

Physical Chemistry Laboratory, 2 credits

Professor: Yi Rao**Contact:** Widtsoe 024; Phone: 435-797-0640; e-mail: yi.rao@usu.edu**Office Hours:** Friday (3:00 - 5:00 pm)**Place & time:** ML-350/354; Tuesday and Thursday 2:30-5:20 p.m**Teaching Assistant:** Mr. Yuqin Qian; email: yuqin.qian@usu.edu**Course Description**

This course consists of 12 experimental laboratories and 2 computational laboratories. This course covers gas properties, thermochemistry, solution phase chemical equilibrium, phase behavior, electrochemistry, kinetics, electric, magnetic and optical properties of substances, IR spectroscopy, Raman spectroscopy, NMR spectroscopy, UV-visible spectroscopy, and reaction dynamics.

Laboratory Fee Statement

A laboratory fee (\$75) is required for this course. The laboratory fee is used to pay for reagents, help maintain the instrumentation and replace broken glassware and covers a small portion of the lab Teaching Assistant's support.

Course Objectives

The purpose of the physical chemistry laboratory is to learn laboratory procedures to measure physical properties of chemicals and to interpret these measurements with the theories describing the phenomena. Laboratory learning objective performance is evaluated through the formal written reports describing the experiments and data analysis.

- Understand laboratory and chemical safety;
- Comprehend concept of physical chemistry and perform chemical measurement calibration;
- Relate the microscopic and macroscopic properties of matter to each other ;
- Use statistical methods for evaluating and interpreting data;
- Assess sources of error in chemical and instrumental analysis and account for errors in data analysis;
- Demonstrate competency in written and oral communication using mathematics if needed ;
- Comprehend the importance of stoichiometry, chemical equilibrium, spectroscopy, and kinetics;
- Apply thermodynamic, kinetic, and quantum methods in an integrated way in all areas of chemistry and biochemistry;

Required textbooks and other materials:

- *Textbook*: Experiments in Physical Chemistry 8th or 9th Edition, C. W. Garland, J. W. Nibler and D. P. Shoemaker, McGraw-Hill (2009)
- *Materials*: textbook, bound laboratory notebook, safety goggles; laboratory coat, pencil, pen, etc.

Evaluation

Performance will be evaluated based on attendance, laboratory performance, data checks, notebooks, oral presentations, data analysis report, laboratory reports, and special project. 7 formal laboratory reports from 14 laboratories that are written using the data obtained during the laboratory session.

Grading

Grades are based on scores obtained on individual laboratory reports, data analysis report, laboratory performance, the student's laboratory notebook, oral presentations, and special project.

Maximum Points	Task
35	7 Laboratory written reports (5 points per report)
12	12 Data Analysis reports (1 points per report)
23	Laboratory performance (18 points) and notebooks (5 points)
15	Oral Presentations (5 points per presentation)
15	Special Project (Design, feasibility, and completion)
100	Total Points

The maximum letter grade ranges will be: A, 90-100%; B, 80-89%; C, 70-79%; D, 60-69%. The ranges may be lowered but will not be raised. Plus (+) and minus (-) grade modifier will be used. The upper 1/3 of a letter grade % range will be assigned (+), the lower 1/3 will receive a (-) modifier.

Formal Laboratory Written Reports

Laboratory reports are due as described in the Section of *Tentative Laboratory Schedule for CHEM 3090*. 1 out of 5 points will be taken off for each late submission. Read Chapter 1 in the text book for information regarding the format of these reports. Reports are typically 6-10 pages (Times New Rome 12 or Arial 11, single line spacing). The use of a computer to prepare the reports is recommended. Each student writes their own report. All figures and data should be included in the report. Submissions of the reports will be made on Canvas.

Data Analysis Reports

The data analysis reports are submitted as a group. Reports only display experimental data and how to obtain physical meanings from the results. Due dates of written reports are listed in the *Tentative Laboratory Schedule for CHEM 3090*. Chapter II is an overview of the statistical treatment of experimental data. Much of this is addressed in the CHEM 3000 lecture but it is good to review this all the same. New material covered in this chapter deals with the propagation of uncertainty.

Scientific Computer Software

Chapter III discusses the use of computer software for data collection and analysis. Of course, we also use computers for preparing laboratory reports. Students will have the opportunity to work on Igor 8.0/9.0 and other scientific software with the TA or the professor if needed. Please download from the link: https://www.wavemetrics.com/order/order_igordownloads.htm. An activation key will be announced in the Organization meeting in the first week.

Oral Communication Skills

There will be four oral presentations during the semester. Place: Witdsoe 330

The first three Presentations will follow laboratory experiments. Each group will prepare **two** 25-30 min presentations on the labs they were assigned. This presentation will consist of an introduction of the physical chemistry concepts, a detailed experimental procedure (including tips and tricks for avoiding pitfalls), and finally a discussion of their results. The purpose of this is to practice communication of experimental results, open a discussion to aid in the preparation of your lab reports and finally to prepare other groups for performing the experiment.

Presentation 4 will occur following the completion of special project. Each group will present how you design your experiment and prepare a presentation/discussion of the experiment. This presentation should include a thorough discussion of the physical chemistry principles and properties measured during the experiment, a discussion on the results obtained by the number of groups this semester and a proposal for improving the accuracy of the experimental measurements/procedure.

Experiments

Students will work in groups of 2 to 4. Here is a list of laboratories performed this semester. “_” : laboratory reports.

I. Gases

1. Joule-Thompson Effect
2. Heat-Capacity Ratios for Gases

II. Transport Properties of Gases

3. Viscosity of Gases

III. Thermochemistry

- 4. Heats of Combustion
- IV. Solutions
 - 5. Partial Molar Volume
- V. Phase Behaviors
 - 6. Vapor Pressure of a Pure Liquid
- VI. Electrochemistry
 - 7. Conductance of Solutions
- XIV. Spectroscopy
 - 8. NMR Determination of Keto-Enol Equilibrium Constants
 - 9. Absorption Spectrum of Iodine (no emission spectrum)
 - 10. Raman Spectroscopy: Vibrational Spectrum of CCl₄
 - 11. Vibrational-Rotational Spectrum of HCl and DCl
- VII. Chemical Kinetics
 - 12. Method of Initial Rates: Iodine Clock
- Computational Laboratories
 - 13. Spectroscopic parameters for HCl and DCl
 - 14. Potential energy surface for the CO + H₂ -> H₂CO reaction

Tentative Laboratory Schedule for CHEM 3090

Week 1 of Jan. 10th January 13th, Organization meeting

Labs 1-4

Week 2 of Jan 17th January 18th, Labs
 January 20th, Presentation

Week 3 of Jan 24st January 25th, Labs
 January 27th, Data Analysis
 Data Analysis reports due on January 28th

Week 4 of Jan 31st Writing reports (**Labs 2 & 4**)
 Report of Lab 2 due on February 1st
 Report of Lab 4 due on February 3rd

Labs 5-8

Week 5 of Feb 7th February 8th, Labs
 February 10th, Labs

Week 6 of Feb 14th February 15th, Presentation
 February 17th, Data Analysis
 Data Analysis reports due on February 18th

Week 7 of Feb 21th Writing reports (**Labs 7 & 8**)
 Report of Lab 7 due on Feb 22nd
 Report of Lab 8 due on Feb 24th

Labs 9-12

Week 8 of Feb 28th March 1st, Labs
 March 3rd, Labs

Week 10 of March 14th March 15th, Presentation

March 17th, Data Analysis
Data Analysis reports due on March 18th
Week 10 of March 21th Writing reports (Labs 9 & 12)
Report of Lab 9 due on March 22nd
Report of Lab 12 due on March 24th

Computational labs

Week 11 of March 28th
Week 12 of April 4th

Writing reports (**Lab 11 combined with computations**)

Report due on April 10th

Special Project

The purpose of the special project is to show how utilize the course knowledge you learned and experimental skills your mastered in the class to design your own project, and to measure physical properties of chemicals, and to interpret these measurements with the theories describing the phenomena.

Phase 1: Brainstorm for a special project (Week of March 14st);

Phase 2: Design a project (Before April 9th);

Phase 3: Demonstrate the project (Week of April 11th);

Preview of Experiments

Video for experiments will be found in Canvas. Please watch them carefully before your laboratories.

Additional Provisions: The administration of Chemistry 3090 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). 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 3090. 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.

COVID-19 Classroom Protocols

In order to continue to provide various forms of face-to-face instruction at USU, and to limit the spread of COVID-19 during the pandemic, students are asked to follow certain classroom protocols during the Spring 2022 semester. Face coverings are strongly encouraged in all classrooms and teaching laboratories.

- Strongly encourage you to wear masks. This will help maintain in-person sessions through the semester.
- Strongly encourage you to get vaccinated and upload their proof of vaccination at aggiehealth.usu.edu. This will help them get released from quarantine quickly by the case containment team if exposed to COVID-19. USU will hold [weekly vaccine clinics](#) throughout September.
- Maintain a 6-foot distance in the classroom, office, laboratory, or other teaching space.
- Stay home if they are sick or suffering even mild symptoms of illness and to get a free COVID-19 test. Students who are sick should be referred to [get tested](#) as soon as possible.

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/riskmgt/>.

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.