San José State University  
Department of Chemistry  
Chem 162L, Physical Chemistry Laboratory  
Section 1 – Fall, 2018

| Instructors: | Bradley M. Stone, Ph.D., Professor of Chemistry  
Roger Terrill, Ph.D., Associate Professor of Chemistry |
| Office Location: | Duncan Hall 412A (Stone); DH-004A (Terrill) |
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(408) 924-4970 (Terrill) |
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roger.terrill@sjsu.edu |
| Office Hours: | TR 1330 – 1400, or by appointment only (Stone).  
TR 1230 – 1320, or by appointment only (Terrill). |
| Class Days/Time: | TR 1430 – 1720 |
| Classroom: | Duncan Hall 10 (as well as DH-11, DH-3, DH-6, Nuclear Science, etc. for instrumentation) |
| Prerequisites: | CHEM 100W or ENGR 100W; and  
CHEM 160 or CHEM 161A with concurrent enrollment in either CHE 158 or CHEM 161B  
A grade of “C” or better is required in all prerequisites. “C−” is not accepted. |
| Credit: | 2 units |

**Texts**

**Required:** Physical Chemistry Laboratory Manual, by Fleming, Van Wyngarden & Terrill (Fall 2017) – sold by the Chemistry Club (SAACS) in DH 20. Note: Versions from previous years are not acceptable since there have been significant changes.


**Materials**

**Required:** Permanently bound laboratory notebook.
Course Web Page

Copies of the course materials such as this Greensheet, major assignment handouts, extra materials, etc. may be found on the course website hosted by Canvas.

Catalog Course Description

Physical chemical measurements with data analysis and written reports.

Overview

In this course, we will conduct several experiments using physical methods to learn about properties of atoms, molecules, compounds and chemical reaction systems. In addition, we will pay very close attention to the critical handling of experimental data including the quantitative estimation of experimental uncertainties.

Course Learning Objectives: The following table indicates the learning objectives for each of the exercises/experiments:

<table>
<thead>
<tr>
<th>Exercise/Experiment (Instructor)</th>
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<tr>
<td>Nuclear Chemistry. In this exercise, students will measure the rate of nuclear decay of a short-lived isotope to determine a number of statistical and physical properties. (Stone)</td>
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<tr>
<td>Kinetics of the Bromination of Acetone. In this experiment, students will measure the rate of reaction for the bromination of acetone in order to determine the rate law for the acid-catalyzed reaction. (Terrill)</td>
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<tr>
<td>The Joule-Thomson Effect. In this experiment, students will measure the Joule-Thomson coefficient for selected gasses and relate results to those predicted based on theoretical methods. (Terrill)</td>
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<tr>
<td>Heat Capacity Ratio for Gasses. In this experiment, students will determine $\gamma$, the ratio of $C_p/C_v$ for several gasses using the speed of sound method. Results will be related to those predicted based on statistical thermodynamics. (Terrill)</td>
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<tr>
<td>Enthalpy of Combustion. In this experiment, students will utilize bomb calorimetry to determine the enthalpy of combustion of a hydrocarbon. (Stone)</td>
</tr>
<tr>
<td>Electronic Spectrum of I$_2$. In this experiment, students will record and analyze an electronic transition of I$_2$ in order to determine the dissociation energy of the molecule in both ground and excited electronic states. (Stone)</td>
</tr>
<tr>
<td>Rotation-Vibration Spectroscopy of HCl and DCl. In this experiment, students will record the 1-0 infrared bands of HCl and DCl and analyze the spectra for structural and energetic data for these molecules. (Terrill/Stone)</td>
</tr>
<tr>
<td>Partial Molal Volumes. In this experiment, students will use the Debye-Huckel Theory to determine partial molal volumes of water and NaCl in solution, from precise density measurements. This laboratory is a great introduction to determining propagation of error. (Stone)</td>
</tr>
<tr>
<td>Vibrational Spectroscopy and Greenhouse Warming Potentials of Polyatomic Molecules. In this experiment we will examine the greenhouse warming potential of a variety of</td>
</tr>
</tbody>
</table>
polyatomic gases based on the overlap of their infrared absorption spectra with the earth’s infrared emission spectrum. (Terrill).

In addition to the above, significant emphasis in this course will be placed on the following learning objectives:

1. laboratory safety (including the interpretation of material safety data sheets (MSDSs) and safe disposal of chemical waste as appropriate for individual experiments)
2. collection of scientific data (including the use of specialized laboratory equipment and the use of a laboratory notebook)
3. advanced methods of data analysis (including least-squares fitting methods and other statistical analyses)
4. preparation of written laboratory reports (including the format used in American Chemical Society publications and an introduction to the peer review process)
5. presentation of scientific data (including the preparation of publication-quality graphical representations)
6. error analysis (including the determination, representation and interpretation of experimental uncertainty)

Finally, a note about the experiments: This is an advanced laboratory class designed to give you a taste of what it is like to work in a real laboratory. In real life, you will rarely perform experiments that are neatly laid out with step-by-step instructions. Consequently, experiments in this course may require you to 1) come up with your own plan for accomplishing a goal, 2) read and follow instruction manuals for instruments, 3) experiment with different settings on an instrument to optimize performance, 4) familiarize yourself with software that runs an instrument, and/or 5) perform “quick and dirty” preliminary experiments to guide your “real” experiments. In addition, as in “real life,” you will almost certainly make a mistake or experience an equipment malfunction and have to repeat some experimental work at some point. Again, this is natural and it is a good opportunity to learn how to deal with such a situation, so you will be prepared when you are on the job.

Program Learning Objectives

This course addresses the following Chemistry Program Learning Objectives

4) Demonstrate understanding of core concepts, methods and limits of scientific investigation to effectively solve problems in physical chemistry.
6) Answer questions regarding safe practices in the laboratory and chemical safety.
7) Demonstrate safe laboratory skills (including proper handling of materials and chemical waste) for particular laboratory experiments.
9) Effectively present a scientific paper orally applying the scientific approach, as at an American Chemical Society symposium.
10) Write a formal scientific laboratory report which applies the scientific approach to address a chemical problem and follows the format and style of an article in a peer-reviewed American Chemical Society journal.
Schedule

Attendance

Be considerate to your lab partners by arriving to class on time. You must complete all experiments in order to receive a passing grade in the class. You will not be allowed to make up laboratory time unless you have an excused absence that must be agreed to in advance by the instructor. In the case of unforeseen sickness or other circumstances, a doctor’s note or dean’s note is required.

Lab Reports

Each student must complete five laboratory experiments. Four of the experiments will be written up in the style of an ACS published paper, one of which (Partial Molal Volumes) will be written up as a formal lab report that will be peer reviewed. Students will work in small groups (typically pairs) to complete lab work, but each student must prepare and submit her or his own laboratory reports. All lab reports will be due one week after the lab work is concluded (see schedule for specific due dates). Reports are due in both electronic and hardcopy forms promptly at the beginning of the laboratory period on the date they are due. Late reports will be marked down 10% for each day or fraction of a day they are late.

Informal laboratory report: (Nuclear Chemistry) will be worth 100 pts., and will focus on the analysis of the experimental data, including uncertainty analysis. These reports should include a one-page summary of the experiment, stating the major goals and conclusions, a complete presentation of the data and analysis of the data, and a quantitative uncertainty analysis that produces an estimated uncertainty in the final reported values and identifies the major quantitative source of experimental uncertainty.

The remainder of the reports will be in a form similar to published papers in the Journal of Physical Chemistry. Major sections of the formal lab report include:

- ABSTRACT
- INTRODUCTION: includes the background and theory needed to interpret the data.
- EXPERIMENTAL: a description of the methods, materials and equipment used for performing the experiment.
- RESULTS/DISCUSSION: A description is given of the procedure in which the experiment was performed, the data collected, the analysis of the data, graphical representations of results derived from raw data and an interpretation of the results. Tables and Figures are presented to help with the interpretation of the results
- CONCLUSION
- UNCERTAINTY ANALYSIS AND COMPARISON TO LITERATURE: the derivation of estimated uncertainties and propagation of errors in the final reported parameters and an interpretation of the calculation pointing to the major source of uncertainty as supported by the computation
- REFERENCES (with citations given in the text).
Students should consult the discussion in the lab manual to become more familiar with the requirements for laboratory reports. The **formal lab report** will be required following the **fourth experiment rotation**. All student will perform the nuclear science experiment and the partial molal volume experiment. The other 3 experiments you will get to pick from the list of available experiments given above.

**Laboratory reports must be submitted in both printed and electronic form.** Formats for electronic submission can be MS Word or Word-readable files such as RTF or ODC. Adobe PDF is acceptable, but not preferred. Electronic submission will be done through Canvas.

**Peer Review**

The formal laboratory report will be subject to peer review. On the initial due date for the formal laboratory report, each student must turn in two copies of their report, machine printed and double-spaced (for clarity and to give room for peer comments). Two students will review the papers and the instructor will provide a review of the third copy. Students will then be given an additional week to revise their reports, incorporating the comments as appropriate. Participation in the peer review process is mandatory and will be worth 100 points.

**Lab Notebook**

A laboratory notebook will be required for all students. All primary data must be taken in the notebook in ink. A portion of the grade will be determined from how effectively each student uses the notebook. Notebooks will be graded twice during the semester. The first notebook grading session will be during the peer review for the formal lab report. Additionally, students must turn in their notebook for grading at the time of their final presentation. Each notebook review will be worth 30 points. (In many industry or research situations, the lab notebook can be used as an important legal document. Good notebook habits are essential for success in any branch of science!)

**Pre-lab Quizzes**

Students will complete a pre-laboratory assignment (forms available on Canvas) before beginning each experiment. This will include completion of a safety section and a one paragraph summary of the objectives of the experiment. The safety section will require consultation with the Material Safety Data Sheets (MSDSs) contained in the MSDS notebook. The summary will identify the physical properties to be explored in each experiment and give an example of the application of the type of property in a commercial or research setting. **Completion of the pre-laboratory assignment is required before a student will be allowed to perform an experiment.** Each pre-laboratory assignment will be worth 10 points.

**Final Presentations**

The final presentations will be given by teams of 2 students (with your lab partner), and will be given on an alternative experiment that you propose for future sections of Chem 162L.
Grading

Grades will be based upon the following point system:

- 1 informal report (nuclear chemistry) 50
- 3 laboratory reports (ACS Style) 300
- 1 formal laboratory report 300
- Pre-lab quizzes 40
- Peer review assignment 100
- Laboratory notebook 60
- Lab participation 50
- Final presentation (during Final period) 100

Total = 1000

A: >90%  A-: 87-89.9%  B+: 82-86.9%  B: 77-81.9%
B-: 72-76.9%  C+: 67-71.9%  C: 62-66.9%  C-: 57-61.9%
D: 50-56.9%  F: <50%

Safety

Students will be expected to maintain safe practices in the lab. Food and drink are expressly forbidden in the laboratory. Proper eye protection must be worn whenever any experimental work is in progress in the laboratory. Also, as a courtesy to your fellow students, please turn pagers and cell phones off or to silent ring during class hours. Failure to abide by safe laboratory practices will result in removal from the course with a grade of F. Students must pass a safety quiz (to be given in the second laboratory meeting) with a score of 80% or better to be allowed to begin experiments. The safety quiz may be repeated with a 10% penalty on the score counted toward the grade for each attempt to get 80% of the questions correct.

Emergencies and Building Evacuations

If you hear a continuously sounding alarm, or are told to evacuate the building by an Emergency Coordinator, walk quickly to the nearest exit. Take your personal belongings as you may not be allowed to return. Follow the instructions of the Emergency Coordinators. Be quiet so you can hear instructions. Once outside, move away from the building. Do not return to the building unless the Police or the Emergency Coordinator announces that this is permissible.

Library Liaison

Yen Tran, yen.tran@sjsu.edu

Safe and Respectful Community

We hope that the classroom and laboratory will serve as an environment that will promote learning and the development of new ideas, as well as be a safe and respectful community. Behavior that interferes with the normal academic function in a classroom or lab is
acceptable. Students exhibiting this behavior will be asked to leave the class. Examples of such behavior include
a) Persistent interruptions or using disrespectful adjectives in response to the comments of others.
b) The use of obscene or profane language.
c) Yelling at classmates and/or faculty.
d) Persistent and disruptive late arrival to or early departure from class without permission.
e) Physical threats, harassing/bullying behavior, or personal insults (even when stated in a joking manner).
f) Use of personal electronic devices such as pagers, cell phones, PDAs in class, unless it is part of the instructional activity.

University Policies

Office of Graduate and Undergraduate Programs maintains university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. You may find all syllabus related University Policies and resources information listed on GUP’s Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/

Academic integrity

Students should know that the University’s Academic Integrity Policy is available at http://info.sjsu.edu/static/catalog/integrity.html. Your own commitment to learning, as evidenced by your enrollment at San Jose State University, and the University’s integrity policy, require you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The Student Conduct and Ethical Development website is available at http://www.sjsu.edu/studentconduct/.

Instances of academic dishonesty will not be tolerated. Cheating on exams or plagiarism (presenting the work of another as your own, or the use of another person’s ideas without giving proper credit) will result in a failing grade and sanctions by the University. For this class, all graded materials must be the original work of the student to whom the grade is assigned unless otherwise specified. Under no circumstances may you look at another student’s written report prior to turning in your own report nor may you provide a copy of your report to another student. This includes materials submitted for peer review! Any text, diagram, chart or data that is not the product of the student author must cite a reference next to it for the source as appropriate. This includes (but is not limited to) material taken from reference books, tables, primary research literature, laboratory manuals and computer programs. Failure to adhere to the principles that protect the academic integrity of this course will be dealt with according to the policies and procedures of the Department of Chemistry, the College of Science and San Jose State University.

If you would like to include in your assignment any material you have submitted, or plan to submit for another class, please note that SJSU’s Academic Policy F06-1 requires approval of instructors.

Campus Policy in Compliance with the American Disabilities Act

If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an
appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 at http://www.sjsu.edu/president/docs/directives/PD_1997-03.pdf requires that students with disabilities requesting accommodations must register with the Accessible Education Center (AEC) at http://www.sjsu.edu/aec to establish a record of their disability.

Note from Prof. Stone: This ensures protection of privacy and allows for appropriate accommodations to be provided in cases where they are necessary. Assignments missed due to disabilities or other special concerns will not be accepted except as requested by the AEC.
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<tr>
<td>Aug</td>
<td>20</td>
<td>21 Greensheet</td>
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<td>23 Lab checkout Safety, waste disposal</td>
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<td></td>
<td>27</td>
<td>28 Uncertainty Analysis</td>
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<td>30 Uncertainty Analysis</td>
<td>31 Last Day to Drop</td>
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<td>September</td>
<td>3</td>
<td>4 Nuclear Lab</td>
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<td>6 Uncert. Analysis – Nuclear Lab Data workup</td>
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<td>12 Last Day to Add</td>
<td>13 Nuclear Lab Report Due</td>
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<td>18 Prelab due Rotation I</td>
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<td>October</td>
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<td>9 Prelab due Rotation II</td>
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<td>11 Report I Due</td>
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<td>30 Prelab due Rotation III</td>
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<td>1 Report II Due</td>
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<td>November</td>
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<td>6 Prelab due Rotation IV: Partial Molal Volumes (Rotation IV will be experiment for formal report)</td>
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<td>15 Report III Due (HCl/DCI)</td>
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<td>19</td>
<td>20 Report IV Due for Peer Review</td>
<td>21</td>
<td>22 Thanksgiving, no class.</td>
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<td>December</td>
<td>26</td>
<td>27 Peer Reviews Due Back</td>
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<td>4 Formal Reports Due</td>
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<td>6 Locker Check-Out</td>
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<td>11 Study Day (Dead Day!)</td>
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<td>Final (Oral Presentations, 1445-1700)</td>
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