The University of Vermont

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CHEM 201 Advanced Chemistry Laboratory

Chem 201 Syllabus - Spring 2013

Course Description:

What the UVM Catalogue says about CHEM 201 - Advanced Chemistry Laboratory:

"Laboratory problems requiring modern analytical, physical, and inorganic synthetic techniques."

What we think you are saying at this point in your college career:

I have finished 2½ years of chemistry. I have completed organic chemistry, and organic lab was awesome. How do I get exciting labs in other areas of chemistry? I mean, freshman chemistry was ok, but lab titrations with a burette are way behind me. I would like to get hands-on experience with modern sophisticated instrumentation and to perform experiments that really challenge my thinking.

Yes boys and girls, that is what we hope we have for you in this two course sequence, CHEM 201 & 202.

CHEM 201 is also a spectroscopy course where you get to learn all about and use:

- Infrared spectroscopy in *lab 1* and again in *lab 2 & 4*
- NMR spectroscopy in *lab 3* and again in *lab 4*
- UV/visible and excitation/emission (fluorimetry) spectrometry in *lab 2*
- Inductively coupled plasma (ICP) atomic emission spectroscopy in *lab 5*
- Mass spectrometry in *lab 6*

Learning Goals:

- **To apply knowledge of chemical and physical principles to the solution of qualitative and quantitative chemical problems**
- **To understand the interplay of observational data, hypotheses, and hypothesis-driven experimentation through application of the scientific method**
- To become proficient in chemical laboratory techniques and apply these techniques to practical and current problems in research
- To be able to read and critically evaluate the chemical and scientific literature
- **To learn to present scientific data clearly and effectively through both written and verbal communication**

Prerequisites that are important:

- **CHEM 161 (recommended, but not required)** – *Because CHEM 201 is the place where we will put in practice the knowledge in quantum chemistry, CHEM 161 is recommended to have been completed prior to CHEM 201. However, the basic knowledge required from CHEM 161 will be repeated in CHEM 201 lectures, such that with some additional reading, a student can complete CHEM 201 without completing CHEM 161 first.*
- **CHEM 142 or 144** – *means you have finished the 1st 2-years of chemistry. Note: it is possible to take CHEM 201 concurrently with CHEM 144, but it is not advised.*
- **CHEM 221** or concurrent enrollment – *CHEM 221 is not really a prerequisite for CHEM 201, but what a waste of your time to play with instruments in CHEM 201 and not know how they work! You will learn all about instrumentation in CHEM 221 and get to play with these instruments in CHEM 201.* ***What a combo: CHEM 221 + 201.***

Lecture:

Mon., Wed., & Fri., 1:55-2:45 pm, Angell B203

The foci of Advanced Chem Lab are the laboratory experiments and the lab write-ups and presentation. The purpose of the class time is to provide lectures about the chemistry and instrumentation that will be in each laboratory. As such, we won't need to meet for 3 class days a week.

See calendar of classes *for which days class will meet.*

Laboratory:

Thurs., 1:00-7:00pm, Cook A105 & the 2nd floor NMR/GCMS room

Text:

No text covers the diverse laboratories in the course. Readings will be provided as (i) photocopies of articles from the scientific literature, (ii) chapters from books and (iii) books on reserve in the chemistry library. Students will also have to search the literature for additional articles and book chapters relevant to particular laboratories.

Course Instructor:

Dwight E. Matthews 656-8114 Cook A205

Graduate Teaching Assistants:

Daniel DePuccio 656-4394 Cook A135 – Expts 3, 4, & 5

Rebecca Harvey 656-0901 Cook AA206/A224 – Expts 1, 2, & 6

Office hours:

Scheduled per student need

UVM Policy on Absences:

Religious Holidays: Students have the right to practice the religion of their choice. Students should submit in writing by the end of the 2nd full week of classes their documented religious holiday schedule for the semester if there are any conflicts with the class or laboratory schedule.

Inter-collegiate Athletics: Members of UVM varsity and junior varsity teams are responsible for documenting in writing any conflicts between their planned athletic schedule and the class (& laboratory) schedule by the end of the 2nd full week of classes.

UVM Policy on Academic Integrity:

Offenses against the Code of Academic Integrity are deemed serious and insult the integrity of the entire academic community. Any suspected violations of the code are taken very seriously and will be forwarded to the Center for Student Ethics & Standards for further investigation. **Details**

How the course grade is determined:

		Points	
Written lab reports (5 x50 points each - see *link on lab reports*)		250	72%
Oral lab report (1 x50)		50	14%
Lab performance and lab notebook	30		
Participation during oral presentations	20	50	14%
	Total:	350	100%
Optional, bonus lab: Design and complete an additional lab experiment of your own — available *ONLY* if there is sufficient open lab time.		50	
Failure to submit a lab report: any missing lab report will be assigned a negative grade		-20	

Update the literature used for the various labs. Bring me (DEM) a good article from the literature or chapter from a book reviewing or discussing a key aspect of any of the labs *that is newer and better than the existing references already cited for the lab*, and I will give you 5 points up to a maximum of 30 points.

More Information About Chem 201:

Lab safety:

- **You will continue the same laboratory safety practices in Chem 201 as per your earlier labs at UVM in the Dept. of Chemistry.**
- In addition, you will be responsible for looking to see what chemicals and what procedures are being used *in advance* of each laboratory. You will be expected to come to the laboratory already equipped with the necessary safety information concerning chemicals to be used in that laboratory.
- You can get the necessary safety information from **the Chem. Dept Lab Safety page** including:
  - **Material Safety Data (MSDS) Info**.
  - **NIOSH/WHO International Chemical Safety Cards**
  - **The UVM Chem Dept Chemistry Safety Bulletin** (PDF file)

Lab notebooks:

Yes you need to keep a laboratory notebook. The notebook is worth up to 9% of your grade. The usual is expected with regard to the notebook:

- The notebooks will be clearly marked with your name and address.
- Each day's entry will be preceded by an entry of the **date** of work.
- All entries will be in permanent ink.
- All entries will be readily readable! Points will be deducted for bad hand-writing and ambiguous numbers.
- All data that needs to be written down (a weight from a balance), will be entered at the time you collect it, not on scraps of paper.
- In this lab, many of the experiments will generate complex data sets using a PC controlling the instrument. You can't write this material down. It needs to be collected in a separate folder or 3-ring binder when it gets printed. You may want to do a "reducing" photocopy of critical pieces of information that need to go in your notebook and use a glue stick to affix them into your notebook. You may also glue typed-procedures into the notebook in place of rewriting procedures, and you may make references to specific instrument operating instructions etc. in a specific manual or hand-out instead of recording this information directly into your notebook.
- It's helpful if you bring a "thumb-drive" or USB memory stick to lab to download data into a format that can be transferred to Excel for further processing and plotting for lab reports.
- Although much of the data you collect will come from a computer controlling an instrument, you still need to record all of the operating parameters of an instrument at the time you are using it.
- You should organize for every experiment in advance, prior to starting it, and try to arrange space in your notebook for that day's experiment accordingly.
- You need your notebook with you at in the laboratory always.

Lab reports:

Get info

Lab oral presentation:

- **Each student chooses one of the six laboratory experiments to present orally to the class, rather than as a written lab report.** The basic format will be the same as the written lab reports. *Communication skills are critical to success in a career in science. Everyone has to present their work during their careers. Here is a perfect opportunity for you to begin in a less threatening environment.*
- You will have ~30 min to present your work and 10 min for the audience (your class & instructors) to ask questions. An overhead computer-projection device projector that connects to a PC and an overhead display camera will be available for your talk, or you may bring your own laptop to hook up.
- The schedule for the oral presentation will be 1st-come 1st-served. You need to send an e-mail to me (**DEM**) stating which presentation date you wish to reserve and which laboratory you wish to present.
- **See the link in the menu above** for details about the oral presentation.

General lab format:

- At the start of each lab, your TA will get together with you to discuss the experiment to be done. This is your best chance to ask questions. Preliminary reading assignments, the general plan for the experiment, etc. will have been given to you at least a week in advance of the experiment.
- Key to success in the course is a positive mental attitude when you arrive to start a lab. We will have done the best we can in preparing an experiment, but Murphy's law will sometimes strike, causing delays or slowing completion of experiments. Should extraordinary difficulties occur, your TA will work with you to extend working hours or to complete the experiment at another time.
- We have planned each laboratory so that all necessary data can be obtained well within the scheduled laboratory time. Although you should plan on being present for the full-scheduled time, we hope to complete the experimental part of each lab in much less than the 6 hours of allotted time.

Brief Synopsis of the Laboratory Experiments:

Lab #1: FT-IR

1 lab day. You will learn how to use a high resolution Fourier transform-infrared spectrometer (FT-IR). We will take advantage of the FT-IR's high spectral resolution to measure various physical chemical vibrational properties of diatomic gases. The 1st gas to be studied will be CO at normal and high resolution modes. The 2nd gas will be HCl. Here you will be able to distinguish the isotopes of ^{35}Cl and ^{37}Cl. You will also prepare ^{2}HCl and measure the spectrum of ^{2}HCl. You will calculate the physical chemistry rotational and rotational-vibrational parameters for both ^{1}HCl and ^{2}HCl. You will also calculate bond strengths from the measured mechanic parameters of these oscillators.

Lab #2: Molecular Spectroscopy

1 lab day. You will use our research-grade UV-visible spectrophotometer and our fluorometer to investigate the fluorescence emission spectra of anthracene. The vibronic features of the fluorescence will be related to conventional IR absorptions.

Lab #3: NMR

1 lab day. You will use the *Varian 500 MHz NMR*. We will take advantage of the instrument's resolution and sensitivity to acquire ^{1}H data for the keto-enol tautomerization equilibrium of ethyl acetoacetate and acetylacetone and measure the equilibrium constants in two different solvents.

Lab #4: Vacuum Chemistry

1 lab day. You will learn how to manipulate, move, sample and measure gases using a vacuum line. Two gases, BF_3 and $(CH_3)_3N$ will be combined to form a solid-state product. The product will be characterized to confirm the reaction.

Lab #5: Atomic Emission Spectroscopy by ICP

2 lab days. You will learn to use the *Perkin-Elmer Optima 7000DV* inductively coupled plasma (ICP) optical emission spectrophotometer to measure calcium, sodium and other ions in ground water by atomic emission. This lab will focus on methods of quantification and interferences.

Lab #6: GCMS

2 lab days. You will learn modern separation techniques via gas chromatography (GC) and analysis techniques via mass spectrometry (MS). You will use the *Varian Saturn 2100T ion trap GCMS* to make your the measurements. You will also learn chemistry required to prepare biological samples for GC measurement by performing micro-chemistry reactions on samples of amino acids. You will separate the individual amino acids by GC and collect spectra by MS for identification of each compound. Using standard mass spectra analysis techniques, you will confirm the identity of each amino acid peak.

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