Supplemental Course Syllabus for CHE 313L, Physical Chemistry Lab

Introduction

This is a laboratory course designed to accompany your 2 semester introductory course in physical chemistry. Ideally it should be taken concurrently with your second semester of p-chem, but it can be taken after you have had 2 semesters of physical chemistry.

The experiments selected for the course (as well as the course’s overall pedagogical design) will be chosen to complement the lecture material and also to advance your scientific, professional and human development.

Accordingly, the experiments will both mirror and extend the material covered in the lecture (including introducing material not specifically covered in the lecture) in the five areas that are generally associated with physical chemistry:

- Quantum Mechanics
- Classical Thermodynamics
- Statistical Thermodynamics
- Spectroscopy
- Chemical Kinetics

In addition, the pedagogy and content of the course will reflect its conception as an introduction to research methods in modern chemistry. This does not require in all cases that state-of-the-art equipment be employed or that leading-edge questions be explored. It does require that you be provided with opportunities to discover and implement technological solutions to experimental problems. We want you to adopt an attitude of innovation, adaptability, and perseverance, but this means we are obliged to provide you with the practical tools you will need in order to realize these very laudable virtues.

Course Objectives

The objectives of this course are designed to reflect the current accepted practices and expectations for physical chemistry in the larger scientific community. They also support the broader goals of the division of mathematics and natural sciences as outlined in its statement of vision, reproduced in Appendix A.

The course will impart to you a working knowledge of the following core areas of laboratory technology and practice:

- Error analysis
- Electronics
- Vacuum technology
- Detection of light
- Other electronic transducers

There will also be a complete integration of computers into your learning experience in the following areas:

- Interfacing computers with experiments
- Measurement and control
- Simulation
- Data reduction and analysis
- Presentation of results

We subscribe fully to the maxim that no experiment has been completed unless its results have been communicated to the scientific community. For this reason, the course will encourage you to move beyond the conventional cookbook style lab report, and to explore other venues for the presentation of their results.
Assignments will require good scientific writing, exposure to public speaking, and utilization of the scientific literature and will include:

- Written Laboratory reports
- Public presentations of results
- Authoring of a journal-quality paper
- Researching the relevant scientific literature

Because the acquisition of knowledge proceeds within a moral and ethical framework, you will be expected to cultivate the following habits of mind:

- Integrity and honesty in obtaining data and reporting on them
- Forthrightness and openness in communications
- Effectiveness and civility in rendering and accepting scientific criticism
- Sound planning and experimental design
- Independent thinking, initiative, and effort.

The guiding principles for this ethical framework will be the applicable sections of the ACS code of ethics, reproduced in Appendix B.

Upon completion of this course, therefore, you should have an experiential knowledge of the following areas:

- Basic procedures and techniques used by physical chemists in acquiring data
- Effective use of computers in acquiring and interpreting experimental data
- Design and implementation of experiments in physical chemistry
- Utilizing the chemical literature in the design of an experiment
- Formal presentation of scientific results
- Ethical and behavioral expectations of an experimental scientist

Organizational Details:

Teacher: Dr. James DeHaven  ALT Room 230 and ALT Room 304  
Phone: ext 7844 (office); 440-6076 (cell)

Text: Laboratory Handouts

Supplementary Materials: Assigned readings from the chemical literature, Software: spreadsheets, data analysis, presentation, simulation, mathematics, Manufacturer's manuals for hardware and software.

Office Hours: Monday 12-1, Friday 12-1 (tentatively). I am always happy to see you by appointment. You are also welcome to come by outside of office hours and I will talk with you if I have time. The hour immediately preceeding a class is generally not a good time to try to see me.

Marks and assignments:

Students will work in pairs but, except where explicitly noted, students are individually responsible for each assignment. Each group will perform all introductory exercises, and 6 experiments chosen from the five areas of physical chemistry. Students are responsible for attending every meeting, for introductory work summaries, written lab reports, a public presentation, maintenance of the highest ethical standards, and mastery of all relevant chemical literature. The details of these requirements are explained below.
The grading scheme for the course will be as follows:

- Summaries of Introductory Materials: 10%
- Lab Reports (4): 30%
- Journal Style Report: 15%
- Public Presentation: 15%
- Grasp of Chemical Literature: 10%
- Subjective Evaluation: 20%

The class will meet for 28 sessions (usually twice each week) of three hours each, divided into three functional areas:

**Area 1:** The first eight sessions will be devoted to the experimental core, wherein the students will learn basic laboratory and computer techniques. You will be expected to keep a notebook and write a concise weekly summary of what they have learned.

**Area 2:** The next 18 meetings will be devoted to the performance of six experiments, chosen so that all 5 areas of physical chemistry are addressed. Each experiment will require you to master an article from the chemical literature associated with the technique or subject matter you are investigating. You will write conventional reports on 4 of these experiments. Reports will be typewritten, with figures and equations drawn in by hand.

Each report will be written in the standard scientific form generally divided into 4 parts:

- Introduction
- Experimental
- Results
- Discussion

These reports will also include a summary of the background article from the chemical literature that you have read. Each student must personally prepare their own lab reports.

You will write a journal style article on one experiment. This will require a literature survey, and adherence to current practices in the scientific literature for writing, organization, figures and diagrams, and citation. You will work in 2 person teams on this project.

You will present one experiment to the full class in the form of a formal presentation and/or poster session as outlined in “Area 3” below.

**Area 3:** The final 2 sessions will be reserved for the public presentation of the students’ results. These presentations will be arranged so that there is no overlap in student presentations, i.e. every attempt will be made to ensure that the greatest possible assortment of laboratory topics are presented. Students will work in teams but the actual presentation must be evenly divided between the two team members.
The labs will be scheduled as follows:

**Area 1: Introductory concepts**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Sessions</th>
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<tbody>
<tr>
<td>Lab Safety</td>
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<tr>
<td>Computer Techniques</td>
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</tr>
<tr>
<td>Data and error</td>
<td>1</td>
</tr>
<tr>
<td>Electronics</td>
<td>3</td>
</tr>
<tr>
<td>High Vacuum Technique</td>
<td>1</td>
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<tr>
<td>Optical Instrumentation</td>
<td>1</td>
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</table>

**Area 2: Laboratory Experiments:** six experiments are to be performed by each team. No two teams engage in the same sequence and sequences are assigned to maximize the variety of experiments that are performed. Three class sessions are allotted for the completion of each lab. Each team must select 6 experiments, at least one of which must be drawn from each of the following 5 areas:

- **Quantum Mechanics**
  - Hydrogen Atom Spectrum
  - Resonance Energy of Benzene

- **Thermodynamics**
  - Electrochemistry: Dependence of cell EMF on temperature and derivation of other thermodynamic quantities
  - Equilibrium Constant for the Gas Phase Dimerization of Acetic Acid
  - GC Phase Diagram

- **Statistical Mechanics**
  - Energy Partitioning: Determination of heat capacities of gases
  - Joule Thompson Effect
  - Transport Phenomena

- **Spectroscopy**
  - Dye Lasers: Use of a tunable dye laser the to acquire LIF spectrum of a gaseous molecule
  - Absorption Spectrum of Iodine Vapor
  - Rotational Spectrum of HCl and DCl

- **Kinetics**
  - Iodine Clock
  - Enzyme Kinetics: Inversion of sucrose
  - Gas Phase Kinetics

**Area 3:** The remaining 2 sessions will be used for presentations of lab results. Presentations will last for 20 minutes, and an additional 10 minutes will be set aside for questioning by the audience.

You must hand your reports in on time. Unless otherwise stated, "On time" means one week after the final session for a given experiment. The subjective evaluation will be based on my assessment of your preparedness for the lab, your initiative and intelligence in performing the experiments, your adherence to lab procedures, particularly those involving safety and the recording of data, and your
care of and respect for the lab equipment and the reagents.

**Cheating Policy:**

Any cheating, any attempts to cheat, and any plagiarism will be penalized. The maximum penalty will be a failure for the course, a letter to the Dean and the program director of the student involved, as well as the initiation (through the appropriate administrative channels) of procedures leading to the expulsion of the student from the college.

If you find yourself in an ambiguous situation, one in which you are uncertain about whether you might be engaged in cheating, simply ask me and I will let you know whether or not I regard the behavior as cheating.

**Letter Grade Equivalents:**

Marks are not curved. Letter grades are assigned according to the equivalents published in the College Catalog:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Score Range</th>
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<tbody>
<tr>
<td>A</td>
<td>93-100</td>
</tr>
<tr>
<td>A-</td>
<td>90-92</td>
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<tr>
<td>B+</td>
<td>87-89</td>
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<tr>
<td>B</td>
<td>83-86</td>
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<tr>
<td>B-</td>
<td>80-82</td>
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<tr>
<td>C+</td>
<td>77-79</td>
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<td>C</td>
<td>73-76</td>
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<tr>
<td>C-</td>
<td>70-72</td>
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<tr>
<td>D+</td>
<td>67-69</td>
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<td>D</td>
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<td>D-</td>
<td>60-62</td>
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<td>F</td>
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Appendix A: Vision Statement of MNS

The Department of Mathematics and Natural Sciences provides service to the college and to its students in several areas:

1) Courses and enrichment for students majoring in mathematics and science;
2) Support courses for students majoring in health sciences;
3) Core courses in science, mathematics and computer science for all students;
4) Research opportunities in the sciences for all students;
5) Remedial courses and services in the sciences for at-risk students;
6) Professional advisement, preparation and support for students intending to pursue post graduate education in science, medicine, dentistry and other related fields.

While the demands of these disparate obligations require targeted responses, the department maintains a coherent set of core values and a clear vision of the relation of its activities to the larger issues that face our society which inform and direct its conduct of all its affairs.

The department seeks to educate scientifically and mathematically literate members of society. We want our students to be able both to apply the education they receive to their own careers, and to utilize it as constructive members of their community and participants in our democratic society. Accordingly, we provide the scientific underpinnings for majors in science, technology, and the health professions. But we also provide a component of education that does not depend on a student’s major so that they can contribute intelligently to the discussions and decision making that characterize our scientific and technological age. We strive to provide this component in a manner that equips our students, regardless of the venue in which we interact with them, with the scientific and analytical tools they need to continue to develop in a world of rapid technological change.

To this end we embrace the following principles:

Ideas have primacy over information.
Education has primacy over training.
An appreciation of the scientific process has primacy over the mere accumulation of factual knowledge.
Freedom of inquiry is the core value that makes it possible for us to understand our world and have a positive impact upon our society.
Our ideas about science are incomplete until and unless we communicate them to others.
Science is integrative: nature does not respect the divisions between academic disciplines, and the scientific habit of thought informs our relationship with areas of knowledge outside the sciences.

To further these principles, we engage in concrete and directed practices.

We teach our courses using curricula and methods that emphasize core scientific ideas. We teach science as though it were a liberal art, routinely examining the interplay between science, mathematics and society; and we review in our courses the historical interplay of people and ideas that has led to the worldwide spread of the scientific model.

Our pedagogy is devoted to how best introduce students to ideas rather than to a particular technology or set of competencies. We educate our students in a way that liberates them from a dependence on narrow technological or procedural rules, and provides them with independent habits of thought, so that they can expand their knowledge to accommodate the changing landscape of scientific knowledge that will shape the world they encounter in the future.

Our classes, laboratories and research efforts are constructed to foster a brave and experimental attitude in
our students. We insist that students experience the process by which scientific knowledge is advanced, and, to the extent that this is possible in undergraduate education, we incorporate this kind of experience into our courses, labs, and research efforts.

We encourage our students to rationally critique what they learn. We subscribe to the maxims that, in science, there is no final authority, and that the debate over scientific truth never ends. Although all of our educational experiences are laden with content, we recognize and communicate to our students the core insight that this content is continuously under review. Consequently, we encourage and expect skepticism and intellectual honesty in the acquisition of scientific knowledge, and in the confrontation with, and evaluation of all claims to scientific truth.

We require written and oral self-expression in all our educational activities and we teach our students to express themselves and defend their positions with rational, organized and civil argumentation.

Our vision of a well educated graduate of our school is a person who has an integrated view of science, who understands the interrelationship between content and process in science, and who has a clear vision of the relationship between science and the ethical, political, and philosophical universe in which he or she lives out his or her life.
Appendix B: ACS Code of Conduct for Chemists (copyright ACS)

The American Chemical Society expects its members to adhere to the highest ethical standards. Indeed, the federal Charter of the Society (1937) explicitly lists among its objectives "the improvement of the qualifications and usefulness of chemists through high standards of professional ethics, education, and attainments..."

Chemists have professional obligations to the public, to colleagues, and to science. One expression of these obligation is embodied in "The Chemist's Creed," approved by the ACS Council in 1965. The principles of conduct enumerated below are intended to replace "The Chemist's Creed." They were prepared by the Council Committee on Professional Relations, approved by the Council (March 16, 1994), and adopted by the Board of Directors (June 3, 1994) for the guidance of Society members in various professional dealings, especially those involving conflicts of interest.

CHEMISTS ACKNOWLEDGE RESPONSIBILITIES TO:

* The Public
Chemists have a professional responsibility to serve the public interest and welfare and to further knowledge of science. Chemists should actively be concerned with the health and welfare of co-workers, consumers, and the community. Public comments on scientific matters should be made with care and precision, without unsubstantiated exaggerated, or premature statements.

* The Science of Chemistry
Chemists should seek to advance chemical science, understand the limitations of their knowledge, and respect the truth. Chemists should ensure that their scientific contribution, and those of their collaborators are thorough, accurate, and unbiased in design, implementation, and presentation.

* The Profession
Chemists should remain current with developments in their field, share ideas and information, keep accurate and complete laboratory records, maintain integrity in all conduct and publications, and give due credit to the contributions of others. Conflicts of interest and scientific misconduct, such as fabrication, and plagiarism, are incompatible with this Code.

* The Employer
Chemist should promote and protect the legitimate interests of their employers, perform work honestly and competently, fulfill obligations, and safeguard proprietary information.

* Employees
Chemist, as employers, should treat subordinates with respect for their professionalism and concern for their well-being, and provide them with a safe, congenial working environment, fair compensation, and proper acknowledgment of their scientific contributions.

* Students
Chemists should regard the tutelage of students as trust conferred by society for the promotion of the student's learning and professional development. Each student should be treated respectfully and without exploitation.

* Associates
Chemists should treat associates with respect, regardless of the level their formal education, encourage them, learn with them, share ideas honestly, and give credit for their contributions.

* Clients
Chemists should serve clients faithfully and incorruptibly, respect confidentiality, advise honestly, and charge fairly.

* The Environment
Chemists should understand and anticipate the environmental consequences of their work. Chemists have responsibility to avoid pollution and to protect the environment.