CHEM 3397 – Se 02
Physical Chemistry Laboratory - I
Spring 2020

Lecture (BE 121): Monday 11:00 to 11:50 am
Lab (BE 213): Wednesday 1:00 – 3:50 pm
Office Hours (V.B. in BE 200): Mon 5:00 – 6:00 pm, Wed 4:15 – 5:15 pm, Thu 11:00 – 12:00 noon
Office Hours (J. H. in BE 203): Mon and Tue 1:00 – 1:50 pm, Wednesday 10:00 – 10:50 am

Instructors:
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Prerequisites: C- or higher in Chemistry 3103 (0215), C- or higher in 3105 (0217), and C- or higher in 3301 (0231).

Attendance Policy: Attendance of all scheduled classes is strictly required.

Any student who has a need for accommodation based on the impact of a disability should contact us privately to discuss the specific situation as soon as possible. Contact Disability Resources and Services at 215-204-1280 in 100 Ritter Annex to coordinate reasonable accommodations for students with documented disabilities.
INTRODUCTION

Physical chemistry is the application of physical methods to the study of molecular processes and properties. It has a long and illustrious history founded primarily on experiment, although the advent of quantum mechanics has allowed for the calculation of molecular properties without the input of experiment (though we're not quite there yet). While much of modern physical chemistry is technically quite sophisticated there are many wonderful experiments that can be performed which demonstrate basic physical and chemical properties of matter.

Chem 3397 is a writing-intensive course. It is one of the capstone courses for chemistry majors at Temple. You will write formal laboratory reports using both brief (“poster”) and full paper format as described and assigned below. Getting the right answer is not enough! A significant part of your grade will be based on style and clarity. Please set aside enough time to achieve this goal.

Major writing-related learning goals:

- Acquire and develop fundamental skills for Scientific Technical Writing through oral and written communication based on quantitative experimental measurements. This will be achieved through the preparation and revision of formal laboratory reports, including argument-driven research-style papers in a format consistent with the American Chemical Society guidelines [http://portal.acs.org/corg/content, search: “writing skills”].

- Incorporate accurate description and detailed conclusive interpretation of quantitative physical chemistry measurements with topic-specific calculations and thorough data analyses.

- Adequately apply the scientific method: define a problem clearly, develop testable hypotheses, execute experiment(s), analyze data and draw appropriate conclusion(s).

- Demonstrate the ability to retrieve specific information from the chemical literature and make effective use of peer-reviewed publications through integration and utilization of this information in the reports.

STRUCTURE OF THE COURSE

There are four experiments in the syllabus spanning thermodynamics to kinetics. You will do all of the experiments and write individual lab reports for each of them. You will see each experimental setup twice. First, guided by an instructor, you will figure out how to make measurements on the assigned apparatus. During this training period, known as "Round Robins", lectures will be given to cover the theoretical background necessary to understand the “what” and “how” of each experiment. The Round Robins will take 3 weeks.

Weekly Notes summarizing reading assignments and written drafts of lab reports will be submitted to Canvas. In your second encounter with the apparatus, you will actually perform the experiment in groups of 2. Prior to the lab, you may be given a quiz and/or be engaged in verbal discussions that will test your understanding of the experiment before you actually perform it. We presume that you can collect the data and analyze it with little input from your instructors. However, there will be a mandatory data analysis period following the completion of each experiment and a writing-related workshop prior to submission of each full format paper. These sessions, indicated as "CL" (Computer Lab) and “WW” (Writing Workshop) in the Experiment Schedule (page 11), will be held in the Chemistry Department Computer Lab. The point of these sessions is to work up the raw data to the point where we can be sure you are on the right track, and to reassure us that you have sufficient knowledge and strategy to write the required sections and assemble them competently into a high-quality report. Please, come prepared.

All of these elements are summarized in the Master Schedule on pages 10-11 of this syllabus.
EXPERIMENTS:
After the Round Robin sessions are completed (about 3 weeks) the class will be broken down into groups of 2 and the experiments will be performed according to the Master Schedule at the end of this syllabus (pages 10 and 11). You are welcome to make a written request for a lab partner before the first set of labs start. However, we will put you into a group if no request is made.

Come prepared to take data! The instructors will be examining your notebooks and your grade will be adversely affected if you do not take your preparation seriously. Your preparation should include an introduction and purpose for the experiment, any relevant calculations or constants you need (molecular weight, density, etc.), answers of any assigned pre-lab questions and prepared tables into which you can write the data as you take it. **If you do not come in prepared as described above you can expect to lose a grade on the lab report.**

**EXPERIMENTS TO BE PERFORMED**

<table>
<thead>
<tr>
<th>Experiment Description</th>
<th>Abbreviation</th>
<th>Duration</th>
<th>Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Tension of Solutions (GNS #25, also look at H #16)</td>
<td>ST</td>
<td>1 lab period</td>
<td>1</td>
</tr>
<tr>
<td>Thin Layer Fuel Cell (Handouts, library/Canvas - reserved materials)</td>
<td>FC</td>
<td>1 lab period</td>
<td>1</td>
</tr>
<tr>
<td>Heat Capacity Ratio (GNS #3 A &amp; B + handout, also look at H #2)</td>
<td>CpCv</td>
<td>1 lab period</td>
<td>1</td>
</tr>
<tr>
<td>Conductance of Solutions (GNS #17, Canvas - reserved materials)</td>
<td>Cond</td>
<td>1 lab period</td>
<td>1</td>
</tr>
</tbody>
</table>

Each experiment takes one lab period. You are expected to work independently at this point and part of your lab grade will reflect this independence. However we expect things to go wrong so don't hesitate to point out a problem or ask a question that requires an instructor's attention.

**LAB TESTS:**
Tests will be given following the introductory lectures based on each topic covered in class during the first 3 weeks prior to the experimental cycle (see p. 4, 10 – 11) and a passing score (minimum 60 %) is a prerequisite to proceed with each corresponding experiment in the lab. Failing the preliminary test for any experiment would prevent the student from being allowed to perform that experiment in the lab and receive any related credit. One make-up test can be given on Monday, of Week 4 during the scheduled lecture time. The purpose of the tests is to make sure you have properly prepared for the labs and will include questions about concepts, experimental details and calculations given sample data. Final Exam will be held as scheduled (see Master Schedule) based on all topics studied including corresponding data analysis.

Each person will take these tests independently. Do not expect any help from your instructor or lab partner. **Some tests are cumulative, all are closed notes/closed book. Please bring a calculator.**

**ERROR ANALYSIS AND USE OF COMPUTER SOFTWARE:**
*(READING ASSIGNMENT)*
The importance of error analysis in this course cannot be overstated but often the students find the amount of error analysis required to be daunting. You should remember much of this from Analytical Chemistry. To help remind you of this material, please read Chapter 2 and 3 of GNS. Chapter 2 is concerned with the mathematical processing of data (calculations and presentation issues) to obtain the desired quantitative results and with the evaluation of uncertainties. The use of computer software (spreadsheets) programs such as
Excell, Quattro Pro) for data analysis is discussed in Chapter 3. Lecture will be given in class and selected problems will be discussed. The methods reviewed will be applied to prepare your lab reports. It is very important to work on the end-of-chapter problems and assure adequate background prior to writing your lab reports. Additional reading assignments will be given for each topic reviewed.

**GRADING:**

Your grade will be calculated according to the following criteria:

1. **Experiment reports:** [scientific content and writing/presentation style]
   a) “poster” style (2): 30%  
   (15% each report: abstract, experimental, data analysis and presentation of figures, tables, captions, conclusions, sample calculations)
   b) “full paper” style (2): 50%  
   (25% each report: abstract, introduction, experimental, results, discussion, conclusion, sample calculations)

2. Pre-lab Tests: Pass!
3. Final Exam: 20% (Based on the experiments, including fundamental concepts)

Grades can be affected by penalties due to poor attendance or inefficient use of scheduled class time. "Scientific content" means the precision, accuracy and competent interpretation of your results, and the quality of your error analysis, graphs, and tables. "Writing / presentation style" means how well you tell the story, how carefully you match verb to subject, your use of tense, and other aspects of style. All graded work will contribute to the final grade as shown above. *Please, do your best on every assignment. We do not anticipate that a "curve" will be applied.*

**LABORATORY NOTEBOOKS:**

You must have a lab notebook, which may be any brand, but should be about 8-1/2 x 11", solidly bound (not wire-bound), with at least 100 numbered pages. All data taken in the lab must be recorded in this notebook neatly and clearly identified so that it is traceable to your report. At the end of each lab period you and the instructor must sign your notebook. This laboratory notebook must be brought to all classes, including calculation (CL, see p. 10 - 11, Master Schedule) and writing workshop (WW, see p. 11) lab periods with detailed sample calculations written prior to the corresponding CL class. These sample calculations should be completed by the end of the computational lab class, then signed and dated by both the student and lab instructor. A Xeroxed copy or a carbon copy of the signed data and sample calculations must be submitted with your laboratory report as an appendix. This is a prerequisite for any lab report submission and evaluation. *No large blank spaces or notes unrelated to the course material can appear in the lab notebook.*

Your notebook should contain a detailed account of all work you performed in the lab. Since your reports can be written only if you have a good record of your work and data, you must keep your notebook readable and up to date. For example, numbers must be accompanied by the appropriate units and be labeled as to what quantity was measured. Unavoidable deviations from the established procedure, problems encountered, mishaps suffered, and other pertinent events/observations should all be recorded. Be a pro and record your work as you go along, not at the end of the day when you’ve forgotten much of what happened.

**LABORATORY REPORTS:**

**Reading Assignments:** Chapters 1-3 from SGN + at least 2 papers (from an ACS journal [http://pubs.acs.org](http://pubs.acs.org), free access on campus) for each full format report, All materials posted under “Course Reserves” and “Course Documents” in Canvas

For each experiment you will prepare a laboratory report using the format described below. The knowledge gained from an experiment is of little value unless it can be communicated. You should write your report in a lucid, easy-to-follow manner, readily comprehensible by anyone with a basic background in physical chemistry. Since this course has been designated a writing-intensive course, a great deal of importance will be attached to the quality of your technical writing.
Two of the major channels for scientific communication include *poster presentations* at professional meetings and *papers* published in peer-reviewed scientific journals. A *poster* includes brief summary of experimental method(s), data and conclusions illustrated by figures and tables, which are presented in-person by the author(s). At least one author is available to answer questions and further explain the details of the work during the poster session. You can find many posters on the walls of our Chemistry Department from a variety of scientific meetings.

When a *scientific paper* is published in a journal, the author is not immediately available to answer questions, so the experiment itself, all data obtained, and all conclusions drawn have to be clearly explained and well argued in writing with respect to the most recent achievements in the scientific field.

During this course you will use both styles to present your experimental data. Please note that prior to writing your full paper reports, it is very helpful to analyze your data carefully and develop a brief “poster” as a skeleton of your work, then add the detailed descriptive part as outlined below.

**Please take note of the following points:**

1. **Your report is to be entirely your own work.** Although you may gather data with your group, you must do the calculations and write-up yourself. Evidence of unacknowledged collaboration in the preparation of your report will result in a penalty. (Note that your report will be graded alongside your partner's.)

2. You are expected to *keep all original files* (complete spreadsheets with graphs, original spectra, word document files etc.) related to any papers you submit for the duration of this course and be ready to present them upon request.

3. **Reports are due two weeks after the day the experiment was completed.** Revised papers are due one week from the day graded originals are returned. Revised papers should be submitted together with graded originals. All changes must be indicated (highlighted) and all questions arising from the original papers must be answered in the revised versions.

4. All reports must be typewritten double-spaced, including equations, tables, and special symbols. Use a word processor with an equation editor. If you do not know how to install this feature one of the instructors can assist you. NEATNESS COUNTS TOWARD YOUR GRADE! Do not hand in reports that are too lightly printed, with excessive amounts of text, figures, or tables, or that are otherwise hard to read.

5. **Plagiarism** - Note that you will take data together but each partner is responsible for his/her own write-up and report. *Duplication of text, graphs, calculations, tables, or formatting used by other students is not acceptable. Copying of any fragments from websites, textbooks, and any other sources is not permissible and an "F" grade will be assigned if this is the case.*

6. **The file for your full format lab report must be submitted electronically via Canvas to receive a grade.** This must be done by the time you submit your hardcopy report and the *file submitted electronically should be identical to the printed paper copy* submitted in class. An “F” grade will be assigned if a full format report is not submitted electronically or the printed copy is found to be different from the corresponding file submitted electronically. To submit a file just log in to your TUPORTAL account and go to the “Canvas” site for Chem 3397. There you will find a link to submit your file. Click on this link and follow the instructions. The window for file submission will be closed by the time class starts on the day of submission. Do not re-submit!

7. Your lab report score will be reduced by one full grade unit for each day that a lab report is late (without a medical excuse).

8. **Calculations:** Calculations should be consistent with the measured data, i.e., do not arbitrarily discard significant figures and, conversely, do not include long strings of meaningless digits. If you have trouble with any calculation, you are encouraged to see one of the instructors in the lab. Always bring your notebook with you to help the instructor locate the source of your difficulties.
“FULL FORMAT” LAB REPORT (REQUIRED):

1. **Cover page:** The first page should contain *exactly* all of the following information (nothing else):
   a. your name and student ID number, section #, group #, type (format) of the report and report #
   b. title of the experiment;
   c. the name(s) of partners, if any;
   d. the dates on which you started and finished the experiment; and
   e. the date on which you are submitting the report. The cover page template is provided in Blackboard. *Do not change text font(s) or the arrangement of the cover page!* 

   **Caution:** An incorrectly labeled cover page may result in your report being misplaced or lost! An “F” grade will be assigned to any missing lab reports.

2. **Abstract:** A concise summary (*250 words or less*) of the purpose of the experiment, what was measured, by what technique, and the relevant results and associated errors. A comparison of the results with theoretical models or known literature values is also appropriate.

3. **Introduction:** A 1-3 page introduction can include background information and the purpose of the experiment, relevant mathematical expressions, theoretical information, etc. *This should be in the form of a narrative (tell a story!),* that prepares another chemist to understand your following work.

4. **Experimental:** This should include text paragraphs describing
   a. **Materials:** *specify* chemical(s) used in a sentence (or few)
   b. **Methods / Techniques:** names of equipment and/or discussion of methods used.
   c. **Procedures:** discussion of procedures (e.g. how solutions were prepared and/or how the values were measured with reference to any corresponding sample calculations in appendix) used for the experiment.

5. **Results:**
   a. A clear *description* of your results must be given, together with the established errors and all appropriate units. It is important to write clearly in complete sentences indicating where the results are presented (e.g. Table I, Figure 2, Graph 1, Appendix I etc.). *A reminder: you are telling a story!* Use a narrative style. Important intermediate results should also be given (for example, averages of several experimental runs, data from chart recordings, etc.).

   b. Make use of graphs and tables whenever possible to show clearly the effect of an independent variable (e.g. temperature, concentration, etc.) on the observable (dependent variable). For graphs make sure you label all axes clearly using the appropriate units. When graphing a model calculation (e.g. a linear fit) it is best to plot the data as points and the fit as a solid line on the same graph. **Make sure you apply a legend to the plot to identify what each line or symbol stands for.** Briefly (within 2-3 text lines) describe the corresponding content using figure and table caption(s). *Avoid repetitions!*

   c. **Errors:** *Sample calculations* of error analysis must be included *in an appendix.* *Results with error estimates* should be included in your Results section with adequate interpretation. The error estimates on the final results may require that you use the propagation of errors technique. Whenever appropriate, perform a suitable statistical analysis of your results and include confidence limits with corresponding degrees of freedom. Add error bars to your plots as needed. If you question the validity of one or more experimental data points and wish to discard them, you will have to provide a reasonable (quantitative, if possible) justification.

   The extent of the error analysis required will vary greatly depending on the experiment.

   d. **Sample calculations:** In an appendix, starting with a symbolic mathematical expression, show one numerical example with corresponding dimensional analysis of each type of calculation using your own data. Describe briefly the operations you performed to reduce your raw data to the final results. For example, if data of the same kind were obtained at three different temperatures, only one sample calculation should be given. On the other hand, if the same set of data was used to obtain two different derived quantities, two sample calculations are
expected, one for each different type of quantity. You must write a complete sentence directing the reader to the appendix.

e. **Model calculations**: This will be appropriate only for some experiments and should be skipped entirely for others. State briefly the basic premises and results of the model. Then use the model to obtain a theoretical estimate of only those quantities derived from **your** experimental data. Show a sample of each different type of theoretical calculation in an appendix.

6. **Discussion**: This section should include comments on the significance of your results and your confidence in them. It should include, where appropriate, comparisons of your results with those in the literature and with the predictions of a theoretical model. Are the results in reasonable agreement with your expectations? Are they consistent with each other? Why or why not? Keep this section brief and to the point, i.e., **directly** related to the actual results **you** obtained. **Questions which you are asked in the notes, Halpern and/or in GNS manual(s) should be answered here.** Collective explanation, interpretation and outline of important relationships among reported results and **groups of results** is expected here. A clear, concise, and specific discussion should be given of the errors, together with a numerical estimate of their effect on your data and on the derived quantities you calculated. In some cases only very minimal discussion of errors is in order, while others may require considerable effort. Do not exceed two pages.

7. **Conclusions (~1/2 page)**

8. **Appendices**: The appendices will include Xeroxed or carbon copies of your laboratory notebook pages for the experiment in question, sample calculations, error analyses, and copies of any cited papers.

**BRIEF (“POSTER”, POWER-POINT SLIDES PREFERRED) LAB REPORT FORMAT:**

1. Cover page
2. Abstract
3. Experimental - Materials, Method(s) and Procedure(s)
4. Results (5b-d only from the “Full Format Report” section above, include 5e if necessary)
5. Conclusions (~1/2 page)
6. Appendices

Assemble your report with the different sections in the order given above. Begin each section on a new page.

**STYLISTIC REQUIREMENTS:**

1. **Graphs**
   a. Graphs **must** be computer generated with the axes clearly labeled, including **units**. Try to scale graphs so that data or curves occupy a significant fraction of the page, i.e., do not bunch all of the information in one corner of the page.
   b. Plot each data point clearly, using different symbols or colors for different sets of data.
   c. Each graph **must** have a **brief figure caption** that describes what kind of information is shown. The brief “poster” format report might have a short title as well. Avoid redundancy: the title should not repeat the same information as the caption. (“X vs. Y” is not a valid title!)
   d. Whenever appropriate, **error bars** should be shown for your experimental data points and **errors of calculated slopes and intercepts** reported (with specified confidence limits and corresponding degrees of freedom).

2. **Tables and figures** **must** include numbering.

3. **References**: In most reports you will refer to theoretical and/or literature information. Each time you do this you must give a complete reference and if possible, add a copy of the paper to your appendix with the corresponding text highlighted.

4. **Use passive voice**; Write in **third person**; do not use “I” or “we”.

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5. *Do not wait until the last minute to prepare your report.* You may run into unexpected trouble – and help may not be available then.

**LAB CLEAN-UP:**
Before you leave at the end of each lab period your group must:
   1. Empty and clean all glassware, except for the containers (properly labelled with name of chemical and date) storing those materials you will use later that week(s).
   2. Clean the bench (and balance area, if you have used it) and surrounding areas.
   3. Store all glassware and equipment *the same way you found it.*
   4. Turn off power to all equipment. Your instructor will not sign your lab notebook (see below) until you have cleaned up.

**SAFETY:**

**Violation of safety rules outlined below may result in expulsion from the lab.***

Serious accidents in Physical Chemistry Laboratories, although rare, are not unheard of. Understand how the apparatus works and what you are asked to do with it before you do it. *Do not exert force* on the equipment or try to do anything to which you encounter resistance – a sure symptom that you are doing something wrong or that there is equipment malfunction. Equipment malfunctions can have serious safety consequences, especially for those experiments using gases at very high pressures, or experiments where potentially lethal voltages may exist. If you are not sure that you understand a particular operation, or if you think that the apparatus may not be functioning properly, ask your instructor.

You must observe the following safety rules for the protection of yourself and those working near you.

1. **Eye protection** – wear approved safety goggles at all times, as required by state law.
2. **Fire hazards** – study the location of the fire extinguisher(s), shower, and eye wash, which will be shown to you by your instructor. Any use of flammable organic solvents constitutes an obvious fire hazard. Organics must not be disposed of in the sink drains; organic waste containers are provided.
3. **Electrical hazards** – In addition to the usual hazards found in chemistry labs, some experiments require the use of electrical circuits carrying potentially lethal voltages. Voltage is not in itself a reliable indication of danger because, since the body's resistance varies so widely, it is not possible to predict in general how much current will exist in response to a given voltage. Prevention is the best medicine for electric shock. That means having a healthy respect for all voltages, and always following safety procedures when working with electrical equipment.
4. **High pressure** – In some experiments you will use gases stored at very high pressure. Gas cylinders must remain securely tied to the benches at all times; you must never attempt to move a cylinder, or change regulator settings. If you run out of gas, tell your instructor.
5. **Broken glass** – You should already be aware, from your previous lab work, of the hazards of broken glass. Observe the appropriate precautions; clean up broken glass immediately (Dustpan and brush, not fingers!) and report any broken or sharp edges to your instructor at once. Never use glass apparatus with cracks or chips.
6. **Mercury** – Handle with care any apparatus containing mercury. Be sure to report any spills, since mercury constitutes a potential health hazard and must be taken care of promptly. Be careful also to keep gold or silver jewelry, watches, etc., out of contact with mercury, which can amalgamate with them.
7. **Pipetting** – Never pipet any liquid by mouth; rubber bulbs are provided for this purpose.
8. **Report** every accident, no matter how minor, to your instructor.
9. If chemicals are to be used for more than 1 period, they must be labeled with the name of chemical (not abbreviated), and the date.
10. **Dispose** of chemicals (glass) in chemical waste (disposable glass) containers provided.
11. **Food and beverages are not allowed** inside the lab.
INCOMPLETES / WITHDRAWALS:
This course will adhere to the Department's and the University Policy regarding the last date to drop or withdraw from the course. The last date to drop is **Monday, January 27th**. Withdrawals can occur until a later time. For the university policy please see [http://policies.temple.edu/getdoc.asp?policy_no=02.10.14](http://policies.temple.edu/getdoc.asp?policy_no=02.10.14). For this semester this date will be **Wednesday, March 18th**. To obtain an "incomplete", the usual incomplete contract must be signed upon completion of 60% of the work. The student's accumulated total to that point should be more than 75% of the possible points. Non-attendance to the lab does not constitute "dropping" the course. Official withdraws can only be done through the Registrar's office.

ATTENDANCE:
A valid reason consistent with Temple University regulations and appropriate documentation are required for excusable absence and arrangements of any accommodations. Missing an experiment (unexcused, without prior arrangements) will result in an “F” grade for the corresponding report(s). Unexcused absence from any subsequent scheduled data analysis class in the computer lab (CL) or writing workshop (WW) will result in a penalty of 25 % from the grade of corresponding lab report. Such penalty (up to 25 %) can also be applied to the corresponding lab report grade for inefficient use of scheduled class time. Students who are physically present in any of the classes, but not adequately prepared (homework reading and written assignments) can be penalized.

HELP!!!
Make certain you take full advantage of all the academic support services available at Temple - on the Main Campus. These include instructor office hours; the Math and Science Resource Center (MSRC) relocated from Curtis Hall Room 17, 13th & Montgomery, Main Campus in addition to Supplemental Instruction sessions. The services provided at the MSRC include one-on-one tutoring, computer lab, weekly group tutorials/supplementary instruction, final exam review sessions, and a resource library. The center is open 6 days a week AND IS FREE. For additional information check [http://www.temple.edu/MSRC](http://www.temple.edu/MSRC). Assistance with editing the text of your written draft(s) can be obtained at the **Temple Writing Center**, 13th Street and Montgomery Avenue, Phone: (215) 204-0702 (see [www.temple.edu/wc](http://www.temple.edu/wc) for more information). You can also ask for assistance at the **library reference desks** concerning literature search.