Physical Chemistry Laboratory, 2 credits

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Office Hours: Thursday (5:30 -6:30 pm) and Friday (4:00 - 5:00 pm)
Place & time: ML-350/354; Tues and Thur 2:30-5:20 p.m
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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 or substances, IR spectroscopy, Raman spectroscopy, NMR spectroscopy, UV-visible spectroscopy, and reaction dynamics.

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:

- 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.

<table>
<thead>
<tr>
<th>Maximum Points</th>
<th>Task</th>
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<tbody>
<tr>
<td>35</td>
<td>7 Laboratory written reports (5 points per report)</td>
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<tr>
<td>24</td>
<td>12 Data Analysis reports (2 points per report)</td>
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<tr>
<td>11</td>
<td>Laboratory performance (6 points) and notebooks (5 points)</td>
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<tr>
<td>15</td>
<td>Oral Presentations (5 points per presentation)</td>
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<tr>
<td>15</td>
<td>Special Project (Design, feasibility, and completion)</td>
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<tr>
<td>100</td>
<td>Total Points</td>
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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 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](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.

The first three Presentations will follow laboratory experiments. Each group will prepare two 15-20 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. The department has the equipment for students to perform laboratories taken from the textbook. The following is a list of laboratories performed this semester.

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

VI. Electrochemistry
   6. Conductance of Solutions

VIII. Electric, Magnetic and Optical Properties
   7. NMR Determination of Paramagnetic Susceptibility

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 DCI

VII. Chemical Kinetics
   12. Method of Initial Rates: Iodine Clock

Computational Laboratories
   13. Spectroscopic parameters for HCl and DCI
   14. Potential energy surface for the CO + H₂ -> H₂CO reaction
Tentative Laboratory Schedule for CHEM 3090

Week 1 of Jan. 19th  January 21th, Organization meeting (zoom)

**Labs 1-4**
- Week 2 of Jan 25th  January 26th, Labs
- Week 2 of Jan 25th  January 28th, Presentation (zoom)
- Week 3 of Feb 1st  February 2nd, Labs
- Week 3 of Feb 1st  February 4th, Data Analysis (zoom)
- Week 4 of Feb 8th  Writing reports (Labs 2 & 4)
  - Report of Lab 2 due on February 8th
  - Report of Lab 4 due on February 14th

**Labs 5-8**
- Week 5 of Feb 15th  February 16th, Labs
- Week 5 of Feb 15th  February 18th, Labs
- Week 6 of Feb 22nd  February 23rd, Presentation (zoom)
- Week 6 of Feb 22nd  February 25th, Data Analysis (zoom)
- Week 7 of March 1st  Writing reports (Labs 6 & 8)
  - Report of Lab 6 due on March 1st
  - Report of Lab 8 due on March 6th

**Labs 9-12**
- Week 8 of March 8th  March 9th, Labs
- Week 8 of March 8th  March 11th, Labs
- Week 9 of March 15th  March 16th, Presentation (zoom)
- Week 9 of March 15th  March 18th, Data Analysis (zoom)
- Week 10 of March 22nd  Writing reports (Labs 9 & 12)
  - Report of Lab 9 due on March 22nd
  - Report of Lab 12 due on March 27th

**Computational labs**
- Week 11 of March 29th  Writing reports (Lab 11 combined with computations)
- Week 12 of April 5th  Report due on April 12th

**Special Project**
- Week of April 19th, Presentation

**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 15th);
   Phase 2: Design a project (Before April 9th);
   Phase 3: Demonstrate the project (Week of April 12th);

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.

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 2021 semester. These protocols are based on CDC, state, and local health department guidelines and requirements are in place not only for your safety but also the safety of the entire campus community.

  • Face coverings are required in all classrooms and teaching laboratories. Students will not be permitted to remain in class without a face covering, as per University Policy 20T.3. Students that do not adhere to the face covering policy will be referred to the Office of Vice President for Student Affairs for a possible violation of the Student Code of Conduct. There may be individual medical circumstances that prevent some students from using face coverings. If you require this exemption, contact the Disability Resource Center prior to
the start of classes to investigate alternative instruction. These circumstances will be rare, but if they do exist, we ask that everyone be respectful.

- Follow faculty instructions regarding social distancing and entering/exiting classrooms.
- Stay home when you are sick, however mild your symptoms.
- Wash your hands frequently with soap and water.

**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.