Introduction and suggested course strategy: This course is envisioned as a gateway course. It is assumed that people taking this course go on to further courses in Chemistry. The course material encountered here -- chemical characterization of aqueous inorganic solutions, thermodynamics, and kinetics -- all find use elsewhere in upper level courses, with particular emphasis in physical chemistry and biochemistry. This course also introduces the discipline of analytical chemistry to the student, mainly through the laboratory component of the course.

Thus, this course seeks to build a sound knowledge base for use in upper level Chemistry courses. It is our expectation that you, the student, be able to USE THINGS you learn here later on. This requires a different level of knowledge than merely RECOGNIZING concepts and/or having some vague knowledge of buzzwords, without a clear rigorous understanding of what they mean. To be successful in upper level chemistry courses, we assert you need CHEMISTRY SKILLS AND UNDERSTANDING BEYOND SIMPLE SUPERFICIALITY. You need to learn to deal with subtleties and nuances. Therefore, the presentation and testing of the lecture material is going to “sweat the details”.

Experience teaches that this course works best for the student when an optimal set of class notes, at the level of detail the tests will cover, is PERSONALLY GENERATED BY THE STUDENT. Using already-available material does not work because there is NOT the focused interaction necessary to “make this material a real part of you”. To really get to know the stuff at the level we’re going to test, you’re going to have to deal with lecture material in an engaged, focused, rigorous manner to produce a detailed and comprehensive set of class notes. The use of these notes will permit you the best chance to achieve desired success when it comes testing time. Experience suggests such a set of desirable notes is achieved by a 2-step process:

1. **attendance at lectures** where the lecture material is taken down by the student as “raw” class notes in as full a manner as possible. This is, frankly, a tough unglamorous task. To aid the student in this process, a set of “skeleton notes” for the day’s material will be made available, but these are only intended as a rough guide for what is to be covered. They are not intended to be comprehensive.

2. **transcription and amplification** of these raw notes (and skeleton note material) to form a complete detailed record of the day’s lecture. This record often works best when presented in narrative form. Optimally, this transcription/amplification process to produce the resulting narrative is accomplished before the next class, while the student’s short term memory is still able to “fill in the gaps” of that day’s lecture notes. Beyond a few days, short term memory fails to provide the requisite detail.

The 2-step process described above is the “classroom strategy” suggested for use in this course. All tests and the final in this course will assume this level of detail on the part of the student.

It should be stated that the student is ALWAYS encouraged to seek help from the instructors on how to implement this suggested “classroom strategy”. Learning to take and rewrite/amplify class notes is a skill, one that can be learned and improved with help. While class notes are not, by
In addition to “lecture concepts” (to be handled via class notes), much course material is of a quantitative “problem set” nature. This is particularly true in the “chemical characterization of aqueous solutions” section of the course. Acid/Base pH problems, redox galvanic cell calculations, Beer’s Law determinations, and fundamental kinetics rate law calculations are examples of the types of “word problem set material” to be found in this course. This “problem set material” is considered important enough to be tested in 2 different formats:

1. as components of all tests and the final.
2. as the exclusive topics in short quizzes. While these quizzes will be prepared with the idea of needing ~20 minutes on the part of the student, the student will be given a reasonable amount of time to complete them. These quizzes will endeavor to test at 3 levels: the most basic level of understanding and skill (“Warm Ups”), an intermediate level of competence (“Sprints”), and, finally, at the desired level of detail (“Killer 440’s”). It is likely that the frequency of quizzes may be one quiz per week. They will be geared to roughly follow the order of topics in the course.

**Lecture Material:** The course content can be subdivided into 3 general areas: the chemical characterization of aqueous systems, thermodynamics, and kinetics. A more detailed description of each topic follows:

**The Chemical Characterization of Chemical Systems:** The following are the topics to be covered in this part of course and the material on which the student will be tested. The embedded problem sets are also presented. The order of presentation is open to modification.

- Nature of a titration -- overview and necessary calculations -- PS 100
- Introduction to minor reactions and to writing specialized K expressions -- PS 120
- Measurements and decision making (use of statistics) -- PS 110 (This material to be covered in laboratory discussion)
- Characterization of aqueous solutions, exemplified by the process of titration -- the pH and pK formats -- use of pH line methodology -- PS 130
- Titration calculations completed -- calculation of pH at equivalence point and at all titration stages -- PS 140
- Complexometric titrations -- water hardness calculations
- Polyprotic Acid Systems -- PS 150
- Buffer Systems -- PS 160
- Spectroscopy -- the Beer-Lambert Law -- PS 190
- Redox Chemistry -- introduction to redox couples -- the Nernst Equation -- PS 170
- Galvanic Cells and associated calculations -- PS 180
Thermodynamics: The following list details the expectations for student learning/skill development in this section of the course. This is also the order in which topics will be covered. In addition to the relevant problem sets, there will be collections of short essay questions which will indicate what is meant by “definitions and qualitative descriptions”. The expectation is that students should be able to:

- Describe the relation between forces and potential energies.
- Describe qualitatively the origins of the various intermolecular forces and their graphical representations.
- Describe the way kinetic energy is related to temperature and its effects on the behavior of molecules governed by intermolecular forces.
- Describe qualitatively how these forces underlie physical transformations that do not involve a change in composition, e.g., phase transitions.
- Describe simple models of how these forces affect chemical reactions.
- Describe the first law of thermodynamics using the concepts of heat and work (see below).
- Define work (macroscopically and microscopically) and write down the mathematical expressions for work as it applies in chemistry.
- Calculate work using mathematical expressions.
- Define heat (macroscopically and microscopically) and its relation to heat capacity.
- Use the heat capacity to calculate energy changes due to temperature changes -- PS 215A
- Describe how heat is exchanged during phase transitions. -- PS215 A
- State the definition of enthalpy, the rationale for its use, and describe its relation to the first law.
- Calculate the heat of a reaction or enthalpies associated with different chemical species using Hess’s law. -- PS 215B
- State the second law of thermodynamics in terms of heat and work and describe how it applies to simple examples.
- State the Clausius definition of entropy and the statement of the second law in terms of entropy. Discuss the meaning of spontaneity as it applies to physical processes.
- Describe simple physical changes in terms of entropy.
- State the mathematical expression for entropy change for various physical processes and be able to use these equations for numerical problems.
- State the Boltzman definition of entropy and describe how it applies to simple physical systems and processes. This statement includes the definitions of macrostate and microstate.
- State and describe the third law of thermodynamics and the meaning of absolute entropies. Calculate the entropy change for a chemical reaction in terms of absolute entropies.
- State the definition of the Gibbs free energy in terms of enthalpy and entropy.
- Determine how temperature affects free energy changes for a particular process given the entropy and enthalpy changes.
- State the mathematical relation between the free energy change for a chemical reaction and its equilibrium constant (The Gibbs equation) and interpret this equation qualitatively.
- Do simple numerical problems using the Gibbs equation.
- Discuss applications of thermodynamics to selected topics
Chemical Kinetics: The following list details the expectations for student learning/skill development in this section of the course. This is also the order in which topics will be covered. In addition to the relevant problem sets, there will be collections of short essay questions which will indicate what is meant by “definitions and qualitative descriptions”. The expectation is that students should be able to:

- Define the rate of a chemical reaction and its relation to concentrations of all chemical species involved in that reaction.
- Define a rate law and a rate constant.
- Define order of a rate law and be able to determine the order of a given rate law.
- Describe the difference between a differential and integrated rate law.
- Describe how the notions of growth, decay and equilibrium apply to a chemical system.
- Write the mathematical expressions for first order kinetics and be able to solve numerical problems using these equations, including determining rate law from empirical data.
- Define and calculate with the expression for the half life of a system described by a first order rate law. Describe the relation of a half-life to the more general notion of a “relaxation time.”
- State the expressions for homogeneous and heterogeneous second order rate laws and how to interpret them qualitatively.
- Describe the concept of a mechanism and an elementary step. Define unimolecular, bimolecular, and trimolecular steps.
- Predict the form of the rate law for an elementary step.

Laboratory Material: As mentioned above, the laboratory part of this course emphasizes the discipline of analytical chemistry and begins to develop a knowledge base in this field. This knowledge base consists of concepts, quantitative data processing skills (more “problem set” material), and physical manipulative skills. These skills include:

- proper use of a balance
- proper use of volumetric glassware
- ability to prepare solutions of desired chemical description
- ability to perform standard “instrumental” analyses, utilizing a pH meter and a spectrophotometer
- ability to process raw measurement data into more useful processed data
- ability to use a spreadsheet (Excel) in laboratory work
- ability to work to a high level of accuracy and precision
- the ability to evaluate the level of accuracy and precision in any set of measurement data, through the use of “statistical data-handling tools”
- ability to evaluate the level of validity (i.e., “level of Confidence”) of decisions made as a consequence of this set of measurement data

While it is hoped that the student develop all the skills listed above, the use of “statistical data-handling tools” is considered particularly important because of its general applicability to all measurement sets. This skill undergirds the discipline of analytical chemistry and will receive particular emphasis in this course. In practical terms, this last area of “statistical tools” will be handled through problem sets as well as a required laboratory exercise.
The Scoring:

- Final -- 30%  (NOTE: the final is cumulative in nature.)
- Three tests -- 35%  **DATES: Jan 21, Feb 11, Mar 18**
- Quizzes -- 10%  (on a near-weekly basis)

**Quiz breakdown (tentative)**

- Chem 111 review material and analyte determination
- Specialized K’s, including pH and pK manipulations
- pH line calculations
- Statistics
- Titration Curves
- Polyprotics
- Buffers
- Galvanic cells and redox
- Spectrophotometry
- Kinetics

- Laboratory -- 25%

**Laboratory breakdown (tentative):**

- Introductory measurement lab -- 10%
- KHP/pH determination -- 30%
- Statistical tools worksheet exercise -- 10%
- Hard Water determination -- 15%
- Buffer preparation exercise -- 10%
- Spectrophotometric biochemical determination -- 25%

Other practical matters of policy:

With regard to laboratory grading:

- **NO LAB REPORTS WILL BE GRADED AFTER THE LAST DAY OF CLASSES** (i.e. 5:00 P.M.) OF THE TERM. Failure to submit a report for an assigned determination = - 20% penalty with NO replacement permitted. The submission of miscellaneous data mistakenly reported = - 60% penalty with NO replacement permitted.

With regard to tests and the final:

- Failure to take any TEST at the assigned time = ZERO grade unless PRIOR PERMISSION TO POSTPONE has been granted. You need to get to us via telephone and/or email. Email works best.
- In the matter of test length: the more areas you can be tested on, the more chances you have to find things you can answer and the smaller will be the effect of your "blanking" on any one question. This suggests a longer period of testing time than one class period. Accordingly, tests will be administered over a contiguous 2-hour block of time on test days. The default time will be in the late afternoon, but other arrangements can be negotiated.
- In the matter of "partial credit": While the student is always entitled to an accounting as to how a particular test, question, etc. was graded, what is NOT in play is a negotiation regarding the amount of partial credit assigned -- i.e. the question was worth 8 points, you were given 2 points but you feel you should have been given 4. It is felt that the student's "bargaining power" is non-existent in this circumstance. (i.e., the answer was WRONG). If it appears that some partial credit is merited, based on a judgment made at the time of grading, partial credit will be issued. This judgment can be holistic in nature, (i.e. influenced by the overall nature of the rest of the test as well as the question being evaluated at the moment).