

**Attendance** is important. If you have good attendance and turn in your assignments (homework) on time, you will be awarded extra bonus credit at the end of the term.

**Homework:** Homework will be assigned. Due dates for these assignments will be made when homework is announced. Most of the problems are those found at the end of the chapter in your textbook. If you want good grades in your exams, do the homework and if you have to, do extra problems at the end of the chapter. By taking time to work on extra problems before the exam, you will be better prepared for the exam problems. Working problems in the book is an ideal way to prepare for this course. Homework will be submitted as a file upload through canvas on a designated weekday.

**Zoom meeting:** Zoom meetings will be used when necessary. If it happens, you will be notified.

**Help Sessions:** There is One Help Session every week. Ayzia Johnson (UTF) will run the session. It is scheduled on Wednesday from 2:00-5:00 pm. Please make full use of this opportunity.

**I-Clicker:** i-clicker will be used in the classroom for two purposes: 1) check attendance; 2) in-class exercises.

**Grading:** Three exams and one cumulative final exam will be given. See course outline below for tentative dates for each exam and the material to be covered. There will be no graded homework. Only written medical excuses or other (documented) extenuating circumstances will be accepted for missing an exam (see below). Three three-hour exams and a final exam will all contribute equally to your class grade (100 pts for each exam). The final examination will be comprehensive and will cover material from the entire semester. The final examination is tentatively scheduled for December 15<sup>th</sup>, Wednesday (12:30-2:20 PM) in ESCL046.

### **Tentative Grading Scale**

A: 100-90% B: 89-80% C: 79-70% D: 69-60% F: below 60%

**Additional Provisions:** The administration of Chemistry 3000 will adhere strictly to the USU Academic Policies outlined in the on-line edition of the Utah State University General Catalog (see: <http://catalog.usu.edu/index.php>). The complete code of Policies and Procedures for Students can also be viewed online at: <http://catalog.usu.edu/content.php?catoid=12&navoid=3139>.

**Disability Statement:** USU welcomes students with disabilities. If you have, or suspect you may have, a physical, mental health, or learning disability that may require accommodations in this course, please contact the Disability Resource Center (DRC) as early in the semester as possible (University Inn # 101, 435-797-2444, [drc@usu.edu](mailto:drc@usu.edu)). All disability related accommodations must be approved by the DRC. Once approved, the DRC will coordinate with faculty to provide accommodations. In accordance with the Americans with Disabilities Act, reasonable accommodation will be provided for all persons with disabilities in order to ensure equal participation in Chemistry 3000. A student who requires an accommodation must contact the Instructor. The disability must be documented by the Disability Resource Center. In cooperation with the Disability Resource Center, reasonable accommodation will be provided for students with Disabilities. Course material may be requested in alternate formats through the Disability Resource Center.

### **Academic Freedom and Professional Responsibilities**

Academic freedom is the right to teach, study, discuss, investigate, discover, create, and publish freely. Academic freedom protects the rights of faculty members in teaching and of students in learning. Freedom in research is fundamental to the advancement of truth. Faculty members are entitled to full freedom in teaching, research, and creative activities, subject to the limitations imposed by professional responsibility. USU Policy 403 further defines academic freedom and professional responsibilities.

### **Academic Integrity - "The Honor System"**

The University expects that students and faculty alike maintain the highest standards of academic honesty. The Code of Policies and Procedures for Students at Utah State University (Student Conduct) addresses academic integrity and honesty and notes the following:

**Academic Integrity:** Students have a responsibility to promote academic integrity at the University by not participating in or facilitating others' participation in any act of academic dishonesty and by reporting all violations or suspected violations of the Academic Integrity Standard to their instructors.

**The Honor Pledge:** To enhance the learning environment at Utah State University and to develop student academic integrity, each student agrees to the following Honor Pledge: "I pledge, on my honor, to conduct myself with the foremost level of academic integrity". Violations of the Academic Integrity Standard (academic violations) include, but are not limited to cheating, falsification, and plagiarism

### **Plagiarism**

Plagiarism includes knowingly "representing by paraphrase or direct quotation, the published or unpublished work of another person as one's own in any academic exercise or activity without full and clear acknowledgment. It also includes the unacknowledged use of materials prepared by another person or agency engaged in the selling of term papers or other academic materials." The penalties for plagiarism are severe. They include warning or reprimand, grade adjustment, probation, suspension, expulsion, withholding of transcripts, denial or revocation of degrees, and referral to psychological counseling.

### **Grievance Process**

Students who feel they have been unfairly treated [in matters other than discipline, admission, residency, employment, traffic, and parking - which are addressed by procedures separate and independent from the Student Code] may file a grievance through the channels and procedures described in the Student Code: Article VII Grievances

### **Sexual Harassment**

Utah State University is committed to creating and maintaining an environment free from acts of sexual misconduct and discrimination and to fostering respect and dignity for all members of the USU community. Title IX and USU Policy 339 address sexual harassment in the workplace and academic setting.

The university responds promptly upon learning of any form of possible discrimination or sexual misconduct. Any individual may contact USU's Affirmative Action/Equal Opportunity (AA/EO) Office for available options and resources or clarification. The university has established a complaint procedure to handle all types of discrimination complaints, including sexual harassment (USU Policy 305), and has designated the AA/EO Director/Title IX Coordinator as the official responsible for receiving and investigating complaints of sexual harassment.

### **Withdrawal Policy, "I" Grade Policy and Dropping Courses**

If a student does not attend a class during the first week of the term or by the second class meeting, whichever comes first, the instructor may submit a request to have the student dropped from the course. (This does not remove responsibility from the student to drop courses which they do not plan to attend.) Students who are dropped from courses will be notified by the Registrar's Office through their preferred e-mail account.

Students may drop courses without notation on the permanent record through the first 20 percent of the class. If a student drops a course following the first 20 percent of the class, a W will be permanently affixed to the student's record (check General Catalog for exact dates).

Students with extenuating circumstances should refer to the policy regarding Complete Withdrawal from the University and the Incomplete (I) Grade policy in the General Catalog.

### **Assumption of Risk**

All classes, programs, and extracurricular activities within the University involve some risk, and some involve travel. The University provides opportunities to participate in these programs on a voluntary basis. Therefore, students should not participate in them if they do not care to assume the risks. Students can ask the respective program leaders/sponsors about the possible risks a program may generate, and if students are not willing to assume the risks, they should not select that program. By voluntarily participating in classes, programs, and extracurricular activities, students do so at their own risk. General information about University Risk Management policies, insurance coverage, vehicle use policies, and risk management forms can be found at <http://www.usu.edu/riskmgmt/>.

### **Mental Health**

Mental health is critically important for the success of USU students. As a student, you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce your ability to participate in daily activities. Utah State University provides free services for students to assist them with addressing these and other concerns. You can learn more about the broad range of confidential mental health services available on campus at Counseling and Psychological Services (CAPS).

Students are also encouraged to download the "SafeUT App" to their smartphones. The SafeUT application is a 24/7 statewide crisis text and tip service that provides real-time crisis intervention to students through texting and a confidential tip program that can help anyone with emotional crises, bullying, relationship problems, mental health, or suicide related issues.

## **Tentative Course Outline for CHEM 3000 (Quantitative Chemical Analysis)**

### **Unit I Methodology for Quantitative Analysis**

1. August 30<sup>th</sup> (M) Chapters 0 & 1. Introduction to Quantitative Analysis
2. September 1<sup>st</sup> (W) Titration and Volumetric Analysis
3. September 3<sup>rd</sup> (F) Titration and Gravimetric Analysis

*September 6<sup>th</sup> No class (Labor Day)*

4. September 8<sup>th</sup> (W) Chapter 3 Experimental Error
5. September 10<sup>th</sup> (F) Chapter 3 Experimental Error
6. September 13<sup>rd</sup> (M) Chapter 4 Statistics
7. September 15<sup>th</sup> (W) Chapter 4 & 5 Statistics and Calibration
8. September 17<sup>th</sup> (F) Chapter 6 Chemical Equilibrium
9. September 20<sup>th</sup> (M) Chapter 6 Chemical Equilibrium
10. September 22<sup>th</sup> (W) Chapter 7 Systematic treatment of equilibrium
11. September 24<sup>th</sup> (F) Chapter 7 Systematic treatment of equilibrium
12. September 27<sup>th</sup> (M) Chapter 8 Monoprotic Acid-Base Equilibrium
13. September 29<sup>th</sup> (W) Chapter 8 Monoprotic Acid-Base Equilibrium

**October 1<sup>st</sup> (F) reserved for the First exam**

### Unit II Chemical Methods for Analysis

1. October 4<sup>th</sup> (M) Chapter 8 Monoprotic Acid-Base Equilibrium
2. October 6<sup>th</sup> (W) Chapter 8 Monoprotic Acid-Base Equilibrium
3. October 8<sup>th</sup> (F) Chapter 8 Monoprotic Acid-Base Equilibrium
4. October 11<sup>th</sup> (M) Chapter 9 Polyprotic Acid-Base Equilibrium
5. October 13<sup>rd</sup> (W) Chapter 9 Polyprotic Acid-Base Equilibrium
- No class* October 15<sup>th</sup> (Fall break)
6. October 18<sup>th</sup> (M) Chapter 9 Polyprotic Acid-Base Equilibrium
7. October 20<sup>th</sup> (W) Chapter 10 Acid-Base Titrations
8. October 22<sup>th</sup> (F) Chapter 10 Acid-Base Titrations
9. October 25<sup>th</sup> (M) Chapter 11 EDTA Titrations
10. October 27<sup>th</sup> (W) Chapter 11 EDTA Titrations

**October 29<sup>th</sup> (F) reserved for the Second exam**

11. November 1<sup>st</sup> (M) Chapter 13 Fundamentals of Electrochemistry
12. November 3<sup>rd</sup> (W) Chapter 13 Fundamentals of Electrochemistry
13. November 5<sup>th</sup> (F) Chapter 13 Fundamentals of Electrochemistry

### Unit III Introductory Instrumental Methods for Analysis

14. November 8<sup>th</sup> (M) Chapter 13 and 14 Potentiometry
15. November 10<sup>th</sup> (W) Chapter 15 Redox Titrations
16. November 12<sup>th</sup> (F) Chapter 15 & 16 Redox Titrations and Electroanalytical methods
17. November 15<sup>th</sup> (M) Chapter 17 Fundamentals of Spectrometry
18. November 17<sup>th</sup> (W) Chapter 17 Fundamentals of Spectrometry
19. November 19<sup>th</sup> (F) Chapter 17 Fundamentals of Spectrometry

**November 22<sup>th</sup> (M) reserved for the Third exam**

*No class* November 24<sup>th</sup> (Thanksgiving)

*No class* November 26<sup>th</sup> (Thanksgiving)

- 20. November 29<sup>th</sup> (M) Chapter 22 Analytical Separations
- 21. December 1<sup>th</sup> (W) Chapter 23 Gas Chromatography
- 22. December 3<sup>rd</sup> (F) Chapter 24 Liquid Chromatography
- 23. December 6<sup>th</sup> (M, No test week) Chapter 24 Liquid Chromatography
- 24. December 8<sup>th</sup> (W, No test week) Review
- 25. December 10<sup>th</sup> (F, No test week) Review

**Final Exam Dec. 15<sup>th</sup> (12:30 – 2:20 pm)**

**Tips on How to do well in CHEM 3000**

**Practice, practice, and practice!!!**

1. Pre-view (i.e. read ahead) the chapter (s) before attending the class, especially for new concepts. Get familiar with your textbook! Look what is included in the appendixes.
2. To excel in Analytical Chemistry requires 1) understanding the important concepts; 2) apply them to “hand-on” problem solving exercises that often requires calculations with chemical equilibrium concepts.
3. Our lecturing time is rather limited. Both important concepts and selected examples will be covered in the class. However, do not expect all types of questions tested will be covered exactly in the class. It is simply NOT possible to cover all types of calculations and problems within the limited class time. It is your responsibility to work on problems related to the lecture. We will be happy to provide as much help possible per requests.
4. Team study is a proven effective way to do well in this class. Make friends and work together!
5. What will be tested from textbook? Study chapter examples (covered the answer, verify your understanding of the problem, do you know how to solve the problems?), then, Do the Exercises and verify the answers at the end of the book. Work on Assigned Problems and verify with answers from solution manual. --- Mark/collect those problems you have difficulty with for the quick review/practice right before the exam.
6. Most of exam problems will be taken from the lecture and assigned problems. Exam questions may not copy exactly, but will be rather similar.
7. Practice before exam: Before the exam, make up a simulated exam (put in some of those marked problems you have difficulty earlier) and give yourself one hour and half on the simulated exam.
8. After each exam, make sure you understand the relevant subjects and can really do the old exam problems. Make good correction notes.