AP Chemistry

Syllabus

Semester I & II

Overview of AP® Chemistry

AP Chemistry meets daily for one 53-minute period. Labs are conducted after school. Approximately seven lab sessions are held each quarter, and about 21 are held each year. At the beginning of the course, I will send a handout home for students' parents that describes the expectations and demands of the course

Required for the course:

- **Notebook – three ring for notes and handouts**
- **Paper**
- **Pen/pencil**
- **Scientific calculator (needs to be able to do log, anti-log, natural log, anti-natural log, scientific notation). TI-83 recommended.**
- **Lab Notebook – spiral notebook in which the pages will not rip out easily. Dedication to just Chemistry Lab.**

Textbook

***Chemistry, Giancoli*, et al**
Pearson/Prentice Hall, 2006

Notebook Policy

Notebooks should be organized as follows:

1. This Syllabus
2. Current Homework
3. Handouts and Packets
4. Periodic Table of Elements
5. Tests and Quizzes

This notebook shall remain neat and organized. You will receive periodic grades on the status of your notebook. This will be part of your quiz grade.

Keep a consistent set of notes and tests/quizzes for the entire semester. These will be for your final exam review. The exam will be cumulative. I will not pass out review copies of any tests or quizzes. I will hand out a review sheet with an outline we will study for the final.

Lab Note book

The Lab Notebook

Your laboratory notebook will be used to record experimental data throughout the school year. I'm using the word "notebook" loosely here: for this particular class this year, you won't be recording your labs in a bound notebook as you did in your chemistry class. In here, each week you'll be writing up each lab using pages from your Engineer's Computation Pad, and turning in each lab individually. In all other ways, you'll need to follow the instructions for the lab "notebook" given here.

Some comments on the general style of the notebook: you are attempting to keep an accurate record of the experimental work you perform in this class. The notebook will not contain a perfect lab report of your experiment -that's something entirely different--but rather a record of what you did, how you did it, and what your results were. Although the notebook may reflect your personal style somewhat, your records need to be formal, neat, and complete enough so that any reasonably knowledgable person familiar with the subject of your experiment -- another student, or the instructor of this course - can read the entries, understand exactly what you did, and if necessary, repeat your experiment.

You need to write in black or blue ink. Pencil is unacceptable in a lab notebook - the marks are easily smeared, and may accidentally be erased. Never remove pages from your notebook, and **never erase anything!** If you make a mistake, draw a line through the mistake or cross it out -you may wish to add a small note indicating why the information you crossed out is incorrect.

Most importantly, **your notebook needs to be set up for the experiment the day *before* the experiment!!!** Some teachers refer to this as the "PreLab." When you come into the laboratory to perform an experiment, it is presumed that you will have already read the lab procedure, understood the details of the experiment, and prepared your notebook with the following information, or at least spaces where you can record the following information. Do *not* simply cut-and-paste the procedure from the lab handout - *write your own procedure* using the lab handout as a guide. On the

day of the experiment, I will be coming around to check that you have correctly prepared your lab notebook with entries for the following items:

Outline of a Notebook Entry

1. **Title of Experiment**
   Make the title, and all of the headings for each section in your notebook, descriptive enough that the reader can find information quickly and easily.
2. **Date and Time of Record**

3. **The Name(s) of Lab Partners**

4. **Objective**
   This should simply be an elaboration of the title, possible giving the method used to conduct the experiment. (1-2 sentences)
5. **Theory**
   Briefly explain the concepts used in the experiment, and a mathematical statement of these concepts and their derivation, if possible. (1-3 sentences)
6. **Equipment List**
   Be as descriptive as possible. List the name of each piece of equipment used, the manufacturer, the model, the serial number, and any other information that may be pertinent to performing the lab.
7. **Experiment Set-Up**
   Include a labeled sketch of the equipment set-up, details of component assembly, circuit diagrams, etc. If the set-up is included in the lab handout, it's easy enough to copy this drawing into your lab notebook. If the set-up is unknown, or will need to be created in the lab, be sure to leave space for sketching your set-up in your notebook.
8. **Statement of Procedure**
   Briefly state the procedure that will be followed in conducting the experiment, either in a paragraph or two or as a numbered list stating the procedure step-by-step. Don't be excessively specific, but don't

leave out any important information either. You may copy the lab handout procedure if it's available (or modify it as you see fit). If you need to develop your own procedure during the lab (as we'll sometimes do), be sure to leave enough space.

9. **Table of Observed Data**
   These tables, like everything else in the notebook, should be constructed *before* you perform the lab. Tables for recording observed data should be clearly labeled with descriptive terms and units, logically organized, with plenty of room in the margins for corrections or notes.

   The day of your lab, data will be entered directly into the table, in blue or black ink, as the experiment is performed. Incorrect data should be neatly lined out, with an explanation of why the data has been lined out written somewhere nearby. The correct data should be written in the table, if possible. If a large number of mistakes have been made, or an entire data table even is found to be incorrect, neatly draw a large "X" over the table, then write a note in the margin explaining the error and referring them to the end of the experiment entry. You can draw a new data table there for entering the correct information.

   Often, we'll be using computers to observe and record data collected in the lab. For these labs only, you may cut out the personalized computer printouts collected in the lab, and use "Scotch"-style adhesive tape to include them in your lab notebook.
10. **Table of Calculated Results (and Sample Calculations)**
    Any calculations necessary to yield final results should be neatly summarised in a Calculations Table. Clearly label all results, and be sure to include units. It isn't necessary to show your work for every single calculation performed, but you *must* include a) all formulae (i.e., F = ma) used to calculate results, and b) samples of each different type of calculation performed (i.e., 120 N = 40.0 kg x 3.00

m/s^2). Showing these details will help the reader to understand your procedure, provide the instructor with evidence that you know what you're doing, and save you time if you need to perform this same type of calculation later on.

11. **Graph(s) of Results**
    Where appropriate (nearly always), plot the data from your Calculations Tables on a graph. A brief review of graphs: All graphs must have a descriptive title, X and Y axes labeled with quantity and units. Adjust the scale of your graph so that the information being presented fills an entire page of your notebook. Data points, if plotted by hand, should be plotted with very small "pinprick" of ink, surrounded by a small, more visible, circle. When appropriate (nearly always) you should attempt to draw a smooth "best fit" line connecting the points. If you are graphing several sets of data on the same graph, clearly identify the different sets of data by using different shapes around the data points (circles, squares, triangles, etc), and include a key to these symbols.

    Instead of plotting by hand, you may wish to use some form of graphing software or spreadsheet program to create your graph. These printed graphs should conform to all the requirements listed above, and be neatly trimmed and taped into your lab notebook.
12. **Discussion**
    The Discussion section of each entry is used to summarize your findings in paragraph form. Typically, the Discussion section will include:
    - **Comparison with Known Values and Error Analysis**
      Compare your results with known values -- how close are your findings to accepted values? Any time that your results have been obtained by more than a single method, or a standard value is available for your result, you must calculate the "percent difference" (in the case of results obtained by two different methods) or "percent error" (in the case of a result

compared to a known quantity).

To calculate the *percent difference* between two measured results, use the formula:

$$\%\ \text{difference} = \frac{|Value2 - Value1|}{|Value2 + Value1|/2} \times 100$$

To calculate the *percent error* between a measured result and a known value, use the formula:

$$\%\ \text{error} = \frac{|MeasuredValue - KnownValue|}{KnownValue} \times 100$$

- **Sources of Experimental Error**
  [Thanks to E. Santochi and K. Hatch-Harrison for much of this section]

  "Experimental error" refers to variability in results due to limitations in the experimental design; it's the reason scientists perform multiple trials of any given experiment, and report their results as a statistal average with a plus or minus deviation included. (In this course, although we will often average measurements, we'll rarely do more advanced statistical analysis). In the "Sources of Experimental Error" section of the report, *do* list any observed reasons that you feel may have contributed to errors in your experiment, including specific problems with the equipment, difficulties in reading the equipment, or limitations in the design of the experiment. *Don't* just guess about why your experiment might have gone wrong -- only mention specific sources of error that you have a legitimate reason to believe affected your results, and explain *how* those sources of error affected your results, e.g. "The average final velocity of the pendulum was 15.6% smaller than it was at the top, which we presume is at least partly caused by loss of energy due to air friction as the pendulum swung down."

Please *don't* refer to "human error." Examples of so-called human error include misreading a ruler, adding the wrong reagent to a reaction mixture, mistiming the reaction, miscalculations, or any kind of mistake. Scientists would never report the results of an experiment affected by human error--instead, they repeat the experiment more carefully.

Points will be deducted from your lab report if you discuss "human error" instead of "experimental error."

- **Questions and Answers**
  Restate any questions posed in the lab handout that you haven't already answered in the course of your entry, and provide answers in complete sentences.

13. **Summary of Results**
    This is a brief, one-paragraph, summary of the results of this experiment, with a discussion of whether or not you think the experiment supports your hypothesis, or the subject material covered in class. Please note that science is unable to "prove" anything, so an experiment that measures forces, masses, and accelerations will never "prove" Newton's Second Law. We often try to "confirm" our physical descriptions of the world, however: your measurements might (and should!) confirm the validity of Newton's Second Law.

    Please note that although the instructor hopes you enjoyed--or at least appreciated--the lab experience, it's not appropriate to include any remarks on how you felt about the assignment, nor whether or

Homework Policy

All homework must be legible. If I cannot read it, it is not graded. You will lose one letter grade and you must complete it again for no more than 90% credit if it was perfect, or less if it was not.

Each assignment passed in must contain you name, period, date and page and numbers of the assignment.

Failure to follow these rules will result in an assignment that will be considered late. See Late Policy.

Calendar of Assignments

You will know each Monday what will be due Friday. You are responsible to turn in all work on time or late deductions will occur. See Late Policy.

Absences

See School Policy.

Plagiarism

See School Policy.

Cheating

See School Policy.

Classroom Management

1. Be respectful to me and others at all times. I have as much right to be able to teach as you have to be in a good learning environment.
2. Come prepared each class with assignments done and material reviewed as requested.
3. Come each day with the materials you need to be successful. Failure to do so will meet with detention.
4. Ask questions. Participate. Get involved.

Inappropriate Behavior Policy

First infraction: Warning
Second infraction: Detention (Mine or Schools)
Third infraction: Administrative Involvement

Homework Club

1. If your overall grade falls to below a "C-", congratulations you are in Homework Club.

Homework Club will meet each week after school from 2:15-2:55.

2. You will continue to come until your grade is at or above a 70%.
3. You must do your science work during this time. If no assignments are accomplished in the time period you will receive detention in addition.
4. Failure to show up will result in severe consequences.

Extra Help

Most days at lunch I will be available for **Extra Help**. If you do not have a lunch that matches mine you must come to one of the after school days announced. If you need help or need to make up an activity or assignment from an absence you may come at any of these times.

Overall Grade Calculations

Once a quarter has ended, your grade is recalculated as a new quarter and averaged with the previous quarter.

Both quarters averaged are equal to 80% overall.

Final Exam, by school policy, is 20% of the full semester grade. It will be a standardized multiple choice exam.

Assignments are due on Fridays of the week assigned unless stated otherwise on that Monday.

Labs will vary in length of time and are due by the following Friday after they were completed. You will turn in your lab books on Friday and they will be returned graded the following Monday. Labs will be Wednesday class or after school. All labs must be completed by 5PM Friday for the week. No before-school labs or after-school labs will be allowed. An optional weekend lab will be considered. There will be about seven 3-hour labs per quarter. See rules on missed labs.

L abs support, convey, and cement the chemical principles presented in lectures and demonstrations. They also provide students with an opportunity to learn new physical skills (such as titration, quantitative transfer, or the use of volumetric equipment), foster good collaborative relationships, and improve problem-solving techniques, while they learn more about how chemistry really works.Â P

All Labs are hands on.

Grading Policy

Grades will be based on a weighted percentage of points possible. The Student Handbook contains the same scale.

A+	97-100	B+	87-89	C+	77-79	D+	67-69
A	93-96	B	83-86	C	73-76	D	63-66
A-	90-92	B-	80-82	C-	70-72	D-	60-62

Failing below 60

Grades will be given in 6 weighting categories as follows:

Tests	35% of quarter grade
Laboratory	15% of quarter grade
Homework and quizzes	15% of quarter grade

Worksheets	15% of quarter grade
Quarter Project/ Paper	15% of quarter grade
Safety and conduct	5% of quarter grade
Cumulative Final Exam	20% of semester grade

Credit Policy

If you fall below 75% in this class at anytime you will be required to attend Homework Club one or two days a week until you are caught up (Instructor will decide which). Failure to come to Homework Club results in a detention, an additional Homework Club, and notification of parents.

Failure to do homework or worksheets on time in a repeated manner will also get you mandatory Homework Club and loss of ½ the credit for that homework assignment. You have 5 school days to make up a missed homework assignment or there is no credit.

Labs not completed or not turned in on time results in an immediate loss of ½ the credit. You will lose all of the credit in one week.

Tests and quizzes not completed due to absence or other circumstance must be done according to School Policy. Failure to do so achieves an automatic zero.

Semester projects are announced 4 weeks into the semester and are generally due by the end of November or the end of April depending on the semester. You will receive the rules when the project is announced. Failure to meet the due date results in an immediate loss of 1/3 the credit with no extension.

Late Policy

You have one day grace for each full day missed due to an illness to complete and pass in the assignment – see School Policy.

Missing class for an activity is not considered an absence. You will need to make arrangements with your Instructor for work missed to have it done in advance. In the case of tests or quizzes you must take them on your return from the activity or receive a zero.

Labs missed due to illness can not be made up. Running multiple labs in makeup is prohibited due to safety. Instead you will be assigned a paper, three typed pages, 250 words per page, to research and type within 5 calendar school days of your returning. You are allowed one alternative paper per quarter. Beyond one absent week, you are required to do alternative labs of the instructors choosing. This will be on the weekend.

Unexcused Absences

You will receive a zero for all work that day. This includes classes you were late by 10 or more minutes. See School Policy.

Frequently Asked Questions

"Can I do an assignment again for more Credit?"

The work that is covered under this policy is worksheets. From the day an assignment is passed back, you have 5 class days to make the corrections and pass in the assignment for re-grading. YOU WILL RECEIVE NO NORE THAN 70% (C-) AS THE HIGHEST GRADE. Note: This does not apply to tests or quizzes. If you did not pass an assignment in on time you cannot get more credit.

"I was absent the day you assigned the work."

All assignments (including worksheets, homework) are given on the Monday of each week and are due by Friday. Tests and quiz dates are also announced on Mondays. Special exceptions may be made for a few labs if they extend longer than expected. You are responsible to call in, check the website, or email me and get the assignment. I can have the assignment at the front office desk waiting for you if you call.

I will try to post the assignments each week on a web site. Or you can email me by 1PM that day to get the assignment for the week. There is no excuse!

"When do I get my work back?"

I will have your assignments graded every weekend and back in your hands on Monday.

Calendar for AP Chemistry

We have 25 chapters to cover in only 28 weeks!

Semester 1

Week 1	Introduction / Metrics / Scientific Method / Safety Chapter 1: Metrics / Lab Write-ups / Powers of 10 Film
Week 2	Chapter 2: Atoms, Molecules and Ions
Weeks 3-4	Chapter 3: Moles and % Composition with

	Reactions
Weeks 4-5	Chapter 4: Types of Reactions
Week 6	Chapter 5: Gasses
Weeks 7-8	Chapter 6: Thermo Chemistry (intro)
Weeks 8-9	Chapter 7: Quantum Theory & Electronic Structure
Weeks 10-11	Chapters 8, 20, 21: Periodic Table and Properties
Week 12	Chapter 9: Chemical Bonding – Basic Concepts
Weeks 13-14	Chapter 10: Chemical Bonding – MO and Hybridization Theory
Weeks 15-16	Chapter 11: Forces, Crystalization, Liquids
Week 17	Review & Finals

Semester 2

Weeks 1-2	Chapter 12: Solution Properties
Weeks 3-4	Chapter 13: Kinetics

Weeks 4-5	Chapter 14: Chemical Equilibrium
Weeks 6-8	Chapters 15 & 16: pH and Ksp
Weeks 8-9	Chapter 17: Thermo Chemistry
Weeks 10-11	Chapter 18: Electro Chemistry
Weeks 12-13	Chapter 23: Nuclear Chemistry
Weeks 14-15	Chapter 21: Organic Chemistry
Weeks 15-16	Review for AP Exam

AP Exam – May

'Labs support, convey, and cement the chemical principles presented in lectures and demonstrations. They also provide students with an opportunity to learn new physical skills (such as titration, quantitative transfer, or the use of volumetric equipment), foster good collaborative relationships, and improve problem-solving techniques, while they learn more about how chemistry really works."

All labs are hands-on.

All of the experiments below will require hands-on work in the laboratory. In collaboration with other students, you will be called upon to collect, process, and manipulate data taken from physical observations, both measured and unmeasured, and then to develop and formally report your conclusions. Lab groups will consist of student pairs and all write ups and conclusions will be individual. All rules of plagiarism apply.

Minimum Lab Schedule

Several Mini-Labs will also be done

Quarter 1

Lab 1	Measurement labs / metrics lab
Lab 2	Naming and structure lab
Lab 3	Determination of the formula of a compound
Lab 4	Determination of % water in a hydrate
Lab 5	Determination of molar mass by vapor density
Lab 6	Determination of the molar volume of a gas
Lab 7	Standardization of a solution using a primary standard

Quarter 2

Lab 8	Determination of molar masses by freezing point depression

Lab 9	Determine concentration by titration
Lab 10	Redox titration
Lab 11	Mass and mole relationship in a chemical reaction
Lab 12	Determine Keq for a reaction
Lab 13	Indicator determination and pH determination
Lab 14	Determination of rates of a reaction and its rate order

Quarter 3

Lab 15	Determination of enthalpy change
Lab 16	Qualitative analysis of cations and anions
Lab 17	Synthesis of coordination compound
Lab 18	Analytical and gravimetric determination
Lab 19	Spectra-photometric analysis
Lab 20	Chromatography
Lab 21	Buffer lab

Quarter 4

Lab 22	Determination of electrochemical series
Lab 23	Electroplating lab
Lab 24	Synthesis of Aspirin
Lab 25	Radio chemistry lab
Lab 26	Bonding comparison lab
Lab 27	VSEPR lab
Lab 28	Magic Lab demonstration tape for TV

A partial list of Lab sources

Determination of Molecular Weight by the Dumas Method, in Modular Laboratory Program in Chemistry Series. (Flinn)

National Science Foundation-sponsored workshops held for many years at Northern Arizona University. (NAU)

Russo, Thomas, and Mark Meszaros. *Vial Organic*. (Russo)
Silberman, Robert G. *ACS Small-Scale Laboratory Assessment Activities*. (Silberman)

Slowinski, Emil J., et al. ***Chemical Principles in the Laboratory*****. 5th ed.**
(Slowinski)

Woodrow Wilson TORCH Institutes. (WWChem)

Areas to be covered by this course: (from the AP on-line)

I. Structure of Matter (20%)

A. Atomic theory and atomic structure
1. Evidence for the atomic theory
2. Atomic masses; determination by chemical and physical means
3. Atomic number and mass number; isotopes
4. Electron energy levels: atomic spectra, quantum numbers, atomic orbitals
5. Periodic relationships including, for example, atomic radii, ionization energies, electron affinities, oxidation states
B. Chemical bonding
1. Binding forces
a. Types: ionic, covalent, metallic, hydrogen bonding, van der Waals (including London dispersion forces)
b. Relationships to states, structure, and properties of matter
c. Polarity of bonds, electronegativities
2. Molecular models
a. Lewis structures
b. Valence bond: hybridization of orbitals, resonance, sigma and pi bonds
c. VSEPR
3. Geometry of molecules and ions, structural isomerism of simple organic molecules and coordination complexes; dipole moments of molecules; relation of properties to structure
C. Nuclear chemistry: nuclear equations, half-lives, and radioactivity; chemical applications

II. States of Matter (20%)

A. Gases
1. Laws of ideal gases
a. Equation of state for an ideal gas
b. Partial pressures
2. Kinetic molecular theory
a. Interpretation of ideal gas laws on the basis of this theory
b. Avogadro's hypothesis and the mole concept
c. Dependence of kinetic energy of molecules on temperature
d. Deviations from ideal gas laws
B. Liquids and solids

1. Liquids and solids from the kinetic-molecular viewpoint
2. Phase diagrams of one-component systems
3. Changes of state, including critical points and triple points
4. Structure of solids; lattice energies
C. Solutions
1. Types of solutions and factors affecting solubility
2. Methods of expressing concentration (use of normalities is not tested)

3. Raoult's law and colligative properties (nonvolatile solutes); osmosis
4. Nonideal behavior (qualitative aspects)

III. Reactions (35 – 40%)

A. Reaction types
1. Acid-base reactions; concepts of Arrhenius, Brønsted-Lowry, and Lewis; coordination complexes; amphoterism
2. Precipitation reactions
3. Oxidation-reduction reactions
a. Oxidation number
b. The role of the electron in oxidation-reduction
c. Electrochemistry: electrolytic and galvanic cells; Faraday's laws; standard half-cell potentials; Nernst equation; prediction of the direction of redox reactions
B. Stoichiometry
1. Ionic and molecular species present in chemical systems: net ionic equations
2. Balancing of equations including those for redox reactions
3. Mass and volume relations with emphasis on the mole concept, including empirical formulas and limiting reactants
C. Equilibrium
1. Concept of dynamic equilibrium, physical and chemical; Le Chatelier's principle; equilibrium constants
2. Quantitative treatment
a. Equilibrium constants for gaseous reactions: K_p, K_c
b. Equilibrium constants for reactions in solution
(1) Constants for acids and bases; pK; pH
(2) Solubility product constants and their application to precipitation and the dissolution of slightly soluble compounds
(3) Common ion effect; buffers; hydrolysis
D. Kinetics
1. Concept of rate of reaction
2. Use of experimental data and graphical analysis to determine reactant order, rate constants, and reaction rate laws
3. Effect of temperature change on rates
4. Energy of activation; the role of catalysts
5. The relationship between the rate-determining step and a mechanism
E. Thermodynamics
1. State functions
2. First law: change in enthalpy; heat of formation; heat of reaction; Hess's law; heats of vaporization and fusion; calorimetry
3. Second law: entropy; free energy of formation; free energy of reaction; dependence of change in free energy on enthalpy and entropy changes
4. Relationship of change in free energy to equilibrium constants and electrode

potentials
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IV. Descriptive Chemistry (10 –15%)

Knowledge of specific facts of chemistry is essential for an understanding of principles and concepts. These descriptive facts, including the chemistry involved in environmental and societal issues, should not be isolated from the principles being studied but should be taught throughout the course to illustrate and illuminate the principles. The following areas should be covered:

1. Chemical reactivity and products of chemical reactions
2. Relationships in the periodic table: horizontal, vertical, and diagonal with examples from alkali metals, alkaline earth metals, halogens, and the first series of transition elements
3. Introduction to organic chemistry: hydrocarbons and functional groups (structure, nomenclature, chemical properties)

V. Laboratory (5 –10%)

The differences between college chemistry and the usual secondary school chemistry course are especially evident in the laboratory work. The AP Chemistry Exam includes some questions based on experiences and skills students acquire in the laboratory:

- making observations of chemical reactions and substances
- recording data
- calculating and interpreting results based on the quantitative data obtained
- communicating effectively the results of experimental work

For information on the requirements for an AP Chemistry laboratory program, the *Guide for the Recommended Laboratory Program* is included on pages 29–39 of this book. The guide describes the general requirements for an AP Chemistry laboratory program and contains a list of recommended experiments. Also included in the guide are resources that AP Chemistry teachers should find helpful in developing a successful laboratory program.

Colleges have reported that some AP students, while doing well on the exam, have been at a serious disadvantage because of inadequate laboratory experience. Meaningful laboratory work is important in fulfilling the requirements of a collegelevel course of a laboratory science and in preparing a student for sophomore-level chemistry courses in college.

Because chemistry professors at some institutions ask to see a record of the laboratory work done by an AP student before making a decision about granting credit, placement, or both, in the chemistry program, students should keep a laboratory notebook that includes reports of their laboratory work in such a fashion that the reports can be readily reviewed.

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Chemical Calculations

The following list summarizes types of problems either explicitly or implicitly included in the preceding material. Attention should be given to significant figures, precision of measured values, and the use of logarithmic and exponential relationships. Critical

analysis of the reasonableness of results is to be encouraged.
1. Percentage composition
2. Empirical and molecular formulas from experimental data
3. Molar masses from gas density, freezing-point, and boiling-point measurements
4. Gas laws, including the ideal gas law, Dalton's law, and Graham's law
5. Stoichiometric relations using the concept of the mole; titration calculations
6. Mole fractions; molar and molal solutions
7. Faraday's laws of electrolysis
8. Equilibrium constants and their applications, including their use for simultaneous equilibria
9. Standard electrode potentials and their use; Nernst equation
10. Thermodynamic and thermochemical calculations
11. Kinetics calculations