CALIFORNIA STATE UNIVERSITY, HAYWARD

Assessment Plan

Department of Chemistry and Biochemistry

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Mission Statement

The Department strives to provide a strong education in chemistry and biochemistry that prepares its students to function and thrive in our society. The Department attempts to increase the problem solving and critical thinking skills of all students. Non-science students will learn about the scientific and chemical aspects of everyday life that allow them to understand issues related to the environment, energy production, disease prevention and nutrition. Students of the sciences will learn the fundamentals of chemistry that control the interactions of elements and molecules that form the building blocks in nature. Chemistry majors will receive extensive instruction in predicting chemical reactivity. Building on an understanding of mathematics, physics, and biology, chemistry majors will receive a background in the major disciplines of chemistry including inorganic, analytical, organic, physical and biochemistry. Students will learn the protocols and techniques for working safely with chemicals. All chemistry majors should have the ability to search the chemical and scientific literature. The Department recognizes the importance of the pursuit of new knowledge through research in the development of skilled scientists and productive members of society, and encourages its students to participate in research projects and cooperative educational opportunities.

The Department of Chemistry and Biochemistry has defined Goals and Objectives for the upper division courses in its Degree Programs:

Chem 3301, 3302, 3303 Organic Chemistry

Students who successfully complete this course should:

1. be able to predict bonding, nomenclature, chemical properties and some physical properties of organic compounds if the molecular structure is known.
2. be able to identify common organic functional groups and show a knowledge of the chemistry and reactivity of each functional group.
3. be able to use the results of the common spectroscopic methods (NMR, IR, UV and mass spectroscopy) to determine the structures of simple organic compounds.
4. know and understand the common reaction mechanisms of organic reactions, and be able to indicate the mechanism and type of intermediate involved in the reactions.
5. be able to safely carry out standard laboratory techniques for the purification of organic compounds, including distillation, recrystallization, gas chromatography, thin layer chromatography, and extraction.
6. be able to measure the infrared spectrum of an unknown solid or liquid and be able to identify the functional groups present.
7. be able to carry out standard functional group transformations of organic compounds, and isolate and characterize the resulting products.

The Outcomes Criteria for objectives 1-4 will be based on the score obtained on the American Chemical Society standardized Organic Chemistry Exam. The exam will be given as the final exam in Chem 3303. A satisfactory criterion will be a class average at the 45th percentile or higher.

The Outcomes Criteria for objectives 5-7 will be based on a capstone assignment for Chem 3303 laboratories. Students will identify two unknown organic compounds, one solid, and one liquid. This will require purification by distillation, the knowledge of chemical reactivities and classification tests, the ability to obtain spectroscopic data, especially FT-IR, and the ability to interpret the results. At least one derivative will be required, requiring a chemical transformation and purification and characterization of the product. A satisfactory criterion will be correct identification by 90% of the students.

Chem 3511, 3512, 3513 Physical Chemistry

Students who successfully complete this course should:

1. understand how reaction energies are measured.
2. understand the properties of the gas phase and the relationship to energy.
3. be able to correlate bond energies with macroscopic energy determinations.
4. recognize the driving force for chemical reactions.
5. understand the concept of equilibrium as it is applied to various reactions.
6. be able to explain the origin of quantum theory.
7. be able to describe the nature of the electron in the hydrogen atom.
8. be able to describe the building up of the periodic table by electron configuration.
9. be able to correlate the changes observed in spectroscopic methods in terms of quantum theory.
10. understand the importance of rates of chemical reactions in the overall scheme of chemistry.
11. be able to calculate reaction order from the time dependence on concentration.
12. be able to understand and describe transition state theory.
13. understand the nature of solids in terms of their nature, bonding, and properties.
14. understand how statistics and probability can be used to develop thermodynamic concepts.

The Outcomes Criteria will be based on the answers obtained for specific question on the Physical Chemistry Standardized Exam.

Chem 3531, 3532 Physical Chemistry Laboratory

Students who successfully complete this course should be able to:

1. make solutions, perform spectroscopic measurements, and test physical chemistry principles using various types of laboratory equipment.
2. keep a clear laboratory notebook in which they describe objectives and procedures, and tabulate data.
3. understand the error inherent in measurement, and be able to determine the magnitude of the resulting error in a calculated quantity.
4. plot data to determine trends using linear and non-linear fitting.
5. compare their experimental results with those from the literature.
6. perform computer modeling calculations as simulations to support experimental data.
7. apply chemical principles of thermodynamics, quantum mechanics and kinetics to understand the significance of the experiments done in the laboratory.
8. write laboratory reports in the format of journal articles, including sections describing introduction, experimental, results and discussion, and conclusions.
9. carry out a literature search on a current topic, and present the results to classmates.

The Outcomes Criteria for objectives 1-2 and 6 will be based on evaluation of the laboratory notebook and of activities in the laboratory. These scores are incorporated into the overall laboratory report score. A satisfactory criterion will be a score of 75 % or more on the appropriate portion of the lab report score sheet (see below) for 90% of the students.

The Outcomes Criteria for objectives 3-5 and 7-8 will be based evaluation of laboratory reports. A satisfactory criterion will be an overall score of 75% or above for 90% of the students.

The Outcomes Criteria for objective 9 will be based evaluation of student presentations, scored for quality of literature search, discussion of relevant chemistry, organization, and presentation to the class. A satisfactory criterion will be an overall score of 75% or above for 90% of the students.

California State University, Hayward
Department of Chemistry
Chemistry 3531-3532

Score Sheet for Physical Chemistry Laboratory Report

Laboratory Experiment Name:
Oral or written report:

	Points possible	Points earned (Comments)
Introduction and Experimental Sections	10	
Results:		
Data, Graphs and Calculations	35	
Error propagation	20	
Discussion:		
Precision:	5	
Accuracy: literature values, discussion of errors	10	
Extra merit:		
Lab work / preparation	10	
Organization, presentation	10	
Total	**100**	

Goals and Objectives for Chem 4161 and 4162 Advanced Inorganic Chemistry

The purpose of this course sequence is to equip students with a working knowledge of the basic concepts and electronic properties of the chemical elements in order to describe and explain the chemical properties and reactivities of the elements in the periodic table. The topics covered are determined by guidelines established by the American Chemical Society and exhibited in the widely used textbooks in U.S. universities. The topics emphasized include:

1. **Atomic structure** - the basis for the periodic arrangement of the elements. Students are expected to learn how to explain the structure of the periodic table and the chemical properties of the elements in terms of the quantum theory of electrons and to use this knowledge to explain and predict chemical and physical properties of the elements. They are also expected to learn how to describe states of atoms in spectroscopic term symbols.

2. **Molecular models** – Students are expected to learn how to predict the formulas and geometries of small molecules and to use mathematical group theory to classify molecular symmetry and understand a molecular orbital description of the molecular electronic states. Student are expected to learn how to use character tables and use symmetry labeling to carry out configuration interactions in creating molecular orbital diagrams of simple molecules.

3. **Chemical reactions** – Students are expected to learn the concepts used in modern chemistry to describe and understand the two important classifications of chemical reactions (1) acid/base and (2) oxidation/reduction. Concepts that should be learned include the important definitions of acids/bases including protonic and nonprotonic and solvent-based definitions.
   Students are also expected to learn how to use emf calculations to predict redox reactions in aqueous solutions.

4. **Coordination Chemistry** – Topics to be learned include nomenclature of coordination complexes, valence bond and ligand field theories of coordination compounds, assignments of ground and excited electronic states of transition metal complexes as well as spectral band assignments, the reaction mechanisms of ligand substitution reactions and the mechanisms of photochemical reactions for transition metal complexes.

5. **Organometallic compounds** - Students are expected to learn the most important types of metal- organic ligand complexes involving pi and sigma metal-carbon coordination bonding.

6. **Chemistry of metal and nonmetal families in the periodic table** – The important small inorganic compounds that are stable in the metal and non-metal families of elements are surveyed in order to gain a wide understanding of the compound types and periodic table trends. Students are expected to be able to explain formulas and properties in terms of the quantum theory of electronic structures learned in the beginning of the course.

The outcomes criteria are based on targeted questions in the mid term exams and on the final exams, as well as on graded homework problem sets designed to measure comprehension of the above learning objectives, and on class participation of the students in group discussion and at the blackboard. A passing grade requires at least a 70 % comprehension estimation of the targeted questions.

Goals and Objectives of Chem 4180 - Advanced Inorganic Chemistry Laboratory

The objective of this laboratory course is to illustrate the chemical principles studied in Chem 4161,and 4162 and to practice using the theoretical tools learned in advanced Inorganic chemistry by synthesizing inorganic and organometallic compounds, measuring their chemical and spectroscopic properties, and discussing the results in formal laboratory reports. In the process the students are expected to learn how to synthesize inorganic compounds, learn how to use an array of instruments including the GC Mass Spec, magnetic susceptibility balance, diode array uv and visible spectrophotometer, and FT-IR. In the process they will practice using some of the basic laboratory procedures important to chemical research including refluxing, distillation, digestion, sublimation, filtration, reagent handling, safety procedures, micropipetting, and melting point measuring. They also are expected to learn how to search the chemical literature for ideas and corroboration of their results and explanations. They are also expected to learn how to write up their results as printed reports that include data and graphs in a style and format that would be acceptable to scientific review.

The outcome criteria are based on careful evaluation of laboratory technique, experiment results, and the laboratory reports. The reports will be returned for correction and rewriting if necessary.

Chemistry 4411 - General Biochemistry (4 units)

Students who successfully complete this course should:

1. understand buffer theory and the preparation of laboratory buffers.
2. know the structures and properties of the twenty amino acids.
3. know the unique properties and chemistry of the peptide bond.
4. recognize the common structural motifs found in proteins --including the alpha-helix, the beta-sheet, and other structural features.
5. know the properties of enzymes and the basics of enzyme kinetics-- including the Michaelis-Menten equation, Lineweaver-Burke equation and graphs, and the basics of enzyme inhibition.

Chemistry 4412 - General Biochemistry (4 units)

Students who successfully complete this course should:

1. understand the basic principles of bioenergetics --including standard and actual free energy changes, and the calculation of these energy changes in biochemical reations.
2. understand the unique chemistry of Adenosine Triphosphate (ATP) -- including standard and actual free energy change values for ATP hydrolysis.
3. know the structure and properties of biologically-important carbohydrates.
4. understand the basic details of the major metabolic pathways found in the cell --including glycolysis, gluconeogenesis, glycogen metabolism, the citric acid cycle, electron transport system, oxidative phosphorylation, and fatty acid oxidation.

Chemistry 4413 -General Biochemistry (4 units)

Students who successfully complete this course should:

1. know the basics of protein and amino acid metabolism -- including amino acid catabolism and anabolism and the urea cycle.
2. know the structure and properties of the purine and pyrimidine nucleotides.
3. know the structural details of the DNA molecule and how it is able to replicate.
4. know the structural details of the RNA molecule and how RNA synthesis and processing occurs in the cell.
5. know how proteins are synthesized in the cell using ribosomes, tRNA, and mRNA.

Chemistry 4430 - General Biochemistry Laboratory, (4 units)

Students who successfully complete this course should:

1. know buffer theory and how to prepare a laboratory buffer.
2. know how to perform protein and enzyme activity assays and how to calculate results from laboratory-derived data.
3. know how to calculate data commonly found in Protein Purification Tables and how to interpret this information.
4. know how to perform enzyme kinetic data analysis and how to present this data in graphical format.
5. know theory and practical details of chromatographic procedures --including gel filtration chromatography, ion-exchange chromatography, and high performance liquid chromatography (HPLC) .
6. know the theory and practical details of electrophoresis of proteins and DNA.
7. know how to develop a well-written laboratory notebook.

Chemistry 4431- Advanced Biochemistry Laboratory (2 units)

Students who successfully complete this course should:

1. know how to isolate and quantitate plasmid DNA.
2. understand the theoretical basis for the Polymerase Chain Reaction (PCR) technique and know the important methodologies for cloning PCR products.
3. amplify various segments of a DNA molecule using PCR.
4. analyze the DNA products of a PCR experiment for size and purity using agarose gel electrophoresis.
5. clone PCR fragments into an expression vector and transform the resulting chimeric DNA into *E. coli* cells.
6. know the theoretical basis for and practical details of performing a Western Blot using SDS-PAGE, electroblotting and detection with primary antibody and enzyme-conjugated secondary antibody.

Outcomes Criteria for Chemistry 4430 and 4431- Biochemistry Laboratory Courses

Specific questions will be embedded into regular course exams/quizzes . These questions will be either multiple-choice or short-answer/essay or problem-solving questions. The specific embedded questions will assess the theoretical/procedural/analytical Goals and Objectives of each course.

Exams completed by Chemistry or Biochemistry majors will be identified and the responses to the embedded questions will be tallied and recorded.
A specific objective will be considered to be achieved if 70% of the students correctly answer the embedded question(s) pertinent to that objective.

Chemistry 4440 - Protein Structure (3 units)

Students who successfully complete this course should:

1. know the structures and properties of the twenty amino acids.
2. know the unique chemistry and properties of the peptide bond and understand the other bonding forces holding proteins together.
3. know how the primary, secondary, and tertiary structural features of proteins are determined.
4. know the unique structural details commonly found in proteins --including the alpha-helix, the beta-sheet, the loop-helix-loop motif, the "Greek Key" motif, and the hairpin motif, among others.
5. know and understand the unique folding patterns found in specific classes of proteins -- including alpha-domain folding patterns, beta-sheet folding pattern and alpha/beta-folding pattern.
6. know how proteins fold into complex 3-D structures.
7. know about the unique 3-D of specific classes of proteins including enzymes, antibodies, virus coat proteins, and DNA-binding proteins.

Chemistry 4450- Nucleic Acid Chemistry (3 units)

Students who successfully complete this course should:

1. understand the various types of sequence elements that make up genes, gene-related sequences and extragenic elements in prokaryotic and eukaryotic genomes.
2. understand promoter structure and mechanisms for regulating transcription through repressors, activators, general and specific transcription factors, enhancers, silencers, external signaling compounds and alteration of nucleosome structure.
3. know the basics of gene cloning and have a general knowledge of vectors and library construction.
4. understand DNA sequencing technology, assembly of contiguous sequences and the use of sequence differences among individuals for DNA fingerprinting.
5. be able to navigate the national and international genome databases on the web and use the BLAST program to search for homologues of specific cDNAs.

Chemistry 4460 - Major Organ Biochemistry (3 units)

Students who successfully complete this course should be able to:

1. understand the basic anatomy of the major organs of the body -- including skeletal muscle, heart, brain, liver, adipose tissue, kidney, and bone tissue.
2. understand the unique cell stuctures found in the major organs of the body -- including skeletal muscle, heart, brain, liver, adipose tissue, kidney, and bone tissue.
3. understand the biochemistry unique to the major organs of the body -- including skeletal muscle, heart, brain, liver, adipose tissue, kidney, and bone tissue.

Outcomes Criteria for Chemistry 4411, 4412, 4413, 4440, 4450, and 4460:

Specific questions will be embedded into regular course midterm exams and final exams. These questions will be either multiple choice, short answer/essay or problem solving questions. The specific embedded questions will assess each of the Goals and Objectives enumerated for each course.
Exams completed by Chemistry or Biochemistry majors will be identified and the responses to the embedded questions will be tallied and recorded. A specific objective will be considered to be achieved if 70% of the students correctly answer the embedded questions(s) pertinent to that objective.

Chem 4601, 4602 Environmental Chemistry Lecture and Laboratory

Students who successfully complete this course should be able to:

1. perform environmental analyses using procedures that include making a sample collection plan, collection of samples, making solutions, and using various types of laboratory and field equipment to test environmental samples.
2. keep a clear laboratory notebook in which they describe objectives and procedures, and tabulate data.
3. plot data to determine trends using linear fitting.
4. compare their experimental results with those from the literature.
5. write laboratory reports in the format of journal articles, including sections describing introduction, experimental, results and discussion, and conclusions.
6. perform calculations involving acid-base equilibria, multiple equilibria, reaction enthalpy, free energy, and first order decay.
7. understand how chemical pollutants can have complex effects on the environment.
8. understand the chemistry of water equilibria, ozone depletion, and the greenhouse effect.
9. participate in classroom discussions on environmental cleanup sites, ozone hole formation, and alternative energy.

The Outcomes Criteria for objectives 1-5 will be based on evaluation of the laboratory notebook and of activities in the laboratory, and scoring of written reports. As a capstone project in the second quarter they will perform laboratory research on a topic of their own choosing. This will involve planning, sample collection, sample processing and analysis, evaluation of data in the context of the literature, and presentation of that topic in a poster session. A satisfactory criterion will be a score of 75 % or more on the appropriate portions of the lab report score sheets and poster presentations for 90% of the students.

The Outcomes Criteria for objectives 6-9 will be based on examinations. A satisfactory criterion will be an overall score of 75% or above for 90% of the students. Examinations will include questions based on information students provide in classroom discussions.

Addendum April 3, 2002

The data collection element in this plan will go into effect as of Spring Quarter, 2002. Data will be analyzed by each of the instructors, and a preliminary report will be made to the chemistry faculty in the Fall Quarter, 2002. Hopefully, this will lead to refinement of data collection methods so that meaningful results will be in hand by the end of Spring Quarter 2003.