CHEM 435
Physical Chemistry Laboratory

Spring Semester, 2017

Time: 1:10 - 4:00 PM TuTh
Location: CB 109 (most of the time)

Web page: http://web.nmsu.edu/~snsm/classes/chem435/

Textbook (not required):
Garland, Nibler and Shoemaker; Experiments in Physical Chemistry, 8th edition.
McGraw-Hill, 2009 (GNS)

Other recommended books (not required):

  (Students should have purchased this book for the lecture course, Chem 433-434)

Prerequisite: Concurrent registration in, or completion of CHEM 434; or permission of the instructor

Instructor: Sergei Smirnov
Office: CB 202
Phone: 646-1547
e-mail: snsm@nmsu.edu
Office Hours: 11:30 – 12:30 TuTh (or by appointment)

Teaching Asst. Deepak Subedi
Office: CB 112
Phone: 646-2144
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Office Hours: TBA
Introduction

Physical Chemistry is made of 50% physics, 50% chemistry, and 50% imagination.
My Interpretation of a famous quote

This course is intended to acquaint the students with the practice of experimental physical chemistry. Considerable effort has gone into linking the content of the labs with the topics of Chem 434 lectures. Nonetheless, the educational philosophy of the labs is that experimental physical chemistry has a life of its own.

The goal of the labs is to provide a modest introduction to this area of scientific activity. Centuries of empiricism have been invested in man's present conceptual view of the physical world. It would be impossible to attempt to illustrate systematically the experimental basis of that view. Some principles will be illustrated in the labs, but many more will simply be applied to the problem at hand. Experimental work is an eminently practical activity. The program is designed to provide a limited encounter with its methods, its fruits, and undoubtedly with some of its frustrations as well.

Objectives:

- To apply the principals of thermodynamics, kinetics and spectroscopy presented in the physical chemistry lecture courses, in some illustrative experiments. To understand the interconnection between experimental foundation and underlying theoretical principals and to appreciate the limitations inherent in both theoretical treatments and experimental measurements.
- To gain familiarity with a variety of physico-chemical measurement techniques. To develop laboratory skills and the ability to work independently.
- To explore all facets of scientific activities – from planning the experiment, conducting it, publishing the results and presenting them in front of an audience

Course – Requirements

Successful completion of the course requires:

One data analysis assignment. After the introduction lecture you will be given an assignment to get acquainted with data analysis.

10 laboratory experiments. This includes an oral pre-lab quiz for each experiment, performance of the experiment in the laboratory, and a written report for each lab. The labs are divided into two sets: thermodynamics and kinetics/spectroscopy. If you wish to do more than the required number of labs, special arrangements may be made with the instructor. The extra credit lab may be suggested by the student.

One oral presentation. You will give an oral presentation to the class about one of the labs from the course describing it to the other students in details as an independent research. Critique and suggestions about improvement of the lab would be particularly encouraged.

Grading:

The students must complete all assignments to receive a passing grade. The overall grade will count based on the five items below:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Points</th>
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<tbody>
<tr>
<td>1 data analysis assignment</td>
<td>20</td>
</tr>
<tr>
<td>10 quizzes of 5 points each</td>
<td>50</td>
</tr>
<tr>
<td>10 lab reports of 30 points each</td>
<td>300</td>
</tr>
<tr>
<td>notebook</td>
<td>30</td>
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<tr>
<td>1 oral presentation</td>
<td>50</td>
</tr>
<tr>
<td>Total possible points</td>
<td>450</td>
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The grades will be assigned based on the total number of points according to the following scheme:

- \[ 385 \leq A \]
- \[ 340 \leq B < 385 \]
- \[ 290 \leq C < 340 \]
- \[ 250 \leq D < 290 \] – I hope we won’t need this
- \[ F < 250 \] – nor this

**Disabilities**

Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act Amendments Act (ADAAA) covers issues relating to disability and accommodations. If a student has questions or needs an accommodation in the classroom (all medical information is treated confidentially), contact:

**Trudy Luken**, Director  
Student Accessibility Services (SAS) - Corbett Center, Rm. 244  
Phone: (575) 646-6840 E-mail: sas@nmsu.edu Website: http://sas.nmsu.edu/

NMSU policy prohibits discrimination on the basis of age, ancestry, color, disability, gender identity, genetic information, national origin, race, religion, retaliation, serious medical condition, sex, sexual orientation, spousal affiliation and protected veterans status.

Furthermore, Title IX prohibits sex discrimination to include sexual misconduct: sexual violence (sexual assault, rape), sexual harassment and retaliation.

For more information on discrimination issues, Title IX, Campus SaVE Act, NMSU Policy Chapter 3.25, NMSU's complaint process, or to file a complaint contact:

**Lauri Millot**, Title IX Coordinator  
**Agustin Diaz**, Title IX Deputy Coordinator  
Office of Institutional Equity (OIE) - O'Loughlin House, 1130 University Avenue  
Phone: (575) 646-3635 E-mail: equity@nmsu.edu Website: http://www.nmsu.edu/~eeo/

Other NMSU Resources:

- NMSU Police Department: (575) 646-3311 www.nmsupolice.com  
- NMSU Police Victim Services: (575) 646-3424  
- NMSU Counseling Center: (575) 646-2731  
- NMSU Dean of Students: (575) 646-1722  
- For Any On-campus Emergencies: 911

**Student Misconduct and Plagiarism:**

The Student Code of Conduct defines academic misconduct, non-academic misconduct and the consequences or penalties for each. The Student Code of Conduct is available in the NMSU Student Handbook online: http://studenthandbook.nmsu.edu/

Plagiarism is using another person's work without acknowledgment, making it appear to be one's own. Intentional and unintentional instances of plagiarism are considered instances of academic misconduct and are subject to disciplinary action such as failure on the assignment, failure of the course or dismissal from the university. The NMSU Library has more information and help on how to avoid plagiarism at http://nmsu.libguides.com/plagiarism
Communications by e-mail:
Feel free to use e-mail to ask questions about the course or material, or to inquire about making an appointment. Note that any requests for changes in the course requirements, such as changing a deadline must be made in person or by telephone. E-mail is simply not sufficiently reliable for these important matters.

Prelab quizzes:
Each student must demonstrate satisfactory knowledge of the principles, objectives and experimental procedures involved in an experiment before beginning the experiment. Some answers to prelab quizzes (those that involve calculations) should be written in your notebooks and shown to your instructor/TA or answered on-line. Consult the list of experiments to determine if you should see the instructor or the TA for a given experiment's quiz. Each prelab quiz is worth a possible maximum of 5 points. If your grade is less than 3 points, you must repeat it before you can continue (final score = score of repeat)

Lab Notebooks:
Each student must keep a laboratory notebook for this course. A spiral bound notebook is sufficient but I recommend something like Hayden & McNeil. Consult Garland, Nibler & Shoemaker, chapter I, for guidelines. Record all data and tape or staple in copies of all spectrometer and computer printouts. The notebooks will be graded separately. Your notebook is a proof that you actually did the experimental work. To avoid loss of data, it is recommended that notes are taken using carbon copies or that photocopies are made frequently as backup. Keep backup copies separate from originals.

Written reports:
Mastering your writing skills, particularly on the subject of scientific research, is imperative for advancing your further careers in a science-related field. It is one of the topics that we will be working on throughout this class and will be linked to perfecting your written reports.

Each written lab report is worth a maximum of 30 points. Consult the handout for the report format. An estimated point assignment for each section of the report is indicated in the handout. Grading for each lab may vary somewhat depending on the particular requirements of each. Due dates for reports are given on the attached syllabus. Students are encouraged to turn reports in early. Rewriting a report for a better grade is possible for early reports. No rewrites allowed after the due date. There is a one point deduction for each day a report is late. This includes weekend days. No reports will be accepted more than 10 days late.

Grading
Each report is worth 30 points. An approximate point distribution is:
Sections I-III, VI 4 points
Section IV (results) 9
Section VI (discussion) 9
Appendices 8

If there are no questions to be answered in appendices, the points will be distributed to the results and discussion sections.
Note: the reports will be judged for organization, clarity, neatness and grammar!

Oral presentations:
You will need to make an oral presentation describing one of the labs. All labs will be distributed at random among all students.
Read chapters 1-2 in GNS for advice on safety, lab notebooks, reports, data analysis and error analysis. It also suggests sources for literature references.

Reports

Practice in writing clear, concise and well organized reports is an important part of the course. A significant part of the course grade derives from the quality of the submitted reports. The primary focus of each report should be on the treatment of the data obtained and the presentation of the results. The format below is slightly different from that given in Shoemaker.

The use of computer word processing, graphing and spread sheets is encouraged, but not required. In particular, calculations and equations may be hand written, since equation writing by computer can be time consuming. You may submit your reports electronically if you wish.

**Physical Chemistry Laboratory Report Format**

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<th>Title</th>
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<td>Name</td>
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<td>date</td>
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I. Introduction (You don’t need to enumerate)

One paragraph to state the purpose of the experiment. Also, if desired, a paragraph summarizing the historical work or practical applications to put the experiment in perspective.

II. Theory

One or two paragraphs explaining the theory underlying the experiment. Discuss the phenomenon to be studied and how the measurements to be made will lead to the desired quantity. The important equations that will be used in analyzing the data should be given here along with any important assumptions. Do not give detailed derivations of the equations. Reference a source for the derivations (for example a text or journal article). Use superscript numbers to refer to references which will be listed in section VI. As explained in Shoemaker et al, equations should be part of complete sentences and symbols should be defined when they first appear. Number equations consecutively and use those numbers to refer to the equations later in the report. The ability to give a verbal explanation of an equation is an important skill all scientists should develop.

III. Experimental

State or reference the source for the procedures used. Discuss any departures from source procedures or unusual problems encountered. DO NOT include a detailed procedure (unless you used a nonstandard approach or altered it) but GIVE A BRIEF description of it (one paragraph).

IV. Results

Include data tabulations, graphs and other numerical results here. Graphs and tables must be titled. Axes, columns, and rows should be clearly labeled including units. Graphed data points should show error limits with circles or flags. Combine when possible similar graphs into one figure, for example when they represent similar data on different substances. Table entries
should also include error limits. Use graph legends when plotting different data sets on the same graph. Curves calculated from theory or fitting routines (such as least squares line fitting) should also be labeled as such. Often in journal articles, figure captions are used to explain graphs. Take a look at the *Journal of Physical Chemistry* to see examples of data presentation used by researchers.

V. Discussion

This is the heart of the report. Critically assess the results of the experiment. How do your data compare with values in the literature? If you can find no literature values, how do your results compare with related values in the literature, or with theoretical predictions? Be sure to reference your literature sources. Use tables to summarize comparisons when there are several to be made. Use questions posed at the end of the lab procedure as a GUIDE; try to respond to all questions but don’t write it as a question-answer dialog.

Explain isolated and general discrepancies from expected results. Differentiate between systematic and random errors and indicated relative magnitudes of qualitative errors.

Finally, in a short paragraph, summarize your impression of the experiment.

VI. References

List the references you used in the report. Use the format in Shoemaker *et al.* or any other commonly used format in scientific writing. For example, you could look at *The Journal of Physical Chemistry* to see the format the American Chemical Society uses.

Appendices. Calculations and Uncertainties in Results

ONE SAMPLE calculation, *i.e.* complete data reduction for one set of data. Attach computer printouts if used. ONE SAMPLE propagated error calculation. Make sure you clearly understand what random and systematic errors are and treat each appropriately. Known systematic errors should simply be used to correct the measurements before doing the calculations. State where the values for the errors used in this calculation come from. Statistically derived errors, such as standard deviations from multiple measurements are preferable as a starting point. If you start with estimated errors as opposed to statistically derived errors, justify them. Chapter 2 in GNS is an excellent reference on error analysis. It is strongly recommended that you read it and make use of it.