CHEMISTRY 236, FALL 2007

Instructor: Joel Tellinghuisen [SC5521; Office Hours 12-1 MTR, 5-6 W]

Assistants: Stephen Chmely
Julia Köhler
Steffen Lindert
Nils Wötzel

Lab Hours: 1:10-4:00 p.m. M–R [SC7510]

Lectures: 4:10-5:00 p.m. Wednesdays [SC5211]

Lab Text: *Experiments in Physical Chemistry* (7th edit.) by Garland, Nibler, and Shoemaker. *Physical Chemistry Laboratory* Class Pak (available at Campus Copy, Rand).

Web Site: http://www.vanderbilt.edu/AnS/Chemistry/Tellinghuisen/

Schedule

Week of	Activity
August 27	Lec (Intro, Stats)
September 3	Comp; Lec (1); Q1(SP1-8)
September 10	Comp; Lec (2); Q2(Ex1)
September 17	Lec (5); Q3(SP9-17)
September 24	LAB; Lec (3); Q4(Ex2)
October 1	LAB; Lec(4); Q5(SP18-25)
October 8	Q6(Ex5); Lec (6,7)
October 15	LAB; Lec (8,9); Q7(Ex3)
October 22	Q8(Ex4)
October 29	LAB; Q9 (Ex7)
November 5	LAB; Q10 (Ex6)
November 12	LAB; Q11 (Ex9)
November 26	makeup LAB Q12 (Ex8)
December 3	

Note: On LAB weeks, students go to SC7510 on their lab day; for Comp, Garland 119. Q = quiz; SP = Statistics Problems; Ex = Experiment.

Experiments (# in lab text)

1. Temperature and Pressure Calibration
2. Inversion of Sucrose (22, modifications)
3. Bomb Calorimetry (6)
4. The Triple Point of a Substance
5. Spectrophotometric Study of Equilibrium
6. Freezing Point Depression (11, mods.)
7. Thermal Expansivity of a Liquid
8. Physical Adsorption of Gases (26)
9. Binary Liquid-Vapor Equilibrium (14, mods.)

Experiments 1-4 constitute a core of required experiments, and 5-9 are electives (see below). The theoretical background needed to understand these experiments is modest — within the scope of general chemistry in many cases. Further, the Class-Pak writeups include theoretical and other support material to make them self-contained; and all experiments will be treated in the lecture portion of the course. For the core experiments, all work must be completed and submitted at the end of the lab day (by 4:30 p.m.).

Grade Computation: Based on laboratory work (results, analysis, and reports — 6×25 + 2×15), quizzes (8×16 + 6×6), computer exercises (4×8), and peer points (24). Final grades will be assigned on the basis of absolute scores, out of a total of 400:

A	345	A–	330	B+	315	B	300	B–	280
C+	270	C	250	C–	230	D+	220	D	210
D–	200								

Each team receives a single grade for each lab, only 2 of which involve reports (elective experiments). The quizzes include prelab quizzes taken (individually) at the start of the lab period. The peer points are to be allocated by each student to his/her lab partners (see below). The lecture quizzes will be best 8 of 10.

Vanderbilt Honor Code: In effect for all work. Lab teams collaborate on all lab work, as discussed more fully below. Students should write and sign the following on each graded assignment: "I pledge my honor that I have neither given nor received unauthorized aid on this assignment." For the purposes of this course, "unauthorized aid" includes (but is not limited to) the use of manufactured data ("dry-labbing") and the use of data and reports obtained by other students in this or in previous years of this course. A violation will cost 100 points.

Students will need goggles and bound notebooks (available in the bookstore); and a lab coat is recommended (purchasable from the Chemistry Storeroom). Students must wear safety goggles, full-length pants or lab coats, and shoes at all times while working in the lab. Sandals are not allowed, nor are foods and beverages. Shorts are permitted only under lab coats.

Laboratory work is scheduled for seven weeks, with the last being for makeup work only. Students will work in teams of three, to be constituted by random number generation. Each team will submit a single set of results/report for each experiment, with all partners sharing credit. Six experiments should be completed, including the four core experiments. Collaboration with other teams is not allowed, unless otherwise specified in special cases.

Laboratory submissions should not be elaborate. The key is clarity. Each submission should be complete and sufficiently well organized that the instructor grading it can follow it easily. Attention will be devoted to the preparation of good tables and figures, properly labeled, with self-sufficient captions.

Writeups for all of the nine experiments are included in the Class Pak. About half of these follow the descriptions in the lab text fairly closely. While the lab text is not required for the course, it is strongly recommended that each team have at least one copy among them.

The laboratory is operated on the "station" principle: Most setups are in place throughout the semester, and students work at the different experiments in accord with a sign-up schedule. All students will do Experiment 1 in either the first or the second scheduled lab week. (Their second experiment in this two-week period must be 2, 5, or 7.) There are two stations for each of Experiments 2–4, but only one for each of the elective experiments (5-9). Thus, teams should plan ahead to ensure that they get their preferences for the two elective experiments. The only provision for repeating botched work is the inclusion of the makeup week in the schedule; *i.e.*, students will be allowed to work only on their scheduled lab days.

Students should come to lab on experiment days prepared to work efficiently. All notes on experimental procedures must be entered manually in the notebook in ink before the start of the period, as must be all "manual" data recorded in the experiment. (*i.e.*, students may not work from Class Paks.) The notebooks must be submitted along with the results/reports, so each team will need three notebooks, one for each team member. In addition, students should utilize wise backup procedures to ensure against loss of data. The main notebook for the experiment must be initialized by the instructor at the end of each lab day. This constitutes a key part of the check-out procedure, and students without such clearance will be liable for any damage or breakage subsequently found at their stations. For all experiments, either final or preliminary (for electives) results and analysis must be submitted at the end of the period, as specified in the CP writeup.

To promote advance preparation for the experiments, PowerPoint (PP) presentations are available on the course web site. Each student will take a short, 6-point written quiz at 1:10 p.m. on the day of the scheduled lab work. These quizzes will be based on the experimental procedures, as covered in the Class Pak, the PP document, and the PreLab Preparation questions in the Class Pak.

Reports for elective experiments are due at 4:00 p.m. on the regular lab day, one week after the completion of the experimental work. Late lab work will result in the loss of 10% per late day. Teams that encounter unanticipated problems may elect to "punt" and do the same or a different experiment in the makeup week. This may be done only once. [Exception: Delays occasioned by equipment problems beyond the control of the students will be accommodated through special arrangements.]

The experiment stations must be left in a condition that will permit the next team using the setup to proceed immediately with their work. Follow the outdoorsman's rule: Leave the site better than you found it. Any carelessness that causes us or another team to lose time will result in the loss of as many as 10 team points for the experiment. This includes incomplete cleanup, unreported breakage of equipment, and spillage of chemicals or water away from the setup, *e.g.* on or by the balances.

The lecture part of the course will be devoted to the statistics of data analysis and the theory and practice of the experiments. Mastery of the Statistics Problems and the Study Problems included at the end of each writeup in the Class Pak is essential for understanding the subject matter of this course and for doing well on the quizzes. Answers (often very terse!) are provided on the course web site. In addition, you are encouraged to collaborate with your colleagues in work on these problems. Your mastery will be tested on the 12 scheduled quizzes, of which you may take as many as 10.

The primary tool for data analysis and presentation in the course is the KaleidaGraph (KG) program, the latest version of which has just been installed in the Microcomputer Lab. The Class Pak includes 4 KG assignments worth 8 points each. You may collaborate on these assignments as you like.

Students will have 24 peer points (total) to allocate to their lab partners (maximum to one partner = 18). This distribution will need to be submitted in writing before Dec. 6 (you will be reminded). It is not necessary to allocate all 24 points. Students who fail to submit allocations will have their points distributed 12:12 (*i.e.*, it is not necessary to submit these if you are happy with the 12:12 distribution).

Tips for Working Efficiently in the Physical Chemistry Laboratory

With its special demands for mustering, analyzing, displaying, and presenting data — often large data sets logged on the computer — physical chemistry laboratory can seem oppressive in its time demands. Those demands can expand significantly when mistakes are made, because they can propagate through an entire analysis. In an attempt to reduce such time-wasting events, I have added "Implementation Tips" to the writeup for each experiment. These aim to help the teams organize their efforts and work efficiently to accomplish their goals, especially their data analysis. By using lab time efficiently, you should be able to complete major parts of the required data analysis before you leave for the day. Indeed, for the four core experiments, you are required to submit completed results at the end of the period (for which purpose we use the time 4:30 p.m.).

These efforts were stimulated by several observations: (1) In most experiments there are long "dead periods," while you wait for something to happen — *e.g.*, bringing a system to equilibrium at some temperature or pressure and then changing one or both of these and repeating. (2) During these dead periods, students often just stand around watching. (3) None of the experiments requires more than two lab partners for successful completion of the lab work, and some can be done well by one person. Thus at least one member of each team can use practically the whole lab period to process and analyze data. In these Tips I assume there is one such designated "data analyst" for each team on a given experiment. Of course it is wise for this member to have at least one other team member check significant elements of the analysis. Also, it is in the educational interests of all team members to rotate responsibilities as you change experiments.

In the lab we have nine Pentium-III computers and two PowerMacs, all equipped with KaleidaGraph (KG). There are also at least four color inkjet printers and one black-and-white. For compatibility with your data analysis work in the Microcomputer Lab, we have the current version of KG installed in the PC computers that are connected to the printers. The computers that log data in Experiments 1, 3, 4, and 6 run a Windows version of the LabWorks program in a multitasking environment. This means that you can even do some data analysis on these computers while you log data (except not at Station 3, where two teams normally work).

The PCs operate under Windows-98SE. This means that they will unfortunately not automatically recognize USB storage devices. I have installed on all of them the software needed for a 3-year-old 128-MB Lexar JumpDrive. However, in my limited experience they will read from few other such devices. Accordingly, you should probably plan to move data the old-fashioned 3.5" diskette way. All of the computers (including the Macs) will read PC-formatted diskettes.

Finally, about the mistakes mentioned above. Unfortunately, nothing can fully protect you from these! Accordingly, I recommend that each team have major parts of its data analysis checked by at least two team members working independently. This is the best way to guard against mistakes and discover them when they happen.

Along these same lines, since you will do six experiments, you might want to consider a rotating division of labor scheme in which you make one team member "foremen," a second one "scribe," and the third "analyst." The duties of the analyst are probably clear. The foreman might typically be the prime mover for the experiment, hence the "main man" for understanding what is going on and coordinating the efforts of the others. She might typically also be the one primarily responsible for putting together the report (where needed). The scribe might be called upon to condense the Class-Pak instructions into the working handwritten (notebook) procedures for the experiment, and also to record key information and data obtained. Of course, all should attempt to doublecheck the data analysis and critique the written report (where that is required).

I am convinced there is much of value to be learned from this course — especially how to work with scientific data in a realistic, indeed professional way — but also a "real-world" look at some fundamental thermo and kinetics that you have all previously encountered in lecture courses. So restrain your preconceived impressions about this course, enjoy, and learn ... and we'll do our best to help!