UC San Diego - WASC Exhibit 7.1
Inventory of Educational Effectiveness Indicators

Academic Program	(2) What are these learning outcomes? / Where are they published? (Please specify)	(3) Other than GPA, what data/evidence is used to determine that graduates have achieved stated outcomes for the degree? (e.g., capstone course, portfolio review, licensure examination)	(4) Who interprets the evidence? What is the process?	(5) How are the findings used?
Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry* *B.S. in Molecular Synthesis* **(1) Have formal learning outcomes been developed?** *Yes* **(6) Date of last Academic Senate Review?** *2008-09*	**Students graduating with a degree should be able to:** A. *Have firm foundations in the fundamentals and applications of current chemical theories for the physical world.* B. *Use molecular understanding in fields that are based upon chemistry: biology, environmental science, and engineering.* C. *Be skilled in problems solving, critical thinking, and analytical reasoning.* D. *Know the proper procedures and regulations for safe handling and use of chemicals and follow the proper procedures and regulations for safety when using chemicals.* E. *Design, carry out, record, and analyze the results of chemical experiments.* F. *Use a broad variety of modern instrumentation and classical techniques in the course of experimentation.* G. *Interpret and evaluate results critically. Identify and quantify uncertainties in measurements and limitations in methodologies.* H. *Use modern library searching and retrieval methods to obtain information about a topic, chemical, chemical technique, or an issue relating to chemistry, going beyond textbooks and common handbooks.* I. *Communicate results of work to chemists and non-chemists, including respect for the tradition of careful citation of prior contributions, both orally and in effective writing.* J. *Collaborate effectively as part of a team to solve problems, debate different points of view, and interact productively with a diverse group of team members.* K. *Understand the ethical, historic, philosophical, and environmental dimensions of problems and issues facing chemists.*	**Data/Evidence:** • *(A, C) Meet the objectives of introductory calculus as specified by the Department of Mathematics (Math 20A/B/C/D)* • *(A, C) Meet the objectives of elementary physics as specified by the Department of Physics (Physics 2A/B/D/2CL)* • *(A, B) Recognize elemental symbols and place the more common elements on a Periodic Chart (CHEM 6A)* • *(A) Use a Periodic Chart to predict elemental and atomic properties, such as electronegativity, size, state of matter, likely reaction partners (CHEM 6A)* • *(A, C) Count molecules in units of moles and write balanced chemical reactions in terms of mole numbers (CHEM 6A)* • *(A, C) Recognize a limiting reagent, calculate amounts of reaction product and yield (CHEM 6A)* • *(A, B) Recognize the differences among materials that are metallic, ionic, or covalently bonded (CHEM 6A)* • *(A) Use molecular orbital theory to explain differences among second row diatomic molecules (CHEM 6A)* • *(A, B) Appreciate the role of nonbonding interactions, in particular with respect to solubilities (CHEM 6A)* • *(A) Use quantum mechanical descriptions for electronic orbitals and molecular symmetry principles to describe chemical bonding (CHEM 120A)* • *(A) Use Lewis Diagrams to predict molecular connectivity (CHEM 6A)* • *(A) Use valence shell repulsion theory to predict shapes of symmetric molecules (CHEM 6A)* • *(A) Sketch 1s, 2s and 2p atomic orbitals and combine them to interpret sp3 ,sp2 and sp hybrid orbitals. (CHEM 6A, CHEM 140A)* • *(A) Sketch molecular orbitals (bonding and antibonding) for any 2-carbon molecule, with peripheral atoms, showing the mathematical signs of the lobes and approximate relative energies. Sketch pi molecular orbitals of conjugated systems. Sketch the structures of carbocations, carbanions and radicals. (CHEM 140A)*	• *The Instructors of later courses that depend upon the students having accomplished the goals in earlier courses* • *Undergraduate Affairs Committee and Vice Chair for Undergraduate Education oversee requirements, which are endorsed by full faculty.* • *Vice Chair for Undergraduate Education acts on all requests/petitions for variation of requirements.* • *CEP review Committee* • *5-year ACS review*	• *ACS collects annual data from all approved departments and publishes outcomes.* • *Internally the department adjusts requirements and course sequences for the major.* • *Individual course instructors use feedback to modify their classes.*

Department: *Chemistry & Biochemistry* ***Major:*** *B.S. in Chemistry* *B.S. in Molecular Synthesis (continued)*	*L. Be able to identify and solve chemical problems and explore new areas of research.* *M. Find gainful employment in industry or government, be accepted at graduate or professional schools, or find employment in school systems as instructors or administrators.* **Learning outcomes published:** • *www.acs.org/cpt* • *Course syllabi* • *www-chem.ucsd.edu/* • *Articulation agreements with California Community Colleges (Project IMPAC)*	• *(A) Understand bond formation and bond energies, and predict which bonds are weak and which are strong. (CHEM 140A)* • *(A) Extend valence shell repulsion theory to treat strain (CHEM 140A)* • *(A) Use a simplified crystal field theory to rationalize structure and reactivity of transition metal complexes and their colors when dissolved in water (CHEM 6C)* • *(A) Use ligand field theory and other quantum methods to predict the molecular structures of transition metal complexes and extend this to organometallics (CHEM 120B)* • *(A, C) Solve the Schroedinger Equation for a 1-d harmonic oscillator to derive eigenvalues and eigenfunctions. Note the equal-spaced energy levels (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger equation for a 1-d square well and for a rigid rotor, noting that energy levels become more widely spaced at high energies (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger Equation for a Coulomb potential, noting that energy levels are spaced more closely at high energies (CHEM 126, CHEM 133)* • *(A, C) Explain energies and transitions for simple atoms at an intermediate level (CHEM 126, CHEM 133)* • *Develop a proper quantum interpretation of bonding for simple molecules (CHEM 126, CHEM 133)* • *(C) Use and be able to interconvert among the several ways of denoting solutions concentrations (CHEM 6A)* • *(A, C) Use the four colligative properties to calculate concentrations or molar masses, depending on known information (CHEM 6A)* • *(A, B) State the 4 great laws of thermodynamics and explain why they are considered great (CHEM 6B)* • *(A) Distinguish state functions from such non-quantities as heat and work (CHEM 6B)* • *(A, C) Manipulate partial derivatives of state quantities using relations such as the Maxwell relations (CHEM 127, CHEM 131)* • *(B, C) Calculate the idealized maximum efficiency of a heat engine or a refrigerator as deduced from a reversible Carnot cycle (CHEM 127, CHEM 131)* • *(B, C) Calculate the maximum efficiency of a less-than-ideal reversible cycle, such as those of Otto or Diesel (CHEM 127, CHEM 131)* • *(A, C) Identify the fallacy in the creationists' erroneous assertion that evolution is inconsistent wit the Second Law (CHEM 6B)*		

Department: *Chemistry & Biochemistry* ***Major:*** *B.S. in Chemistry* *B.S. in Molecular Synthesis (continued)*		• *(A) Explain why it is that reactions that heat their surroundings are likely to be spontaneous and why it is that even some that cool their surroundings can be spontaneous. (CHEM 6B)* • *(A, B, C) Use Hess's Law to combine thermal energies for chemical reactions when one combines consecutive atomic combinations (CHEM 6B)* • *(A, B, C) Use tables of free energies to compute equilibrium constants (CHEM 6B)* • *(A, C) Evaluate equilibrium constants from information about concentrations or partial pressures; or use equilibrium constants to deduce concentrations or partial pressures at equilibrium, given some initial condition (CHEM 6B)* • *(A, B) Distinguish strong and weak acids and bases (CHEM 6B)* • *(B, C) Convert between the pH scale and concentrations of protons or proton acceptors in aqueous solution (CHEM 6B)* • *(C, D, E, F, G) Carry out titrations to determine the pH of an unknown aqueous solution to acceptable accuracy and precision. (CHEM 6B, CHEM 6BL)* • *(B, C) Generalize the concept of a titration to any chemical or biochemical measurement (CHEM 114A, CHEM 112A)* • *(B, D, E, G) Desire and prepare a pH buffer of required pH and ionic strength (CHEM 6B. CHEM 100A)* • *(A) Compare and contrast Arrhenius, Bronsted, and Lewis acids (CHEM 6B)* • *(A, B, C) Write balanced equations for oxidation-reduction reactions, including the participation of solvent water (CHEM 6C)* • *(A, B) Use redox tables to predict the spontaneous direction for reactivity in redox reactions, and have some intuitive notions even without a table of potentials (CHEM 6C)* • *(C) Calculate the reversible emf expected for an arbitrary redox reaction, using tables, for any combination of concentrations of solutes and pressures of gasses (CHEM 6C)* • *(A, C) Deduce reaction rate laws and rate constants from initial rate data (CHEM 6C)* • *(C) Transform data from measurements of kinetic processes to produce a linear plot and deduce reaction order and rate constants from such plots (CHEM 6C)* • *(A) Explain the role of catalysts in a reaction and give some examples (CHEM 6C)* • *(A, B) Distinguish addition polymers from condensation polymers and give examples of each (CHEM 6C)*		

Department: *Chemistry & Biochemistry* ***Major:*** *B.S. in Chemistry* *B.S. in Molecular Synthesis (continued)*		• *(A, B) Distinguish homogeneous and heterogeneous catalysis, and write reaction schemes for each (CHEM 120B, CHEM 231)* • *(A, B) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A, CHEM 127)* • *(C) Derive rigorously the Michaelis-Menten scheme (CHEM 132, CHEM 231)* • *(C, D, E, F, G) Apply the principles of gravimetry to determine the amount of analyte in an unknown sample (CHEM 6BL)* • *(C, D, E, F, G) Titrate a weak acid with a strong base to determine the molar mass, pKa, and identity of the acid (CHEM 6BL)* • *(C, D, E, F) Determine the specific heat of a metal, the heat of fusion of water, and the heat of neutralization of an acid-base reaction via coffee-cup calorimetry (CHEM 6BL)* • *(C, D, E, F, G) Use oxidation-reduction titration to determine the oxalate content in the iron oxalate complex (CHEM 6BL)* • *(D, E, F) Synthesize an iron (III) oxalate complex (CHEM 6BL)* • *(C, D, E, F, G) Use spectrophotometry to determine the iron content in the iron oxalate complex (CHEM 6BL)* • *(C, D, E, F) Understand and follow a semimicro qualitative analysis scheme to characterize a mixture of common metal ions (CHEM 6BL)* • *(E, F) Investigate the atomic emission spectra of various elements (CHEM 6BL)* • *(E, H) Maintain a clearly written lab notebook as a permanent record of experimental results (CHEM 6BL)* • *(I) Write a simple report in standard format emulating publication in a science journal (CHEM 6BL)* • *(D, E, F) Apply knowledge of chemical bonding and synthetic laboratory skills to synthesize, analyze, and characterize inorganic chemical compounds. (CHEM 123)* • *(F) Demonstrate skill using a computer spreadsheet (CHEM 100A)* • *(F, I) Demonstrate proficiency with computer graphing (CHEM 100A)* • *(D, E, F, I) Characterize reaction kinetics in a laboratory (CHEM 100A)* • *(C, D, E, F, G, I) Measure chemical equilibria in solution (CHEM 100A)* • *(C, D, E, F, G, I) Use electrochemical techniques and ion selective electrodes to determine ion concentrations (CHEM 100A)* • *(C, D, E, F, G, H, I) Use column chromatography to separate components of a mixture (CHEM 100A)*		

Department: *Chemistry & Biochemistry* ***Major:*** *B.S. in Chemistry* *B.S. in Molecular Synthesis (continued)*		• *(B, C, D, E, F, G, H, I, J, K) Use gas chromatography to separate mixtures, using several different detection strategies, including mass spectrometry (CHEM 100A)* • *(B, C, D, E, F, G, H, I, J, K) Use high performance liquid chromatography to separate mixtures (CHEM 100A, CHEM 100BL)* • *(A, B, E, G, I, J) Demonstrate proficiency in statistical analysis and error estimation beyond what was learned in the lower labs (CHEM 105A, CHEM 100BL)* • *(A, C) Use spectral information and heat capacities to calculate partition function. Use partition functions to calculate equilibrium constants (CHEM 132)* • *(A, C) Draw conformations of alkanes and cycloalkanes (Newman projections, wedge/dotted-line structures). Graph the relation between conformation and potential energy for these molecules. Predict preferred conformations, including those of substituted cyclohexanes. Calculate the ratio of conformers based on relative energies (CHEM 140A)* • *(A, B) Explain how conformations around bonds translate into global shape changes and dictate the overall structure of big molecules, emphasizing relevancy for biological structures (CHEM 140B)* • *(A, C) Recognize strain in various conformations and predict effect on stability and as a driving force for reactivity and rearrangements (CHEM 140B)* • *(A) Define and recognize stereoisomer, enantiomer, diastereomer, conformation, configuration, meso, epimer, resolution. Recognize inversion, retention and racemization. All these for any molecule (CHEM 140A)* • *(A) Sketch a molecule with a chiral center so as to show unambiguously the configuration using both Fischer projection and perspective drawing. Determine the configuration (R or S) of any chiral center from a perspective drawing (CHEM 140A)* • *(C) Calculate "specific rotation" from the experimental optical rotation and concentration (CHEM 140B)* • *(A) Determine the configuration (E or Z) of any double bond (CHEM 140A)* • *(A, C) Describe the formation and relative stabilities of carbocations as related to hyperconjugation (CHEM 140A)* • *(H) Convert IUPAC names of simple molecules to chemical structures (CHEM 140A, CHEM 140B)* • *(A, C) Write contributor structures to a resonance hybrid for simple molecules and rate the importance of each contributor (CHEM 140A)*		

Department: *Chemistry & Biochemistry* ***Major:*** *B.S. in Chemistry* *B.S. in Molecular Synthesis (continued)*		• *(A) Analyze inter and intramolecular forces and estimate solubility, melting point and boiling point. Describe the molecular events occurring during the processes of dissolving, melting and boiling (CHEM 140A)* • *(A, B) Explain the unique role of water as a solvent (CHEM 6A)* • *(A, B) Use the unique solvation properties of water to predict or retrodict organic molecular structure with emphasis on molecules of biochemical interest (CHEM 140A, CHEM 140C)* • *(A, B, C) Estimate relative acidities and basicities of organic compounds based on estimation of the stabilities of their conjugate base and acid. Calculate the pH of a solution of a weak acid or base from the analytical concentration and Ka. Calculate the proportions of protonated and non-protonated species at a given pH (CHEM 140A, CHEM 140B)* • *(A) Locate reactive sites within a molecule and draw correct electron-pushing arrows for reactions based on electronic properties and structure instead of rote memorization of mechanisms. (CHEM 140A, CHEM 140B)* • *(A) Explain by words and equations the factors affecting the rate of a chemical reaction, including temperature. Analyze kinetic data and determine the order of a reaction. Validate reaction mechanisms by comparison with kinetic data (CHEM 140A, CHEM 140B)* • *(A) Distinguish between kinetic and thermodynamic products of reactions. Explain reasons for obtaining one product rather than the other (CHEM 140B)* • *(A) Use the concepts of delocalization and resonance for estimation of bond lengths, electronic distribution, stability, aromaticity, basicity, acidity and reactivity (CHEM 140A)* • *(A, C) Draw conclusions about a reaction mechanism from the stereochemistry of the products. Given a proposed mechanism for a reaction, predict the stereochemistry (CHEM 140B, CHEM 140C, CHEM 154)* • *(C, D, E) Define and recognize regioselective, stereoselective and stereospecific reactions. Describe resolution of a racemic mixture by converting it to a diastereomeric mixture (CHEM 140A)* • *(B) Understand and explain the importance of chiral recognition in biological systems (CHEM 140A, CHEM 140C)*		

Department: *Chemistry & Biochemistry* ***Major:*** *B.S. in Chemistry* *B.S. in Molecular Synthesis (continued)*		• *(A) Distinguish nucleophiles from electrophiles and list examples of each. Write chemical equations to describe the currently accepted mechanism(s) for major reactions: radical, SN1, SN2, E1, E2, electrophilic addition, electrophilic substitution, conjugate addition, addition-elimination, pericyclic. Explain how each mechanism is deduced from experimental kinetic data and stereochemistry of the products. Be able to specify structures and energetics of intermediates in multistep reactions. (CHEM 140A, CHEM 140B)* • *(A) Describe how the terms oxidation and reduction are used in organic chemistry (CHEM 140A)* • *(A) Recognize and predict rearrangements of carbocations (CHEM 140A)* • *(A) Identify all major functional groups and the reactivity of each (CHEM 140A, CHEM 140B)* • *(B) Identify the functional groups prominent in reactions that biomolecules undergo (CHEM 140C)* • *(D, E, F, G) Conduct a retrosynthetic analysis of a given compound and outline the forward steps and reagents that are required (CHEM 140B, CHEM 140C)* • *(B, K) Be aware of the pervasiveness of organic substances in the environment (CHEM 140A, CHEM 149B)* • *(B, K) Identify and discuss some of the common polymers and macromolecules, at a level more soils than in C (CHEM 140C)* • *(F) UV-VIS: Use the terms chromophore, molar absorptivity, wavelength at maximum, transition, pi - pi*, n - pi* (CHEM 140B)* • *(C, E, F) UV-VIS: Use UV-VIS data to calculate concentrations and assist in determining chemical structure (CHEM 6BL, CHEM 100A, CHEM 140B)* • *UV-VIS: Explain the effect of conjugation on the absorption wavelength by sketching the molecular orbitals and relative energies (CHEM 140B)* • *(A) IR: Describe the molecular transitions responsible for the infrared absorption (CHEM 140B)* • *(C, E, G) IR: Use the characteristic absorption frequencies (data provided) of functional groups to assist in determining the structure of an unknown compound (CHEM 143A, CHEM 143C)* • *(A, C, F) IR: Predict how electronic and structural factors affect the infrared absorption of functional groups, particularly carbonyls (CHEM 140B, CHEM 143A)* • *(B, K) IR: Explain the connection between infrared absorption and the "greenhouse effect" (CHEM 140A, CHEM 149A)*		

Department: *Chemistry & Biochemistry* ***Major:*** *B.S. in Chemistry* *B.S. in Molecular Synthesis (continued)*		• *(C, F, G) NMR: Magnetic resonance of protons and carbon: Identify the number of non-equivalent protons and carbons in a given molecule based on symmetry. Assign peaks of an NMR spectrum to likely chemical environments. Identify the relative numbers of protons of an unknown using integration. Identify the presence of neighboring protons from splitting patterns and coupling constants. Use NMR spectrum to elucidate the structure of an unknown compound (CHEM 140B)* • *(C, F, G) NMR: Predict the NMR spectrum from a structure (number of peaks, multiplicity and chemical shift) (CHEM 140B)* • *(C, F, G) NMR: Use the proton decoupled ^{13}C NMR spectrum to assist in the determination of the structure of an unknown compound (CHEM 140B)* • *(G) NMR: Distinguish solvent and reference NMR signals from that of the sample (CHEM 140B)* • *(A, F, G) NMR: Understand and explain conformational averaging in NMR spectra (CHEM 140AB)* • *(A, E, F) Characterize reaction products by spectroscopic methods, as available (CHEM 143A, CHEM 143B)* • *(E, F) Document data and observation accurately (CHEM 6BL, CHEM 143A)* • *(D, E) Lab: Carry out a task with a proficient and confident manner while working alone (CHEM 6BL, CHEM 143A)* • *(D, E, F, G, H, I, J, K) Lab: Work as a member of team in an efficient manner toward a common goal (CHEM 105A, CHEM 143D)* • *(D, E) Lab: Maintain safe practices for oneself and others (CHEM 6BL)* • *(D, E) Lab: Minimize waste and dispose of waste legally and correctly (CHEM 6BL, CHEM 143A)* • *(A, E, F) Lab: Relate laboratory procedures, whether synthetic or analytical, to underlying theory (CHEM 105A, CHEM 143A)* • *(D, E, F) Lab: Demonstrate and use subsequently: Recrystallization, extraction, evaporation, TLC, column chromatography, distillation (CHEM 143A)* • *(D, E) Lab: Demonstrate when and how to reduce hazards by using hoods, glove boxes, or oxygen-free techniques (CHEM 6BL, CHEM 143A)* • *(E, I, J) Lab: Document procedures and results completely, accurately, and with complete honesty in notebooks kept to professional standards (CHEM 6BL, CHEM 100A, CHEM 143A)*		

Department: *Chemistry & Biochemistry* ***Major:*** *B.S. in Chemistry* *B.S. in Molecular Synthesis (continued)*		• *(D, E, F, G) Operate a variety of laboratory instruments and apparatus for synthesis and for analysis, with explicit direction or, eventually, following written manuals (CHEM 100A, CHEM 105A, CHEM 143A)* • *(E, G, H, I) Analyze experimental data, using proper statistical methods and construction of graphs that re effective in communicating results to others (CHEM 6BL, CHEM 100A)* • *(E, G, I, J) Distinguish precision and accuracy. Distinguish systematic from random error and blatant mistakes. Identify these in reports and present quantitative limits on error when it is possible to do so (CHEM 100AL, CHEM 105A)* • *(D, E, H) Search and retrieve chemical information from various databases (CHEM 105A, CHEM 143C)* • *(H, K) Read, analyze and critically evaluate journal papers in various subfields of chemistry (CHEM 6BL, Et al.)* • *(I, K) Write scientific reports in a concise, organized and effective style (CHEM 6BL, CHEM 100A, CHEM 143A/B)* • *(I, K) Report scientific findings and inferences in oral presentations in clear and organized fashion, using visual tools, mostly PowerPoint® computer methods (CHEM 105A)* • *(A) Incorporate into one's own repertoire a broad familiarity with useful synthetic reactions for organic chemistry (CHEM 152)* • *(A, C) Be able to propose methods of preparation of carbon-carbon bonds. Be able to formulate oxidation reduction sequences for chemical transformations. Be familiar with the repertory of reagents and protecting groups (CHEM 152)* • *(A, C) Know, decipher, and use mechanisms of a wide variety of organic reactions (CHEM 154)* • *(A, C) Recognize relation between molecular structure and reactivity(CHEM 140A, CHEM 154)* • *(A, B, C, D, E, H, K, L) Plan synthetic routes that are both effective and economic, for complex molecules involving control of stereochemistry.(CHEM 155)* • *(C, E, F, G, H) At an advanced level, be proficient with techniques for determining physical properties of organic molecules (CHEM 156)* • *(A) Apply molecular-orbital theory to questions of stability and chemical reactivity (CHEM 156)* • *(A, B, C) Formulate pathways for biosynthesis of natural products explain how molecules interact with and recognize each other (CHEM 157)* • *(C, F, G, H, I) Propose molecular structures consistent with spectroscopic data (CHEM143C, CHEM 158)*		

Department: *Chemistry & Biochemistry* ***Major:*** *B.S. in Chemistry* *B.S. in Molecular Synthesis (continued)*		• *(A, C, K) Explain the theory of origin of life (CHEM 114A)* • *(A, B) Describe the difference between eukaryotic and prokaryotic cells (CHEM 114A)* • *(A) Recognize the 20 amino acids and explain the differences in their chemical properties (CHEM 114A)* • *(A) Explain and sketch the periodic arrangements of secondary structures within a protein fold (CHEM 114A)* • *(A) Understand the packing of secondary structure units to form a tertiary fold (CHEM 114A)* • *(A) Identify the packing of tertiary folds to form specific quaternary structures (CHEM 114A)* • *(A) Use analysis of hydrophobic interactions and properties of water and how they influence protein folding in solution and in membranes (CHEM 114A)* • *(A) Distinguish and explain negative and positive cooperativity and allosteric interactions (CHEM 114A)* • *(A) Describe the organization of the membranes and the influence of specific chain properties on the fluidity of the membrane (CHEM 114A)* • *(A) Know that specific classes of proteins called enzymes are catalysts of chemical reactions (CHEM 114A)* • *(C) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A)* • *(A, C) Review the properties of buffers and concept of pH and explain how solution pH can influence protein stability and enzyme kinetics (CHEM 114A)* • *(A, C) Distinguish competitive, non-competitive, and uncompetitive inhibitors affect observed rates of reactions (CHEM 114A)* • *(A) Explain how inhibitors can be used as drugs (CHEM 114A)* • *(A) Describe the structure and properties of DNA in terms that take advantage of insights provided by organic chemistry (CHEM 114A)*		

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Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry* **(1) Have formal learning outcomes been developed?** *Yes* **(6) Date of last Academic Senate Review?** *1998-99 (previous)* *2008-09(current)*	**Students graduating with a degree should be able to:** N. *Have firm foundations in the fundamentals and applications of current chemical theories for the physical world and the rigorous foundations of learning, teaching, and assessment.* O. *Use molecular understanding in fields that are based upon chemistry: biology, environmental science, and engineering.* P. *Be skilled in problems solving, critical thinking, and analytical reasoning.* Q. *Know the proper procedures and regulations for safe handling and use of chemicals and follow the proper procedures and regulations for safety when using chemicals.* R. *Design, carry out, record, and analyze the results of chemical experiments.* S. *Use a broad variety of modern instrumentation and classical techniques in the course of experimentation.* T. *Interpret and evaluate results critically. Identify and quantify uncertainties in measurements and limitations in methodologies.* U. *Use modern library searching and retrieval methods to obtain information about a topic, chemical, chemical technique, or an issue relating to chemistry, going beyond textbooks and common handbooks.* V. *Communicate results of work to chemists and non-chemists, including respect for the tradition of careful citation of prior contributions, both orally and in effective writing.* W. *Collaborate effectively as part of a team to solve problems, debate different points of view, and interact productively with a diverse group of team members.* X. *Understand the ethical, historic, philosophical, and environmental dimensions of problems and issues facing chemists.*	**Data/Evidence:** • *(A, C) Meet the objectives of introductory calculus as specified by the Department of Mathematics (Math 20A/B/C/D)* • *(A, C) Meet the objectives of elementary physics as specified by the Department of Physics (Physics 2A/B/D/2CL)* • *(A, B) Recognize elemental symbols and place the more common elements on a Periodic Chart (CHEM 6A)* • *(A) Use a Periodic Chart to predict elemental and atomic properties, such as electronegativity, size, state of matter, likely reaction partners (CHEM 6A)* • *(A, C) Count molecules in units of moles and write balanced chemical reactions in terms of mole numbers (CHEM 6A)* • *(A, C) Recognize a limiting reagent, calculate amounts of reaction product and yield (CHEM 6A)* • *(A, B) Recognize the differences among materials that are metallic, ionic, or covalently bonded (CHEM 6A)* • *(A) Use molecular orbital theory to explain differences among second row diatomic molecules (CHEM 6A)* • *(A, B) Appreciate the role of nonbonding interactions, in particular with respect to solubilities (CHEM 6A)* • *(A) Use quantum mechanical descriptions for electronic orbitals and molecular symmetry principles to describe chemical bonding (CHEM 120A)* • *(A) Use Lewis Diagrams to predict molecular connectivity (CHEM 6A)* • *(A) Use valence shell repulsion theory to predict shapes of symmetric molecules (CHEM 6A)* • *(A) Sketch 1s, 2s and 2p atomic orbitals and combine them to interpret sp3 ,sp2 and sp hybrid orbitals. (CHEM 6A, CHEM 140A)* • *(A) Sketch molecular orbitals (bonding and antibonding) for any 2-carbon molecule, with peripheral atoms, showing the mathematical signs of the lobes and approximate relative energies. Sketch pi molecular orbitals of conjugated systems. Sketch the structures of carbocations, carbanions and radicals. (CHEM 140A)*	• *The Instructors of later courses that depend upon the students having accomplished the goals in earlier courses* • *Undergraduate Affairs Committee and Vice Chair for Undergraduate Education oversee requirements, which are endorsed by full faculty.* • *Vice Chair for Undergraduate Education acts on all requests/petitions for variation of requirements.* • *CEP review Committee* • *5-year ACS review*	• *ACS collects annual data from all approved departments and publishes outcomes.* • *Internally the department adjusts requirements and course sequences for the major.* • *Individual course instructors use feedback to modify their classes.*

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*	*Y. Be able to identify and solve chemical problems and explore new areas of research.* *Z. Find gainful employment in industry or government, be accepted at graduate or professional schools, or find employment in school systems as instructors or administrators.* **Learning outcomes published:** • *www.acs.org/cpt* • *Course syllabi* • *www-chem.ucsd.edu/* • *Articulation agreements with California Community Colleges (Project IMPAC)*	• *(A) Understand bond formation and bond energies, and predict which bonds are weak and which are strong. (CHEM 140A)* • *(A) Extend valence shell repulsion theory to treat strain (CHEM 140A)* • *(A) Use a simplified crystal field theory to rationalize structure and reactivity of transition metal complexes and their colors when dissolved in water (CHEM 6C)* • *(A) Use ligand field theory and other quantum methods to predict the molecular structures of transition metal complexes and extend this to organometallics (CHEM 120B)* • *(A, C) Solve the Schroedinger Equation for a 1-d harmonic oscillator to derive eigenvalues and eigenfunctions. Note the equal-spaced energy levels (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger equation for a 1-d square well and for a rigid rotor, noting that energy levels become more widely spaced at high energies (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger Equation for a Coulomb potential, noting that energy levels are spaced more closely at high energies (CHEM 126, CHEM 133)* • *(A, C) Explain energies and transitions for simple atoms at an intermediate level (CHEM 126, CHEM 133)* • *Develop a proper quantum interpretation of bonding for simple molecules (CHEM 126, CHEM 133)* • *(C) Use and be able to interconvert among the several ways of denoting solutions concentrations (CHEM 6A)* • *(A, C) Use the four colligative properties to calculate concentrations or molar masses, depending on known information (CHEM 6A)* • *(A, B) State the 4 great laws of thermodynamics and explain why they are considered great (CHEM 6B)* • *(A) Distinguish state functions from such non-quantities as heat and work (CHEM 6B)* • *(A, C) Manipulate partial derivatives of state quantities using relations such as the Maxwell relations (CHEM 127, CHEM 131)* • *(B, C) Calculate the idealized maximum efficiency of a heat engine or a refrigerator as deduced from a reversible Carnot cycle (CHEM 127, CHEM 131)* • *(B, C) Calculate the maximum efficiency of a less-than-ideal reversible cycle, such as those of Otto or Diesel (CHEM 127, CHEM 131)* • *(A, C) Identify the fallacy in the creationists' erroneous assertion that evolution is inconsistent wit the Second Law (CHEM 6B)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		• *(A) Explain why it is that reactions that heat their surroundings are likely to be spontaneous and why it is that even some that cool their surroundings can be spontaneous. (CHEM 6B)* • *(A, B, C) Use Hess's Law to combine thermal energies for chemical reactions when one combines consecutive atomic combinations (CHEM 6B)* • *(A, B, C) Use tables of free energies to compute equilibrium constants (CHEM 6B)* • *(A, C) Evaluate equilibrium constants from information about concentrations or partial pressures; or use equilibrium constants to deduce concentrations or partial pressures at equilibrium, given some initial condition (CHEM 6B)* • *(A, B) Distinguish strong and weak acids and bases (CHEM 6B)* • *(B, C) Convert between the pH scale and concentrations of protons or proton acceptors in aqueous solution (CHEM 6B)* • *(C, D, E, F, G) Carry out titrations to determine the pH of an unknown aqueous solution to acceptable accuracy and precision. (CHEM 6B, CHEM 6BL)* • *(B, C) Generalize the concept of a titration to any chemical or biochemical measurement (CHEM 114A, CHEM 112A)* • *(B, D, E, G) Desire and prepare a pH buffer of required pH and ionic strength (CHEM 6B. CHEM 100A)* • *(A) Compare and contrast Arrhenius, Bronsted, and Lewis acids (CHEM 6B)* • *(A, B, C) Write balanced equations for oxidation-reduction reactions, including the participation of solvent water (CHEM 6C)* • *(A, B) Use redox tables to predict the spontaneous direction for reactivity in redox reactions, and have some intuitive notions even without a table of potentials (CHEM 6C)* • *(C) Calculate the reversible emf expected for an arbitrary redox reaction, using tables, for any combination of concentrations of solutes and pressures of gasses (CHEM 6C)* • *(A, C) Deduce reaction rate laws and rate constants from initial rate data (CHEM 6C)* • *(C) Transform data from measurements of kinetic processes to produce a linear plot and deduce reaction order and rate constants from such plots (CHEM 6C)* • *(A) Explain the role of catalysts in a reaction and give some examples (CHEM 6C)* • *(A, B) Distinguish addition polymers from condensation polymers and give examples of each (CHEM 6C)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		• *(A, B) Distinguish homogeneous and heterogeneous catalysis, and write reaction schemes for each (CHEM 120B, CHEM 231)* • *(A, B) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A, CHEM 127)* • *(C) Derive rigorously the Michaelis-Menten scheme (CHEM 132, CHEM 231)* • *(C, D, E, F, G) Apply the principles of gravimetry to determine the amount of analyte in an unknown sample (CHEM 6BL)* • *(C, D, E, F, G) Titrate a weak acid with a strong base to determine the molar mass, pKa, and identity of the acid (CHEM 6BL)* • *(C, D, E, F) Determine the specific heat of a metal, the heat of fusion of water, and the heat of neutralization of an acid-base reaction via coffee-cup calorimetry (CHEM 6BL)* • *(C, D, E, F, G) Use oxidation-reduction titration to determine the oxalate content in the iron oxalate complex (CHEM 6BL)* • *(D, E, F) Synthesize an iron (III) oxalate complex (CHEM 6BL)* • *(C, D, E, F, G) Use spectrophotometry to determine the iron content in the iron oxalate complex (CHEM 6BL)* • *(C, D, E, F) Understand and follow a semimicro qualitative analysis scheme to characterize a mixture of common metal ions (CHEM 6BL)* • *(E, F) Investigate the atomic emission spectra of various elements (CHEM 6BL)* • *(E, H) Maintain a clearly written lab notebook as a permanent record of experimental results (CHEM 6BL)* • *(I) Write a simple report in standard format emulating publication in a science journal (CHEM 6BL)* • *(F) Demonstrate skill using a computer spreadsheet (CHEM 100A)* • *(F, I) Demonstrate proficiency with computer graphing (CHEM 100A)* • *(D, E, F, I) Characterize reaction kinetics in a laboratory (CHEM 100A)* • *(C, D, E, F, G, I) Measure chemical equilibria in solution (CHEM 100A)* • *(C, D, E, F, G, I) Use electrochemical techniques and ion selective electrodes to determine ion concentrations (CHEM 100A)* • *(C, D, E, F, G, H, I) Use column chromatography to separate components of a mixture (CHEM 100A)* • *(B, C, D, E, F, G, H, I, J, K) Use gas chromatography to separate mixtures, using several different detection strategies, including mass spectrometry (CHEM 100A)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		• *(B, C, D, E, F, G, H, I, J, K) Use high performance liquid chromatography to separate mixtures (CHEM 100A, CHEM 100BL)* • *(A, B, E, G, I, J) Demonstrate proficiency in statistical analysis and error estimation beyond what was learned in the lower labs (CHEM 105A, CHEM 100BL)* • *(A, C) Use spectral information and heat capacities to calculate partition functions (CHEM 132)* • *(A, C) Use partition functions to calculate equilibrium constants (CHEM 132)* • *(A, C) Draw conformations of alkanes and cycloalkanes (Newman projections, wedge/dotted-line structures). Graph the relation between conformation and potential energy for these molecules. Predict preferred conformations, including those of substituted cyclohexanes. Calculate the ratio of conformers based on relative energies (CHEM 140A)* • *(A, B) Explain how conformations around bonds translate into global shape changes and dictate the overall structure of big molecules, emphasizing relevancy for biological structures (CHEM 140B)* • *(A, C) Recognize strain in various conformations and predict effect on stability and as a driving force for reactivity and rearrangements (CHEM 140B)* • *(A) Define and recognize stereoisomer, enantiomer, diastereomer, conformation, configuration, meso, epimer, resolution. Recognize inversion, retention and racemization. All these for any molecule (CHEM 140A)* • *(A) Sketch a molecule with a chiral center so as to show unambiguously the configuration using both Fischer projection and perspective drawing. Determine the configuration (R or S) of any chiral center from a perspective drawing (CHEM 140A)* • *(C) Calculate "specific rotation" from the experimental optical rotation and concentration (CHEM 140B)* • *(A) Determine the configuration (E or Z) of any double bond (CHEM 140A)* • *(A, C) Describe the formation and relative stabilities of carbocations as related to hyperconjugation (CHEM 140A)* • *(H) Convert IUPAC names of simple molecules to chemical structures (CHEM 140A, CHEM 140B)* • *(A, C) Write contributor structures to a resonance hybrid for simple molecules and rate the importance of each contributor (CHEM 140A)* • *(A) Analyze inter and intramolecular forces and estimate solubility, melting point and boiling point. Describe the molecular events occurring during the processes of dissolving, melting and boiling (CHEM 140A)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		• *(A, B) Explain the unique role of water as a solvent (CHEM 6A)* • *(A, B) Use the unique solvation properties of water to predict or retrodict organic molecular structure with emphasis on molecules of biochemical interest (CHEM 140A, CHEM 140C)* • *(A, B, C) Estimate relative acidities and basicities of organic compounds based on estimation of the stabilities of their conjugate base and acid. Calculate the pH of a solution of a weak acid or base from the analytical concentration and Ka. Calculate the proportions of protonated and non-protonated species at a given pH (CHEM 140A, CHEM 140B)* • *(A) Locate reactive sites within a molecule and draw correct electron-pushing arrows for reactions based on electronic properties and structure instead of rote memorization of mechanisms. (CHEM 140A, CHEM 140B)* • *(A) Explain by words and equations the factors affecting the rate of a chemical reaction, including temperature. Analyze kinetic data and determine the order of a reaction. Validate reaction mechanisms by comparison with kinetic data (CHEM 140A, CHEM 140B)* • *(A) Distinguish between kinetic and thermodynamic products of reactions. Explain reasons for obtaining one product rather than the other (CHEM 140B)* • *(A) Use the concepts of delocalization and resonance for estimation of bond lengths, electronic distribution, stability, aromaticity, basicity, acidity and reactivity (CHEM 140A)* • *(A, C) Draw conclusions about a reaction mechanism from the stereochemistry of the products. Given a proposed mechanism for a reaction, predict the stereochemistry (CHEM 140B, CHEM 140C, CHEM 154)* • *(C, D, E) Define and recognize regioselective, stereoselective and stereospecific reactions. Describe resolution of a racemic mixture by converting it to a diastereomeric mixture (CHEM 140A)* • *(B) Understand and explain the importance of chiral recognition in biological systems (CHEM 140A, CHEM 140C)* • *(A) Distinguish nucleophiles from electrophiles and list examples of each. Write chemical equations to describe the currently accepted mechanism(s) for major reactions: radical, SN1, SN2, E1, E2, electrophilic addition, electrophilic substitution, conjugate addition, addition-elimination, pericyclic. Explain how each mechanism is deduced from experimental kinetic data and stereochemistry of the products. Be able to specify structures and energetics of intermediates in multistep reactions. (CHEM 140A, CHEM 140B)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		• *(A) Describe how the terms oxidation and reduction are used in organic chemistry (CHEM 140A)* • *(A) Recognize and predict rearrangements of carbocations (CHEM 140A)* • *(A) Identify all major functional groups and the reactivity of each (CHEM 140A, CHEM 140B)* • *(B) Identify the functional groups prominent in reactions that biomolecules undergo (CHEM 140C)* • *(D, E, F, G) Conduct a retrosynthetic analysis of a given compound and outline the forward steps and reagents that are required (CHEM 140B, CHEM 140C)* • *(B, K) Be aware of the pervasiveness of organic substances in the environment (CHEM 140A, CHEM 149B)* • *(B, K) Identify and discuss some of the common polymers and macromolecules, at a level more soils than in C (CHEM 140C)* • *(F) UV-VIS: Use the terms chromophore, molar absorptivity, wavelength at maximum, transition, pi - pi*, n - pi* (CHEM 140B)* • *(C, E, F) UV-VIS: Use UV-VIS data to calculate concentrations and assist in determining chemical structure (CHEM 6BL, CHEM 100A, CHEM 140B)* • *UV-VIS: Explain the effect of conjugation on the absorption wavelength by sketching the molecular orbitals and relative energies (CHEM 140B)* • *(A) IR: Describe the molecular transitions responsible for the infrared absorption (CHEM 140B)* • *(C, E, G) IR: Use the characteristic absorption frequencies (data provided) of functional groups to assist in determining the structure of an unknown compound (CHEM 143A, CHEM 143C)* • *(A, C, F) IR: Predict how electronic and structural factors affect the infrared absorption of functional groups, particularly carbonyls (CHEM 140B, CHEM 143A)* • *(B, K) IR: Explain the connection between infrared absorption and the "greenhouse effect" (CHEM 140A, CHEM 149A)* • *(C, F, G) NMR: Magnetic resonance of protons and carbon: Identify the number of non-equivalent protons and carbons in a given molecule based on symmetry. Assign peaks of an NMR spectrum to likely chemical environments. Identify the relative numbers of protons of an unknown using integration. Identify the presence of neighboring protons from splitting patterns and coupling constants. Use NMR spectrum to elucidate the structure of an unknown compound (CHEM 140B)* • *(C, F, G) NMR: Predict the NMR spectrum from a structure (number of peaks, multiplicity and chemical shift) (CHEM 140B)* • *(C, F, G) NMR: Use the proton decoupled ^{13}C NMR*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		*spectrum to assist in the determination of the structure of an unknown compound (CHEM 140B)* • *(G) NMR: Distinguish solvent and reference NMR signals from that of the sample (CHEM 140B)* • *(A, F, G) NMR: Understand and explain conformational averaging in NMR spectra (CHEM 140AB)* • *(A, E, F) Characterize reaction products by spectroscopic methods, as available (CHEM 143A, CHEM 143B)* • *(E, F) Document data and observation accurately (CHEM 6BL, CHEM 143A)* • *(D, E) Lab: Carry out a task with a proficient and confident manner while working alone (CHEM 6BL, CHEM 143A)* • *(D, E, F, G, H, I, J, K) Lab: Work as a member of team in an efficient manner toward a common goal (CHEM 105A, CHEM 143D)* • *(D, E) Lab: Maintain safe practices for oneself and others (CHEM 6BL)* • *(D, E) Lab: Minimize waste and dispose of waste legally and correctly (CHEM 6BL, CHEM 143A)* • *(A, E, F) Lab: Relate laboratory procedures, whether synthetic or analytical, to underlying theory (CHEM 105A, CHEM 143A)* • *(D, E, F) Lab: Demonstrate and use subsequently: Recrystallization, extraction, evaporation, TLC, column chromatography, distillation (CHEM 143A)* • *(D, E, F) Lab: Set up and use apparatus to carry out a variety of reaction types (CHEM 143A)* • *(D, E) Lab: Demonstrate when and how to reduce hazards by using hoods, glove boxes, or oxygen-free techniques (CHEM 6BL, CHEM 143A)* • *(E, I, J) Lab: Document procedures and results completely, accurately, and with complete honesty in notebooks kept to professional standards (CHEM 6BL, CHEM 100A, CHEM 143A)* • *(D, E, F, G) Operate a variety of laboratory instruments and apparatus for synthesis and for analysis, with explicit direction or, eventually, following written manuals (CHEM 100A, CHEM 105A, CHEM 143A)* • *(E, G, H, I) Analyze experimental data, using proper statistical methods and construction of graphs that re effective in communicating results to others (CHEM 6BL, CHEM 100A)* • *(E, G, I, J) Distinguish precision and accuracy. Distinguish systematic from random error and blatant*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		*mistakes. Identify these in reports and present quantitative limits on error when it is possible to do so (CHEM 100AL, CHEM 105A)* • *(D, E, H) Search and retrieve chemical information from various databases (CHEM 105A, CHEM 143C)* • *(H, K) Read, analyze and critically evaluate journal papers in various subfields of chemistry (CHEM 6BL, Et al.)* • *(I, K) Write scientific reports in a concise, organized and effective style (CHEM 6BL, CHEM 100A, CHEM 143A/B)* • *(I, K) Report scientific findings and inferences in oral presentations in clear and organized fashion, using visual tools, mostly PowerPoint® computer methods (CHEM 105A)* • *(A, C) Recognize relation between molecular structure and reactivity (CHEM 140A)* • *(A, C, K) Explain the theory of origin of life (CHEM 114A)* • *(A, B) Describe the difference between eukaryotic and prokaryotic cells (CHEM 114A)* • *(A) Recognize the 20 amino acids and explain the differences in their chemical properties (CHEM 114A)* • *(A) Explain and sketch the periodic arrangements of secondary structures within a protein fold (CHEM 114A)* • *(A) Understand the packing of secondary structure units to form a tertiary fold (CHEM 114A)* • *(A) Identify the packing of tertiary folds to form specific quaternary structures (CHEM 114A)* • *(A) Use analysis of hydrophobic interactions and properties of water and how they influence protein folding in solution and in membranes (CHEM 114A)* • *(A) Distinguish and explain negative and positive cooperativity and allosteric interactions (CHEM 114A)* • *(A) Describe the organization of the membranes and the influence of specific chain properties on the fluidity of the membrane (CHEM 114A)* • *(A) Know that specific classes of proteins called enzymes are catalysts of chemical reactions (CHEM 114A)* • *(C) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A)* • *(A, C) Review the properties of buffers and concept of pH and explain how solution pH can influence protein stability and enzyme kinetics (CHEM 114A)* • *(A, C) Distinguish competitive, non-competitive, and uncompetitive inhibitors affect observed rates of*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		*reactions (CHEM 114A)* • *(A) Explain how inhibitors can be used as drugs (CHEM 114A)* • *(A) Describe the structure and properties of DNA in terms that take advantage of insights provided by organic chemistry (CHEM 114A)* • *(A, B, K) Outline the specific mechanism and reactions for the tropospheric production of ozone. Explain the sources and causes of ozone precursor emissions. Demonstrate an understanding of ozone control strategies and the tools used to determine whether ozone formation in a region is VOC or NOx limited. Understand the relative reactivities of hydrocarbons in terms of their ozone formation potential; outline the specific reactions involved for a given hydrocarbon. Understand the roles of nitrous acid and nitrogen trioxide in the formation of tropospheric ozone (CHEM 149A, CHEM 173)* • *(A, B, K) Describe the design of a three-way catalytic convertor; identify the pollutants and reactions involved. Understand the tradeoffs necessary in optimizing performance with regard to ozone formation. Be familiar with the specific catalysts used (CHEM 149A)* • *(A, B, K) Outline the multistep mechanism for the oxidation of methane to carbon dioxide. Understand each of the reactions involved, the rate-limiting step and the stable molecules formed during the oxidation process (CHEM 149A, CHEM 173)* • *(A, B, K) Understand the role of the hydroxyl radical in tropospheric chemistry, how it is formed, how it re acts, and what its sinks are (CHEM 149A)* • *(A, B, K) For a given reaction, use bond energy tables to estimate whether it is endothermic or exothermic; relate this result to the expected rate of the reaction for atmospheric reactions that involve free radicals. Use energy level diagrams and an understanding of chemical kinetics to support this rationale (CHEM 149A)* • *(A, B, K) Outline the multistep mechanism for the complete oxidation of doubly bonded carbon compounds to carbon dioxide. Understand each of the reactions involved (CHEM 149A, CHEM 173)* • *(A, B, K) Know wavelengths associated with UV-A, UV-B, and UV-C regions of the spectrum and the transparency of the atmosphere for each. Explain which of these regions have the greatest adverse impact on human health (CHEM 149A)* • *(A, B, K) Discuss the adverse human consequences concerning ozone concentration changes in the earth's stratosphere (CHEM 149A)* • *(A, B, K) Explain how temperature changes with altitude. Outline the reactions that cause this change.*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		*Compare the degree of air mixing that occurs in the troposphere and stratosphere (CHEM 149A, CHEM 173)* • *(A, B, K) Understand how ozone concentration varies with altitude; explain using chemical reaction rates. Outline the Chapman reactions involved (CHEM 149A)* • *(A, B, H, K) Discuss the mechanism involved with the noncatalytic and catalytic destruction of ozone. Discuss the work published by Roland and Molina during the early 1970's concerning stratospheric ozone. Explain the late 1970's concern about supersonic transport planes on stratospheric ozone. Explain whether this is still a concern today. Understand and explain why a depletion of stratospheric ozone occurs during early spring over the South Pole (CHEM 149A, CHEM 173)* • *(A, B, K) Understand why HCFC's are being used to replace CFC's. Use key reactions to explain why they are much less effective in depleting stratospheric ozone.* • *(A, B, K) Explain why fluorine radicals are not of concern for stratospheric ozone depletion. (CHEM 149A)* • *(A, B, K) Understand ozone's toxicity and how anthropogenic pollutants affect ozone levels. Explain the NO switch mechanism that that governs whether NO limits or increases ozone production. Identify the major oxidants producing photochemical smog; understand how they are formed. Write chemical equations for smog. Apply the steady-state approximation to deduce the concentration of atomic oxygen in terms of O2 and O3 concentrations. Use this to explain atomic oxygen in the lower two layers of the atmosphere (CHEM 149A)* • *(A, B, K) Use reaction kinetics to explain quantitatively atmospheric concentrations. For species that can decompose through several mechanisms, show how the overall lifetime is related to mechanism-specific lifetimes (CHEM 149A, CHEM 173)* • *(A, B, K) Relate the ozone concentration changes occurring over recent decades in the stratosphere to the expected effect these changes have on oxidants in the troposphere. Support your prediction. Discuss the major biogenic reactive organic emissions in our region of the country (CHEM 149A, CHEM 173)* • *(A, B, K) Identify and characterize the three types of aerosols found in the stratosphere; identify their composition, location, and the conditions required for them to form. Outline the main reactions that occur at the surface or within stratospheric aerosols. Explain the effects of temperature on these. Relate the volcano explosions of the early 1990's to the stratospheric heterogeneous chemistry that occurred over the next several years. (CHEM 149A, CHEM 173)* • *(A, B, K) Understand what is meant by the reaction probability factor, □, reactivity of aerosol surfaces. Relate □*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		*temperature. Outline the two major roles that stratospheric aerosols have on stratospheric ozone depletion (CHEM 149A)* • *(A, B, K) Outline ways in which adsorption at a solid-water interface affects interactions at the interface. Describe the active surface sites of minerals, including--acid-base, metal binding, ligand-exchange, and ternary surface complex formation. Relate the processes that occur at the solid-water interface to global changes that occur (CHEM 149B)* • *(A, B, K) Explain how pH affects the adsorption of both metal ions and anions; explain the basis for trends (CHEM 149B)* • *(A, B, K) Explain how biological surfaces interact with metal ions in water (CHEM 149B)* • *(A, B, K) Outline the mechanism through which acidic water dissolves (chemically weathers) an aluminosilicate mineral (CHEM 149B)* • *(A, B, K) Relate the concentration of nutrients with distance from the ocean's surface (CHEM 149B)* • *(A, B, K) Outline the reactions involved in acid rain. Outline the mechanism for homogeneous oxidation of sulfur dioxide; compare with aqueous phase oxidation of SO2. Relate atmospheric CO2 levels to rain acidity (CHEM 149B)* • *(A, B, K) Discuss how sulfur dioxide emissions are reduced to include lime scrubbers, pyritic sulfur, and selective catalytic reduction (CHEM 149B)* • *(A, B, K) Describe natural and enhanced greenhouse effects. Identify the two and three more important substances for each. Describe their infrared absorption features. Describe what is meant by thermal radiation and identify the two properties of thermal radiation that change with temperature. Identify molecular properties that govern absorption of infrared and microwave radiation (CHEM 149B)* • *(A, B, K) Explain how and why ocean levels are expected to be affected by global warming (CHEM 149B)* • *(A, B, K) Discuss the Kyoto protocol and the progress being made by the United States in reaching the protocol objectives (CHEM 149B)* • *(A, B, K) For carbon dioxide in the atmosphere, discuss the two primary ocean sinks and the important reactions involved. Explain how an increase in atmospheric carbon dioxide can affect the solubility of sea shells. Outline the role of biological organisms in governing the level of atmospheric carbon dioxide. Discuss the concentration of nutrients in the ocean as a function of depth. Outline how carbon is moved to ocean depths by living organisms (CHEM 149B)* • *(A, B, K) Discuss the major and minor reservoirs of carbon on earth. Outline the importance of fossil fuel combustion on atmospheric carbon dioxide. Describe*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry with specialization in Earth Science* *B.S. in Environmental Chemistry*		*expectations over the next century. Outline the equilibria in which carbon is accumulated or dispensed from its two major reservoirs (CHEM 149B)* • *(B, K) Explain the pros and cons of alternative energies. Use cost benefits analysis to evaluate each: nuclear, wind, solar, geothermal, tidal, and biofuels (CHEM 149B)* • *(A, B, K) Explain the history and use of pesticides. Relate the case study of DDT and the start of the modern environmental movement. Discuss the issue of environmental stability, bioaccumulation and biomagnification. Use a model Earth to predict the distribution of pollutants between air, water, sediments and soils. Explain the forces behind the chain of pesticides developed post DDT. Explain the benefits of Integrated Pest Management (CHEM 149B)* • *(A, B, K) Describe the sources, fates and environmental impacts of PCBs, PAHs and EEs. Use chemical knowledge to identify their relative toxicities (CHEM 149B)* • *(A, B, K) Describe the sources, distribution, health effects and remediation of heavy metal pollution. Distinguish between speciation of heavy metals and rank relative toxicity. Describe the treatment for heavy metal poisoning and the differences between exposure in adults and children. Discuss alternatives to the use of these metals and/or their recycling (CHEM 149B)* • *(A, B, K) Describe the treatment and storage of municipal waste. Describe the chemical process that occur in a sanitary landfill. Describe the 4 Rs. Describe the recycling of paper, plastics and electronic waste (CHEM 149B)* • *(A, B, K) Describe the processes involved in the treatment of drinking water and waste water. Compare and contrast different methods. Describe in detail the chemistry of chlorination. Describe primary, secondary and tertiary treatment. Explain the use of AOM and flocullati (CHEM 149B)* • *(D, E, H, I, J, L) Independent research is encouraged but not required (CHEM 199)* ***For Chemistry/Earth Science:*** • *Complete five earth science courses, meeting the objective set by that department.* ***For Environmental Chemistry:*** • *Complete four courses in the social sciences that are relevant, such as those from economics or political science or urban planning, meeting the objectives set by those departments.*		

UC San Diego - WASC Exhibit 7.1
Inventory of Educational Effectiveness Indicators

Academic Program	(2) **What are these learning outcomes?** **Where are they published?** **(Please specify)**	(3) **Other than GPA, what data/evidence is used to determine that graduates have achieved stated outcomes for the degree? (e.g., capstone course, portfolio review, licensure examination)**	(4) **Who interprets the evidence?** **What is the process?**	(5) **How are the findings used?**
Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry* **(1) Have formal learning outcomes been developed?** *Yes* **(6) Date of last Academic Senate Review?** *1998-99 (previous)* *2008-09(current)*	**Students graduating with a degree should be able to:** *AA. Have firm foundations in the fundamentals and applications of current chemical theories for the physical world and the rigorous foundations of learning, teaching, and assessment.* *BB. Use molecular understanding in fields that are based upon chemistry: biology, environmental science, and engineering.* *CC. Be skilled in problems solving, critical thinking, and analytical reasoning.* *DD. Know the proper procedures and regulations for safe handling and use of chemicals and follow the proper procedures and regulations for safety when using chemicals.* *EE. Design, carry out, record, and analyze the results of chemical experiments.* *FF. Use a broad variety of modern instrumentation and classical techniques in the course of experimentation.* *GG. Interpret and evaluate results critically. Identify and quantify uncertainties in measurements and limitations in methodologies.* *HH. Use modern library searching and retrieval methods to obtain information about a topic, chemical, chemical technique, or an issue relating to chemistry, going beyond textbooks and common handbooks.* *II. Communicate results of work to chemists and non-chemists, including respect for the tradition of careful citation of prior contributions, both orally and in effective writing.* *JJ. Collaborate effectively as part of a team to solve problems, debate different points of view, and interact productively with a diverse group of team members.* *KK. Understand the ethical, historic, philosophical, and environmental dimensions of problems and issues facing chemists.*	**Data/Evidence:** • *(A, C) Meet the objectives of introductory calculus as specified by the Department of Mathematics (Math 20A/B/C/D)* • *(A, C) Meet the objectives of elementary physics as specified by the Department of Physics (Physics 2A/B/D/2CL)* • *(A, B) Recognize elemental symbols and place the more common elements on a Periodic Chart (CHEM 6A)* • *(A) Use a Periodic Chart to predict elemental and atomic properties, such as electronegativity, size, state of matter, likely reaction partners (CHEM 6A)* • *(A, C) Count molecules in units of moles and write balanced chemical reactions in terms of mole numbers (CHEM 6A)* • *(A, C) Recognize a limiting reagent, calculate amounts of reaction product and yield (CHEM 6A)* • *(A, B) Recognize the differences among materials that are metallic, ionic, or covalently bonded (CHEM 6A)* • *(A) Use molecular orbital theory to explain differences among second row diatomic molecules (CHEM 6A)* • *(A, B) Appreciate the role of nonbonding interactions, in particular with respect to solubilities (CHEM 6A)* • *(A) Use quantum mechanical descriptions for electronic orbitals and molecular symmetry principles to describe chemical bonding (CHEM 120A)* • *(A) Use Lewis Diagrams to predict molecular connectivity (CHEM 6A)* • *(A) Use valence shell repulsion theory to predict shapes of symmetric molecules (CHEM 6A)* • *(A) Sketch 1s, 2s and 2p atomic orbitals and combine them to interpret sp3 ,sp2 and sp hybrid orbitals. (CHEM 6A, CHEM 140A)* • *(A) Sketch molecular orbitals (bonding and antibonding) for any 2-carbon molecule, with peripheral atoms, showing the mathematical signs of the lobes and approximate relative energies. Sketch pi molecular orbitals of conjugated systems. Sketch the structures of carbocations, carbanions and radicals. (CHEM 140A)*	• *The Instructors of later courses that depend upon the students having accomplished the goals in earlier courses* • *Undergraduate Affairs Committee and Vice Chair for Undergraduate Education oversee requirements, which are endorsed by full faculty.* • *Vice Chair for Undergraduate Education acts on all requests/petitions for variation of requirements.* • *CEP review Committee* • *5-year ACS review*	• *ACS collects annual data from all approved departments and publishes outcomes.* • *Internally the department adjusts requirements and course sequences for the major.* • *Individual course instructors use feedback to modify their classes.*

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*	*LL. Be able to identify and solve chemical problems and explore new areas of research.* *MM. Find gainful employment in industry or government, be accepted at graduate or professional schools, or find employment in school systems as instructors or administrators.* **Learning outcomes published:** • *www.acs.org/cpt* • *Course syllabi* • *www-chem.ucsd.edu/* • *Articulation agreements with California Community Colleges (Project IMPAC)*	• *(A) Understand bond formation and bond energies, and predict which bonds are weak and which are strong. (CHEM 140A)* • *(A) Extend valence shell repulsion theory to treat strain (CHEM 140A)* • *(A) Use a simplified crystal field theory to rationalize structure and reactivity of transition metal complexes and their colors when dissolved in water (CHEM 6C)* • *(A) Use ligand field theory and other quantum methods to predict the molecular structures of transition metal complexes and extend this to organometallics (CHEM 120B)* • *(A, C) Solve the Schroedinger Equation for a 1-d harmonic oscillator to derive eigenvalues and eigenfunctions. Note the equal-spaced energy levels (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger equation for a 1-d square well and for a rigid rotor, noting that energy levels become more widely spaced at high energies (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger Equation for a Coulomb potential, noting that energy levels are spaced more closely at high energies (CHEM 126, CHEM 133)* • *(A, C) Explain energies and transitions for simple atoms at an intermediate level (CHEM 126, CHEM 133)* • *Develop a proper quantum interpretation of bonding for simple molecules (CHEM 126, CHEM 133)* • *(C) Use and be able to interconvert among the several ways of denoting solutions concentrations (CHEM 6A)* • *(A, C) Use the four colligative properties to calculate concentrations or molar masses, depending on known information (CHEM 6A)* • *(A, B) State the 4 great laws of thermodynamics and explain why they are considered great (CHEM 6B)* • *(A) Distinguish state functions from such non-quantities as heat and work (CHEM 6B)* • *(A, C) Manipulate partial derivatives of state quantities using relations such as the Maxwell relations (CHEM 127, CHEM 131)* • *(B, C) Calculate the idealized maximum efficiency of a heat engine or a refrigerator as deduced from a reversible Carnot cycle (CHEM 127, CHEM 131)* • *(B, C) Calculate the maximum efficiency of a less-than-ideal reversible cycle, such as those of Otto or Diesel (CHEM 127, CHEM 131)* • *(A, C) Identify the fallacy in the creationists' erroneous assertion that evolution is inconsistent wit the Second Law (CHEM 6B)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		• *(A) Explain why it is that reactions that heat their surroundings are likely to be spontaneous and why it is that even some that cool their surroundings can be spontaneous. (CHEM 6B)* • *(A, B, C) Use Hess's Law to combine thermal energies for chemical reactions when one combines consecutive atomic combinations (CHEM 6B)* • *(A, B, C) Use tables of free energies to compute equilibrium constants (CHEM 6B)* • *(A, C) Evaluate equilibrium constants from information about concentrations or partial pressures; or use equilibrium constants to deduce concentrations or partial pressures at equilibrium, given some initial condition (CHEM 6B)* • *(A, B) Distinguish strong and weak acids and bases (CHEM 6B)* • *(B, C) Convert between the pH scale and concentrations of protons or proton acceptors in aqueous solution (CHEM 6B)* • *(C, D, E, F, G) Carry out titrations to determine the pH of an unknown aqueous solution to acceptable accuracy and precision. (CHEM 6B, CHEM 6BL)* • *(B, C) Generalize the concept of a titration to any chemical or biochemical measurement (CHEM 114A, CHEM 112A)* • *(B, D, E, G) Desire and prepare a pH buffer of required pH and ionic strength (CHEM 6B. CHEM 100A)* • *(A) Compare and contrast Arrhenius, Bronsted, and Lewis acids (CHEM 6B)* • *(A, B, C) Write balanced equations for oxidation-reduction reactions, including the participation of solvent water (CHEM 6C)* • *(A, B) Use redox tables to predict the spontaneous direction for reactivity in redox reactions, and have some intuitive notions even without a table of potentials (CHEM 6C)* • *(C) Calculate the reversible emf expected for an arbitrary redox reaction, using tables, for any combination of concentrations of solutes and pressures of gasses (CHEM 6C)* • *(A, C) Deduce reaction rate laws and rate constants from initial rate data (CHEM 6C)* • *(C) Transform data from measurements of kinetic processes to produce a linear plot and deduce reaction order and rate constants from such plots (CHEM 6C)* • *(A) Explain the role of catalysts in a reaction and give some examples (CHEM 6C)* • *(A, B) Distinguish addition polymers from condensation polymers and give examples of each (CHEM 6C)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		• *(A, B) Distinguish homogeneous and heterogeneous catalysis, and write reaction schemes for each (CHEM 120B, CHEM 231)* • *(A, B) Distinguish homogeneous and heterogeneous catalysis, and write reaction schemes for each (CHEM 120B, CHEM 231)* • *(A, B) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A, CHEM 127)* • *(C, D, E, F, G) Apply the principles of gravimetry to determine the amount of analyte in an unknown sample (CHEM 6BL)* • *(C, D, E, F, G) Titrate a weak acid with a strong base to determine the molar mass, pKa, and identity of the acid (CHEM 6BL)* • *(C, D, E, F) Determine the specific heat of a metal, the heat of fusion of water, and the heat of neutralization of an acid-base reaction via coffee-cup calorimetry (CHEM 6BL)* • *(C, D, E, F, G) Use oxidation-reduction titration to determine the oxalate content in the iron oxalate complex (CHEM 6BL)* • *(D, E, F) Synthesize an iron (III) oxalate complex (CHEM 6BL)* • *(C, D, E, F, G) Use spectrophotometry to determine the iron content in the iron oxalate complex (CHEM 6BL)* • *(C, D, E, F) Understand and follow a semimicro qualitative analysis scheme to characterize a mixture of common metal ions (CHEM 6BL)* • *(E, F) Investigate the atomic emission spectra of various elements (CHEM 6BL)* • *(E, H) Maintain a clearly written lab notebook as a permanent record of experimental results (CHEM 6BL)* • *(I) Write a simple report in standard format emulating publication in a science journal (CHEM 6BL)* • *(F) Demonstrate skill using a computer spreadsheet (CHEM 100A)* • *(F, I) Demonstrate proficiency with computer graphing (CHEM 100A)* • *(D, E, F, I) Characterize reaction kinetics in a laboratory (CHEM 100A)* • *(C, D, E, F, G, I) Measure chemical equilibria in solution (CHEM 100A)* • *(C, D, E, F, G, I) Use electrochemical techniques and ion selective electrodes to determine ion concentrations (CHEM 100A)* • *(C, D, E, F, G, H, I) Use column chromatography to separate components of a mixture (CHEM 100A)* • *(B, C, D, E, F, G, H, I, J, K) Use gas chromatography to separate mixtures, using several different detection*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		*strategies, including mass spectrometry (CHEM 100A)* • *(B, C, D, E, F, G, H, I, J, K) Use high performance liquid chromatography to separate mixtures (CHEM 100A, CHEM 100BL)* • *(A, B, E, G, I, J) Demonstrate proficiency in statistical analysis and error estimation beyond what was learned in the lower labs (CHEM 105A, CHEM 100BL)* • *(A, C) Draw conformations of alkanes and cycloalkanes (Newman projections, wedge/dotted-line structures). Graph the relation between conformation and potential energy for these molecules. Predict preferred conformations, including those of substituted cyclohexanes. Calculate the ratio of conformers based on relative energies (CHEM 140A)* • *(A, B) Explain how conformations around bonds translate into global shape changes and dictate the overall structure of big molecules, emphasizing relevancy for biological structures (CHEM 140B)* • *(A, C) Recognize strain in various conformations and predict effect on stability and as a driving force for reactivity and rearrangements (CHEM 140B)* • *(A) Define and recognize stereoisomer, enantiomer, diastereomer, conformation, configuration, meso, epimer, resolution. Recognize inversion, retention and racemization. All these for any molecule (CHEM 140A)* • *(A) Sketch a molecule with a chiral center so as to show unambiguously the configuration using both Fischer projection and perspective drawing. Determine the configuration (R or S) of any chiral center from a perspective drawing (CHEM 140A)* • *(C) Calculate "specific rotation" from the experimental optical rotation and concentration (CHEM 140B)* • *(A) Determine the configuration (E or Z) of any double bond (CHEM 140A)* • *(A, C) Describe the formation and relative stabilities of carbocations as related to hyperconjugation (CHEM 140A)* • *(H) Convert IUPAC names of simple molecules to chemical structures (CHEM 140A, CHEM 140B)* • *(A, C) Write contributor structures to a resonance hybrid for simple molecules and rate the importance of each contributor (CHEM 140A)* • *(A) Analyze inter and intramolecular forces and estimate solubility, melting point and boiling point. Describe the molecular events occurring during the processes of dissolving, melting and boiling (CHEM 140A)* • *(A, B) Explain the unique role of water as a solvent (CHEM 6A)* • *(A, B) Use the unique solvation properties of water to predict or retrodict organic molecular structure with*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		*emphasis on molecules of biochemical interest (CHEM 140A, CHEM 140C)* • *(A, B, C) Estimate relative acidities and basicities of organic compounds based on estimation of the stabilities of their conjugate base and acid. Calculate the pH of a solution of a weak acid or base from the analytical concentration and Ka. Calculate the proportions of protonated and non-protonated species at a given pH (CHEM 140A, CHEM 140B)* • *(A) Locate reactive sites within a molecule and draw correct electron-pushing arrows for reactions based on electronic properties and structure instead of rote memorization of mechanisms. (CHEM 140A, CHEM 140B)* • *(A) Explain by words and equations the factors affecting the rate of a chemical reaction, including temperature. Analyze kinetic data and determine the order of a reaction. Validate reaction mechanisms by comparison with kinetic data (CHEM 140A, CHEM 140B)* • *(A) Distinguish between kinetic and thermodynamic products of reactions. Explain reasons for obtaining one product rather than the other (CHEM 140B)* • *(A) Use the concepts of delocalization and resonance for estimation of bond lengths, electronic distribution, stability, aromaticity, basicity, acidity and reactivity (CHEM 140A)* • *(A, C) Draw conclusions about a reaction mechanism from the stereochemistry of the products. Given a proposed mechanism for a reaction, predict the stereochemistry (CHEM 140B, CHEM 140C, CHEM 154)* • *(C, D, E) Define and recognize regioselective, stereoselective and stereospecific reactions. Describe resolution of a racemic mixture by converting it to a diastereomeric mixture (CHEM 140A)* • *(B) Understand and explain the importance of chiral recognition in biological systems (CHEM 140A, CHEM 140C)* • *(A) Distinguish nucleophiles from electrophiles and list examples of each. Write chemical equations to describe the currently accepted mechanism(s) for major reactions: radical, SN1, SN2, E1, E2, electrophilic addition, electrophilic substitution, conjugate addition, addition-elimination, pericyclic. Explain how each mechanism is deduced from experimental kinetic data and stereochemistry of the products. Be able to specify structures and energetics of intermediates in multistep reactions. (CHEM 140A, CHEM 140B)* • *(A) Describe how the terms oxidation and reduction are used in organic chemistry (CHEM 140A)* • *(A) Recognize and predict rearrangements of carbocations (CHEM 140A)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		• *(A) Identify all major functional groups and the reactivity of each (CHEM 140A, CHEM 140B)* • *(B) Identify the functional groups prominent in reactions that biomolecules undergo (CHEM 140C)* • *(D, E, F, G) Conduct a retrosynthetic analysis of a given compound and outline the forward steps and reagents that are required (CHEM 140B, CHEM 140C)* • *(B, K) Be aware of the pervasiveness of organic substances in the environment (CHEM 140A, CHEM 149B)* • *(B, K) Identify and discuss some of the common polymers and macromolecules, at a level more soils than in C (CHEM 140C)* • *(F) UV-VIS: Use the terms chromophore, molar absorptivity, wavelength at maximum, transition, pi - pi*, n - pi* (CHEM 140B)* • *(C, E, F) UV-VIS: Use UV-VIS data to calculate concentrations and assist in determining chemical structure (CHEM 6BL, CHEM 100A, CHEM 140B)* • *UV-VIS: Explain the effect of conjugation on the absorption wavelength by sketching the molecular orbitals and relative energies (CHEM 140B)* • *(A) IR: Describe the molecular transitions responsible for the infrared absorption (CHEM 140B)* • *(C, E, G) IR: Use the characteristic absorption frequencies (data provided) of functional groups to assist in determining the structure of an unknown compound (CHEM 143A, CHEM 143C)* • *(A, C, F) IR: Predict how electronic and structural factors affect the infrared absorption of functional groups, particularly carbonyls (CHEM 140B, CHEM 143A)* • *(B, K) IR: Explain the connection between infrared absorption and the "greenhouse effect" (CHEM 140A, CHEM 149A)* • *(C, F, G) NMR: Magnetic resonance of protons and carbon: Identify the number of non-equivalent protons and carbons in a given molecule based on symmetry. Assign peaks of an NMR spectrum to likely chemical environments. Identify the relative numbers of protons of an unknown using integration. Identify the presence of neighboring protons from splitting patterns and coupling constants. Use NMR spectrum to elucidate the structure of an unknown compound (CHEM 140B)* • *(C, F, G) NMR: Predict the NMR spectrum from a structure (number of peaks, multiplicity and chemical shift) (CHEM 140B)* • *(C, F, G) NMR: Use the proton decoupled* ^{13}C *NMR spectrum to assist in the determination of the structure of an unknown compound (CHEM 140B)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		• *(G) NMR: Distinguish solvent and reference NMR signals from that of the sample (CHEM 140B)* • *(A, F, G) NMR: Understand and explain conformational averaging in NMR spectra (CHEM 140AB)* • *(A, E, F) Characterize reaction products by spectroscopic methods, as available (CHEM 143A, CHEM 143B)* • *(E, F) Document data and observation accurately (CHEM 6BL, CHEM 143A)* • *(D, E) Lab: Carry out a task with a proficient and confident manner while working alone (CHEM 6BL, CHEM 143A)* • *(D, E, F, G, H, I, J, K) Lab: Work as a member of team in an efficient manner toward a common goal (CHEM 105A, CHEM 143D)* • *(D, E) Lab: Maintain safe practices for oneself and others (CHEM 6BL)* • *(D, E) Lab: Minimize waste and dispose of waste legally and correctly (CHEM 6BL, CHEM 143A)* • *(A, E, F) Lab: Relate laboratory procedures, whether synthetic or analytical, to underlying theory (CHEM 105A, CHEM 143A)* • *(D, E, F) Lab: Demonstrate and use subsequently: Recrystallization, extraction, evaporation, TLC, column chromatography, distillation (CHEM 143A)* • *(D, E) Lab: Demonstrate when and how to reduce hazards by using hoods, glove boxes, or oxygen-free techniques (CHEM 6BL, CHEM 143A)* • *(E, I, J) Lab: Document procedures and results completely, accurately, and with complete honesty in notebooks kept to professional standards (CHEM 6BL, CHEM 100A, CHEM 143A)* • *(D, E, F, G) Operate a variety of laboratory instruments and apparatus for synthesis and for analysis, with explicit direction or, eventually, following written manuals (CHEM 100A, CHEM 105A, CHEM 143A)* • *(E, G, H, I) Analyze experimental data, using proper statistical methods and construction of graphs that re effective in communicating results to others (CHEM 6BL, CHEM 100A)* • *(E, G, I, J) Distinguish precision and accuracy. Distinguish systematic from random error and blatant mistakes. Identify these in reports and present quantitative limits on error when it is possible to do so (CHEM 100AL, CHEM 105A)* • *(D, E, H) Search and retrieve chemical information from various databases (CHEM 105A, CHEM 143C)* • *(H, K) Read, analyze and critically evaluate journal*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		*papers in various subfields of chemistry (CHEM 6BL, Et al.)* • *(I, K) Write scientific reports in a concise, organized and effective style (CHEM 6BL, CHEM 100A, CHEM 143A/B)* • *(I, K) Report scientific findings and inferences in oral presentations in clear and organized fashion, using visual tools, mostly PowerPoint® computer methods (CHEM 105A)* • *(A, C, K) Explain the theory of origin of life (CHEM 114A)* • *(A, B) Describe the difference between eukaryotic and prokaryotic cells (CHEM 114A)* • *(A) Recognize the 20 amino acids and explain the differences in their chemical properties (CHEM 114A)* • *(A) Explain and sketch the periodic arrangements of secondary structures within a protein fold (CHEM 114A)* • *(A) Understand the packing of secondary structure units to form a tertiary fold (CHEM 114A)* • *(A) Identify the packing of tertiary folds to form specific quaternary structures (CHEM 114A)* • *(A) Use analysis of hydrophobic interactions and properties of water and how they influence protein folding in solution and in membranes (CHEM 114A)* • *(A) Distinguish and explain negative and positive cooperativity and allosteric interactions (CHEM 114A)* • *(A) Describe the organization of the membranes and the influence of specific chain properties on the fluidity of the membrane (CHEM 114A)* • *(A) Know that specific classes of proteins called enzymes are catalysts of chemical reactions (CHEM 114A)* • *(C) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A)* • *(A, C) Review the properties of buffers and concept of pH and explain how solution pH can influence protein stability and enzyme kinetics (CHEM 114A)* • *(A, C) Distinguish competitive, non-competitive, and uncompetitive inhibitors affect observed rates of reactions (CHEM 114A)* • *(A) Explain how inhibitors can be used as drugs (CHEM 114A)* • *(A) Describe the structure and properties of DNA in terms that take advantage of insights provided by organic chemistry (CHEM 114A)* • *(A) Understand the difference between anabolic and catabolic processes in metabolism (CHEM 114B)* • *(A, C) Use knowledge from organic chemistry reaction*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		*mechanisms to follow metabolic pathways (CHEM 114B)* • *(A, C) Understand experimental approaches to tracing metabolic pathways (CHEM 114B)* • *(A) Be able to describe anabolic and catabolic proceses are coupled with energetics from hydrolysis of ATP (CHEM 114B)* • *(A) Understand oxidation and reduction and electron transfer reactions in biological systems (CHEM 114B)* • *(A) Understand that reaction coordinate diagrams are useful for thermodynamics of coupling of anabolic and catabolic processes in metabolism (CHEM 114B)* • *(A) Be able to trace through the Calvin cycle (CHEM 114B)* • *(A, C) Follow the fate of precursors and radioactive labels in the metabolic reactions (CHEM 114B)* • *(A, B, K) Relate glycogen metabolism to diseases (CHEM 114B)* • *(A) Use knowledge of thermodynamics to describe transport through membranes (CHEM 114B)* • *(A) Use knowledge of kinetics to describe transport through membranes (CHEM 114B)* • *(A) Identify the enzymes and molecules involved in the citric acid cycle (CHEM 114B)* • *(A, B, K) Understand the mechanism of common metabolic diseases (CHEM 114B)* • *(A, B) Describe the central dogma (CHEM 114A/C)* • *(A, B) Know the reaction in photosynthesis (CHEM 114C)* • *(A) Know the properties of nucleic acid structure and how that forces the conformation of the DNA (CHEM 114C)* • *(A, B, K) Know the genetic code (CHEM 114C)* • *(A, K) Know the concepts of translation and transcription (CHEM 114C)* • *(A) Know how recombinant DNA technology works (CHEM 114C)* • *(A) Know the difference between RNA and DNA (CHEM 114C)* • *(A, B, K) Understand the mechanism of DNA repair and their relationship to diseases (CHEM 114C)* • *(A, B, K) Know the structure of viral particle and their mechanism of infection (CHEM 114C)* • *(A, K) Understand the concepts of gene expression and genomic organization (CHEM 114C)* • *(D, E, F) Develop the skills to purify proteins from tissues and recombinant sources (CHEM 112A)* • *(D, E, F, G) Develop the skills to analyze purity of*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		*proteins (CHEM 112A)* • *(D, E, G) Develop the skills to analyze how purity and specific activity are coupled (CHEM 112A)* • *(D, E, F, H, I) Develop the skills to identify posttranslational modification of proteins (CHEM 112A)* • *(C, D, E, F, G, I) Develop the skills to conduct accurate kinetic analyses (CHEM 112A)* • *(D, E, F) Develop the skills to run polyacrylamide gel electrophoresis and isoelectric focusing (CHEM 112A)* • *(D, E, F) Develop the skills to identify tissue specific difference in isoenzyme contents (CHEM 112A)* • *(D, E, F) Develop the skills to subclone DNA fragment into plasmid vectors (CHEM 112B)* • *(D, E, F) Develop the skills to use restriction enzymes to cut DNAs (CHEM 112B)* • *(D, E, F) Develop the skills to run agarose gel electrophoresis (CHEM 112B)* • *(D, E, F) Develop the skills to isolate DNA fragment from agarose gels (CHEM 112B)* • *(D, E, F, I) Develop the skills to transform hors organism for protein expression and drug resistance (CHEM 112B)* • *(D, E, H, I, J, L) Independent research is encouraged but not required (CHEM 199)* ***Biochemistry/Chemistry only:*** • *(A, C) Understand how stability and thermodynamics are related to driving protein folding (CHEM 113)* • *(A) Describe the theory of funneled landscapes and evolution in driving efficient folding (CHEM 113)* • *(A, C) Be able to calculate the difference in thermodynaic stability of wild-type and mutant proteins (CHEM 113)* • *(A, C) Be able to calculate the populations of foleded and unfolded proteins from thermodynamic parameters (CHEM 113)* • *(A) Be able to calculate the entropy and enathalpy of ligand binding (CHEM 113)* • *(H, K, L) Be able to read and use journal scientific literature (CHEM 113)* • *(A, H, L) Make detailed analysis of enzyme catalysis from primary (recent) literature (CHEM 116)* • *(A, C, H, L) Be able to find strength and weaknesses in particular approach to analyzing enzyme mechanisms (CHEM 116)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Biochemistry/ Chemistry* *B.S. in Pharicological Chemistry (continued)*		***Pharmacological Chemistry only:*** • *(B, K) Complete an introduction to pharmacy and pharmacology as profession (CHEM 92)* • *(A, B, C, D, H, J, K) Understand, explain, and interpret the interaction between chemo-biological agents (drugs) and the human physiology and global nature (CHEM 118)* • *(A, K) Complete one year of study in biology with some laboratory experience, meeting the goals specified by the Division of Biology (various)* • *(K) Complete one quarter of economics, meeting the goals specified by the Department of Economics (ECON 1 or 3)*		

UC San Diego - WASC Exhibit 7.1
Inventory of Educational Effectiveness Indicators

Academic Program	(2) What are these learning outcomes? / Where are they published? (Please specify)	(3) Other than GPA, what data/evidence is used to determine that graduates have achieved stated outcomes for the degree? (e.g., capstone course, portfolio review, licensure examination)	(4) Who interprets the evidence? What is the process?	(5) How are the findings used?
Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics* **(1) Have formal learning outcomes been developed?** *Yes* **(6) Date of last Academic Senate Review?** *1998-99 (previous)* *2008-09(current)*	**Students graduating with a degree should be able to:** *NN. Have firm foundations in the fundamentals and applications of current chemical theories for the physical world and the rigorous foundations of learning, teaching, and assessment.* *OO. Use molecular understanding in fields that are based upon chemistry: biology, environmental science, and engineering.* *PP. Be skilled in problems solving, critical thinking, and analytical reasoning.* *QQ. Know the proper procedures and regulations for safe handling and use of chemicals and follow the proper procedures and regulations for safety when using chemicals.* *RR. Design, carry out, record, and analyze the results of chemical experiments.* *SS. Use a broad variety of modern instrumentation and classical techniques in the course of experimentation.* *TT. Interpret and evaluate results critically. Identify and quantify uncertainties in measurements and limitations in methodologies.* *UU. Use modern library searching and retrieval methods to obtain information about a topic, chemical, chemical technique, or an issue relating to chemistry, going beyond textbooks and common handbooks.* *VV. Communicate results of work to chemists and non-chemists, including respect for the tradition of careful citation of prior contributions, both orally and in effective writing.* *WW. Collaborate effectively as part of a team to solve problems, debate different points of view, and interact productively with a diverse group of team members.* *XX. Understand the ethical, historic, philosophical, and environmental dimensions of problems and issues facing chemists.*	**Data/Evidence:** • *(A, C) Meet the objectives of introductory calculus as specified by the Department of Mathematics (Math 20A/B/C/D)* • *(A, C) Meet the objectives of elementary physics as specified by the Department of Physics (Physics 2A/B/D/2CL)* • *(A, B) Recognize elemental symbols and place the more common elements on a Periodic Chart (CHEM 6A)* • *(A) Use a Periodic Chart to predict elemental and atomic properties, such as electronegativity, size, state of matter, likely reaction partners (CHEM 6A)* • *(A, C) Count molecules in units of moles and write balanced chemical reactions in terms of mole numbers (CHEM 6A)* • *(A, C) Recognize a limiting reagent, calculate amounts of reaction product and yield (CHEM 6A)* • *(A, B) Recognize the differences among materials that are metallic, ionic, or covalently bonded (CHEM 6A)* • *(A) Use molecular orbital theory to explain differences among second row diatomic molecules (CHEM 6A)* • *(A, B) Appreciate the role of nonbonding interactions, in particular with respect to solubilities (CHEM 6A)* • *(A) Use quantum mechanical descriptions for electronic orbitals and molecular symmetry principles to describe chemical bonding (CHEM 120A)* • *(A) Use Lewis Diagrams to predict molecular connectivity (CHEM 6A)* • *(A) Use valence shell repulsion theory to predict shapes of symmetric molecules (CHEM 6A)* • *(A) Sketch 1s, 2s and 2p atomic orbitals and combine them to interpret sp3 ,sp2 and sp hybrid orbitals. (CHEM 6A, CHEM 140A)* • *(A) Sketch molecular orbitals (bonding and antibonding) for any 2-carbon molecule, with peripheral atoms, showing the mathematical signs of the lobes and approximate relative energies. Sketch pi molecular orbitals of conjugated systems. Sketch the structures of carbocations, carbanions and radicals. (CHEM 140A)*	• *The Instructors of later courses that depend upon the students having accomplished the goals in earlier courses* • *Undergraduate Affairs Committee and Vice Chair for Undergraduate Education oversee requirements, which are endorsed by full faculty.* • *Vice Chair for Undergraduate Education acts on all requests/petitions for variation of requirements.* • *CEP review Committee* • *5-year ACS review*	• *ACS collects annual data from all approved departments and publishes outcomes.* • *Internally the department adjusts requirements and course sequences for the major.* • *Individual course instructors use feedback to modify their classes.*

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics (continued)*	*YY. Be able to identify and solve chemical problems and explore new areas of research.* *ZZ. Find gainful employment in industry or government, be accepted at graduate or professional schools, or find employment in school systems as instructors or administrators.* **Learning outcomes published:** • *www.acs.org/cpt* • *Course syllabi* • *www-chem.ucsd.edu/* • *Articulation agreements with California Community Colleges (Project IMPAC)*	• *(A) Understand bond formation and bond energies, and predict which bonds are weak and which are strong. (CHEM 140A)* • *(A) Extend valence shell repulsion theory to treat strain (CHEM 140A)* • *(A) Use a simplified crystal field theory to rationalize structure and reactivity of transition metal complexes and their colors when dissolved in water (CHEM 6C)* • *(A) Use ligand field theory and other quantum methods to predict the molecular structures of transition metal complexes and extend this to organometallics (CHEM 120B)* • *(A, C) Solve the Schroedinger Equation for a 1-d harmonic oscillator to derive eigenvalues and eigenfunctions. Note the equal-spaced energy levels (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger equation for a 1-d square well and for a rigid rotor, noting that energy levels become more widely spaced at high energies (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger Equation for a Coulomb potential, noting that energy levels are spaced more closely at high energies (CHEM 126, CHEM 133)* • *(A, C) Explain energies and transitions for simple atoms at an intermediate level (CHEM 126, CHEM 133)* • *Develop a proper quantum interpretation of bonding for simple molecules (CHEM 126, CHEM 133)* • *(C) Use and be able to interconvert among the several ways of denoting solutions concentrations (CHEM 6A)* • *(A, C) Use the four colligative properties to calculate concentrations or molar masses, depending on known information (CHEM 6A)* • *(A, B) State the 4 great laws of thermodynamics and explain why they are considered great (CHEM 6B)* • *(A) Distinguish state functions from such non-quantities as heat and work (CHEM 6B)* • *(A, C) Manipulate partial derivatives of state quantities using relations such as the Maxwell relations (CHEM 127, CHEM 131)* • *(B, C) Calculate the idealized maximum efficiency of a heat engine or a refrigerator as deduced from a reversible Carnot cycle (CHEM 127, CHEM 131)* • *(B, C) Calculate the maximum efficiency of a less-than-ideal reversible cycle, such as those of Otto or Diesel (CHEM 127, CHEM 131)* • *(A, C) Identify the fallacy in the creationists' erroneous assertion that evolution is inconsistent wit the Second Law (CHEM 6B)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics (continued)*		• *(A) Explain why it is that reactions that heat their surroundings are likely to be spontaneous and why it is that even some that cool their surroundings can be spontaneous. (CHEM 6B)* • *(A, B, C) Use Hess's Law to combine thermal energies for chemical reactions when one combines consecutive atomic combinations (CHEM 6B)* • *(A, B, C) Use tables of free energies to compute equilibrium constants (CHEM 6B)* • *(A, C) Evaluate equilibrium constants from information about concentrations or partial pressures; or use equilibrium constants to deduce concentrations or partial pressures at equilibrium, given some initial condition (CHEM 6B)* • *(A, B) Distinguish strong and weak acids and bases (CHEM 6B)* • *(B, C) Convert between the pH scale and concentrations of protons or proton acceptors in aqueous solution (CHEM 6B)* • *(C, D, E, F, G) Carry out titrations to determine the pH of an unknown aqueous solution to acceptable accuracy and precision. (CHEM 6B, CHEM 6BL)* • *(B, C) Generalize the concept of a titration to any chemical or biochemical measurement (CHEM 114A, CHEM 112A)* • *(B, D, E, G) Desire and prepare a pH buffer of required pH and ionic strength (CHEM 6B. CHEM 100A)* • *(A) Compare and contrast Arrhenius, Bronsted, and Lewis acids (CHEM 6B)* • *(A, B, C) Write balanced equations for oxidation-reduction reactions, including the participation of solvent water (CHEM 6C)* • *(A, B) Use redox tables to predict the spontaneous direction for reactivity in redox reactions, and have some intuitive notions even without a table of potentials (CHEM 6C)* • *(C) Calculate the reversible emf expected for an arbitrary redox reaction, using tables, for any combination of concentrations of solutes and pressures of gasses (CHEM 6C)* • *(A, C) Deduce reaction rate laws and rate constants from initial rate data (CHEM 6C)* • *(C) Transform data from measurements of kinetic processes to produce a linear plot and deduce reaction order and rate constants from such plots (CHEM 6C)* • *(A) Explain the role of catalysts in a reaction and give some examples (CHEM 6C)* • *(A, B) Distinguish addition polymers from condensation polymers and give examples of each (CHEM 6C)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics (continued)*		• *(A, B) Distinguish homogeneous and heterogeneous catalysis, and write reaction schemes for each (CHEM 120B, CHEM 231)* • *(A, B) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A, CHEM 127)* • *(C) Derive rigorously the Michaelis-Menten scheme (CHEM 132, CHEM 231)* • *(C, D, E, F, G) Apply the principles of gravimetry to determine the amount of analyte in an unknown sample (CHEM 6BL)* • *(C, D, E, F, G) Titrate a weak acid with a strong base to determine the molar mass, pKa, and identity of the acid (CHEM 6BL)* • *(C, D, E, F) Determine the specific heat of a metal, the heat of fusion of water, and the heat of neutralization of an acid-base reaction via coffee-cup calorimetry (CHEM 6BL)* • *(C, D, E, F, G) Use oxidation-reduction titration to determine the oxalate content in the iron oxalate complex (CHEM 6BL)* • *(D, E, F) Synthesize an iron (III) oxalate complex (CHEM 6BL)* • *(C, D, E, F, G) Use spectrophotometry to determine the iron content in the iron oxalate complex (CHEM 6BL)* • *(C, D, E, F) Understand and follow a semimicro qualitative analysis scheme to characterize a mixture of common metal ions (CHEM 6BL)* • *(E, F) Investigate the atomic emission spectra of various elements (CHEM 6BL)* • *(E, H) Maintain a clearly written lab notebook as a permanent record of experimental results (CHEM 6BL)* • *(I) Write a simple report in standard format emulating publication in a science journal (CHEM 6BL)* • *(F) Demonstrate skill using a computer spreadsheet (CHEM 100A)* • *(F, I) Demonstrate proficiency with computer graphing (CHEM 100A)* • *(D, E, F, I) Characterize reaction kinetics in a laboratory (CHEM 100A)* • *(C, D, E, F, G, I) Measure chemical equilibria in solution (CHEM 100A)* • *(C, D, E, F, G, I) Use electrochemical techniques and ion selective electrodes to determine ion concentrations (CHEM 100A)* • *(C, D, E, F, G, H, I) Use column chromatography to separate components of a mixture (CHEM 100A)* • *(B, C, D, E, F, G, H, I, J, K) Use gas chromatography to separate mixtures, using several different detection strategies, including mass spectrometry (CHEM 100A)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics (continued)*		• *(B, C, D, E, F, G, H, I, J, K) Use high performance liquid chromatography to separate mixtures (CHEM 100A, CHEM 100BL)* • *(A, B, E, G, I, J) Demonstrate proficiency in statistical analysis and error estimation beyond what was learned in the lower labs (CHEM 105A, CHEM 100BL)* • *(A, C) Use spectral information and heat capacities to calculate partition functions (CHEM 132)* • *(A, C) Use partition functions to calculate equilibrium constants (CHEM 132)* • *(A, C) Solve the time-dependent Schroedinger Equation to calculate the transition probability for electric dipole transitions between quantum states of atoms or small molecules (CHEM 135)* • *(A, C) Understand quantitatively and in depth the spectroscopies that are described qualitatively in other lecture and lab courses: UV (electronic), IR and Raman (vibrational), magnetic (NMR), and possibly others (CHEM 135)* • *(A, C) Draw conformations of alkanes and cycloalkanes (Newman projections, wedge/dotted-line structures). Graph the relation between conformation and potential energy for these molecules. Predict preferred conformations, including those of substituted cyclohexanes. Calculate the ratio of conformers based on relative energies (CHEM 140A)* • *(A, B) Explain how conformations around bonds translate into global shape changes and dictate the overall structure of big molecules, emphasizing relevancy for biological structures (CHEM 140B)* • *(A, C) Recognize strain in various conformations and predict effect on stability and as a driving force for reactivity and rearrangements (CHEM 140B)* • *(A) Define and recognize stereoisomer, enantiomer, diastereomer, conformation, configuration, meso, epimer, resolution. Recognize inversion, retention and racemization. All these for any molecule (CHEM 140A)* • *(A) Sketch a molecule with a chiral center so as to show unambiguously the configuration using both Fischer projection and perspective drawing. Determine the configuration (R or S) of any chiral center from a perspective drawing (CHEM 140A)* • *(C) Calculate "specific rotation" from the experimental optical rotation and concentration (CHEM 140B)* • *(A) Determine the configuration (E or Z) of any double bond (CHEM 140A)* • *(A, C) Describe the formation and relative stabilities of carbocations as related to hyperconjugation (CHEM 140A)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics (continued)*		• *(H) Convert IUPAC names of simple molecules to chemical structures (CHEM 140A, CHEM 140B)* • *(A, C) Write contributor structures to a resonance hybrid for simple molecules and rate the importance of each contributor (CHEM 140A)* • *(A) Analyze inter and intramolecular forces and estimate solubility, melting point and boiling point. Describe the molecular events occurring during the processes of dissolving, melting and boiling (CHEM 140A)* • *(A, B) Explain the unique role of water as a solvent (CHEM 6A)* • *(A, B) Use the unique solvation properties of water to predict or retrodict organic molecular structure with emphasis on molecules of biochemical interest (CHEM 140A, CHEM 140C)* • *(A, B, C) Estimate relative acidities and basicities of organic compounds based on estimation of the stabilities of their conjugate base and acid. Calculate the pH of a solution of a weak acid or base from the analytical concentration and Ka. Calculate the proportions of protonated and non-protonated species at a given pH (CHEM 140A, CHEM 140B)* • *(A) Locate reactive sites within a molecule and draw correct electron-pushing arrows for reactions based on electronic properties and structure instead of rote memorization of mechanisms. (CHEM 140A, CHEM 140B)* • *(A) Explain by words and equations the factors affecting the rate of a chemical reaction, including temperature. Analyze kinetic data and determine the order of a reaction. Validate reaction mechanisms by comparison with kinetic data (CHEM 140A, CHEM 140B)* • *(A) Distinguish between kinetic and thermodynamic products of reactions. Explain reasons for obtaining one product rather than the other (CHEM 140B)* • *(A) Use the concepts of delocalization and resonance for estimation of bond lengths, electronic distribution, stability, aromaticity, basicity, acidity and reactivity (CHEM 140A)* • *(A, C) Draw conclusions about a reaction mechanism from the stereochemistry of the products. Given a proposed mechanism for a reaction, predict the stereochemistry (CHEM 140B, CHEM 140C, CHEM 154)* • *(C, D, E) Define and recognize regioselective, stereoselective and stereospecific reactions. Describe resolution of a racemic mixture by converting it to a diastereomeric mixture (CHEM 140A)* • *(B) Understand and explain the importance of chiral recognition in biological systems (CHEM 140A, CHEM 140C)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics (continued)*		• *(A) Distinguish nucleophiles from electrophiles and list examples of each. Write chemical equations to describe the currently accepted mechanism(s) for major reactions: radical, SN1, SN2, E1, E2, electrophilic addition, electrophilic substitution, conjugate addition, addition-elimination, pericyclic. Explain how each mechanism is deduced from experimental kinetic data and stereochemistry of the products. Be able to specify structures and energetics of intermediates in multistep reactions. (CHEM 140A, CHEM 140B)* • *(A) Describe how the terms oxidation and reduction are used in organic chemistry (CHEM 140A)* • *(A) Recognize and predict rearrangements of carbocations (CHEM 140A)* • *(A) Identify all major functional groups and the reactivity of each (CHEM 140A, CHEM 140B)* • *(D, E, F, G) Conduct a retrosynthetic analysis of a given compound and outline the forward steps and reagents that are required (CHEM 140B, CHEM 140C)* • *(B, K) Be aware of the pervasiveness of organic substances in the environment (CHEM 140A, CHEM 149B)* • *(B, K) Identify and discuss some of the common polymers and macromolecules, at a level more soils than in C (CHEM 140C)* • *(F) UV-VIS: Use the terms chromophore, molar absorptivity, wavelength at maximum, transition, pi - pi*, n - pi* (CHEM 140B)* • *(C, E, F) UV-VIS: Use UV-VIS data to calculate concentrations and assist in determining chemical structure (CHEM 6BL, CHEM 100A, CHEM 140B)* • *UV-VIS: Explain the effect of conjugation on the absorption wavelength by sketching the molecular orbitals and relative energies (CHEM 140B)* • *(A) IR: Describe the molecular transitions responsible for the infrared absorption (CHEM 140B)* • *(C, E, G) IR: Use the characteristic absorption frequencies (data provided) of functional groups to assist in determining the structure of an unknown compound (CHEM 143A, CHEM 143C)* • *(A, C, F) IR: Predict how electronic and structural factors affect the infrared absorption of functional groups, particularly carbonyls (CHEM 140B, CHEM 143A)* • *(B, K) IR: Explain the connection between infrared absorption and the "greenhouse effect" (CHEM 140A, CHEM 149A)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics (continued)*		• *(C, F, G) NMR: Magnetic resonance of protons and carbon: Identify the number of non-equivalent protons and carbons in a given molecule based on symmetry. Assign peaks of an NMR spectrum to likely chemical environments. Identify the relative numbers of protons of an unknown using integration. Identify the presence of neighboring protons from splitting patterns and coupling constants. Use NMR spectrum to elucidate the structure of an unknown compound (CHEM 140B)* • *(C, F, G) NMR: Predict the NMR spectrum from a structure (number of peaks, multiplicity and chemical shift) (CHEM 140B)* • *(C, F, G) NMR: Use the proton decoupled ^{13}C NMR spectrum to assist in the determination of the structure of an unknown compound (CHEM 140B)* • *(G) NMR: Distinguish solvent and reference NMR signals from that of the sample (CHEM 140B)* • *(A, F, G) NMR: Understand and explain conformational averaging in NMR spectra (CHEM 140AB)* • *(A, E, F) Characterize reaction products by spectroscopic methods, as available (CHEM 143A, CHEM 143B)* • *(E, F) Document data and observation accurately (CHEM 6BL, CHEM 143A)* • *(D, E) Lab: Carry out a task with a proficient and confident manner while working alone (CHEM 6BL, CHEM 143A)* • *(D, E, F, G, H, I, J, K) Lab: Work as a member of team in an efficient manner toward a common goal (CHEM 105A, CHEM 143D)* • *(D, E) Lab: Maintain safe practices for oneself and others (CHEM 6BL)* • *(D, E) Lab: Minimize waste and dispose of waste legally and correctly (CHEM 6BL, CHEM 143A)* • *(A, E, F) Lab: Relate laboratory procedures, whether synthetic or analytical, to underlying theory (CHEM 105A, CHEM 143A)* • *(D, E, F) Lab: Demonstrate and use subsequently: Recrystallization, extraction, evaporation, TLC, column chromatography, distillation (CHEM 143A)* • *(D, E, F) Lab: Set up and use apparatus to carry out a variety of reaction types (CHEM 143A)* • *(D, E) Lab: Demonstrate when and how to reduce hazards by using hoods, glove boxes, or oxygen-free techniques (CHEM 6BL, CHEM 143A)* • *(E, I, J) Lab: Document procedures and results completely, accurately, and with complete honesty in notebooks kept to professional standards (CHEM 6BL, CHEM 100A, CHEM 143A)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics (continued)*		• *(D, E, F, G) Operate a variety of laboratory instruments and apparatus for synthesis and for analysis, with explicit direction or, eventually, following written manuals (CHEM 100A, CHEM 105A, CHEM 143A)* • *(E, G, H, I) Analyze experimental data, using proper statistical methods and construction of graphs that re effective in communicating results to others (CHEM 6BL, CHEM 100A)* • *(E, G, I, J) Distinguish precision and accuracy. Distinguish systematic from random error and blatant mistakes. Identify these in reports and present quantitative limits on error when it is possible to do so (CHEM 100AL, CHEM 105A)* • *(D, E, H) Search and retrieve chemical information from various databases (CHEM 105A, CHEM 143C)* • *(H, K) Read, analyze and critically evaluate journal papers in various subfields of chemistry (CHEM 6BL, Et al.)* • *(I, K) Write scientific reports in a concise, organized and effective style (CHEM 6BL, CHEM 100A, CHEM 143A)* • *(I, K) Report scientific findings and inferences in oral presentations in clear and organized fashion, using visual tools, mostly PowerPoint® computer methods (CHEM 105A)* • *(C, F, G, H, I) Propose molecular structures consistent with spectroscopic data (CHEM 143C, CHEM 158)* • *(A, C, K) Explain the theory of origin of life (CHEM 114A)* • *(A, B) Describe the difference between eukaryotic and prokaryotic cells (CHEM 114A)* • *(A) Recognize the 20 amino acids and explain the differences in their chemical properties (CHEM 114A)* • *(A) Explain and sketch the periodic arrangements of secondary structures within a protein fold (CHEM 114A)* • *(A) Understand the packing of secondary structure units to form a tertiary fold (CHEM 114A)* • *(A) Identify the packing of tertiary folds to form specific quaternary structures (CHEM 114A)* • *(A) Use analysis of hydrophobic interactions and properties of water and how they influence protein folding in solution and in membranes (CHEM 114A)* • *(A) Distinguish and explain negative and positive cooperativity and allosteric interactions (CHEM 114A)* • *(A) Describe the organization of the membranes and the influence of specific chain properties on the fluidity of the membrane (CHEM 114A)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemical Physics (continued)*		• *(A) Know that specific classes of proteins called enzymes are catalysts of chemical reactions (CHEM 114A)* • *(C) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A)* • *(A, C) Review the properties of buffers and concept of pH and explain how solution pH can influence protein stability and enzyme kinetics (CHEM 114A)* • *(A, C) Distinguish competitive, non-competitive, and uncompetitive inhibitors affect observed rates of reactions (CHEM 114A)* • *(A) Explain how inhibitors can be used as drugs (CHEM 114A)* • *(A) Describe the structure and properties of DNA in terms that take advantage of insights provided by organic chemistry (CHEM 114A)* • *(A, C) Become proficient in the understanding and use of partial differential equations, meeting the objectives specified by the Math Department (MATH 110)* • *(A, C) Become proficient in intermediate classical mechanics, or in intermediate electromagnetic theory, meeting objectives as specified by the Physics Department (PHYS 100A/B or 110A/B)* • *(D, E, H, I, J, L) Independent research is encouraged but not required (CHEM 199)*		

UC San Diego - WASC Exhibit 7.1
Inventory of Educational Effectiveness Indicators

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Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education* **(1) Have formal learning outcomes been developed?** *Yes* **(6) Date of last Academic Senate Review?** *1998-99 (previous)* *2008-09(current)*	**Students graduating with a degree should be able to:** *AAA. Have firm foundations in the fundamentals and applications of current chemical theories for the physical world and the rigorous foundations of learning, teaching, and assessment.* *BBB. Use molecular understanding in fields that are based upon chemistry: biology, environmental science, and engineering.* *CCC. Be skilled in problems solving, critical thinking, and analytical reasoning.* *DDD. Know the proper procedures and regulations for safe handling and use of chemicals and follow the proper procedures and regulations for safety when using chemicals.* *EEE. Design, carry out, record, and analyze the results of chemical experiments.* *FFF. Use a broad variety of modern instrumentation and classical techniques in the course of experimentation.* *GGG. Interpret and evaluate results critically. Identify and quantify uncertainties in measurements and limitations in methodologies.* *HHH. Use modern library searching and retrieval methods to obtain information about a topic, chemical, chemical technique, or an issue relating to chemistry, going beyond textbooks and common handbooks.* *III. Communicate results of work to chemists and non-chemists, including respect for the tradition of careful citation of prior contributions, both orally and in effective writing.* *JJJ. Collaborate effectively as part of a team to solve problems, debate different points of view, and interact productively with a diverse group of team members.* *KKK. Understand the ethical, historic, philosophical, and environmental dimensions of problems and issues facing chemists.*	**Data/Evidence:** • *(A, C) Meet the objectives of introductory calculus as specified by the Department of Mathematics (Math 20A/B/C/D)* • *(A, C) Meet the objectives of elementary physics as specified by the Department of Physics (Physics 2A/B/D/2CL)* • *(A, B) Recognize elemental symbols and place the more common elements on a Periodic Chart (CHEM 6A)* • *(A) Use a Periodic Chart to predict elemental and atomic properties, such as electronegativity, size, state of matter, likely reaction partners (CHEM 6A)* • *(A, C) Count molecules in units of moles and write balanced chemical reactions in terms of mole numbers (CHEM 6A)* • *(A, C) Recognize a limiting reagent, calculate amounts of reaction product and yield (CHEM 6A)* • *(A, B) Recognize the differences among materials that are metallic, ionic, or covalently bonded (CHEM 6A)* • *(A) Use molecular orbital theory to explain differences among second row diatomic molecules (CHEM 6A)* • *(A, B) Appreciate the role of nonbonding interactions, in particular with respect to solubilities (CHEM 6A)* • *(A) Use quantum mechanical descriptions for electronic orbitals and molecular symmetry principles to describe chemical bonding (CHEM 120A)* • *(A) Use Lewis Diagrams to predict molecular connectivity (CHEM 6A)* • *(A) Use valence shell repulsion theory to predict shapes of symmetric molecules (CHEM 6A)* • *(A) Sketch 1s, 2s and 2p atomic orbitals and combine them to interpret sp3 ,sp2 and sp hybrid orbitals. (CHEM 6A, CHEM 140A)* • *(A) Sketch molecular orbitals (bonding and antibonding) for any 2-carbon molecule, with peripheral atoms, showing the mathematical signs of the lobes and approximate relative energies. Sketch pi molecular orbitals of conjugated systems. Sketch the structures of carbocations, carbanions and radicals. (CHEM 140A)*	• *The Instructors of later courses that depend upon the students having accomplished the goals in earlier courses* • *Undergraduate Affairs Committee and Vice Chair for Undergraduate Education oversee requirements, which are endorsed by full faculty.* • *Vice Chair for Undergraduate Education acts on all requests/petitions for variation of requirements.* • *CEP review Committee* • *5-year ACS review*	• *ACS collects annual data from all approved departments and publishes outcomes.* • *Internally the department adjusts requirements and course sequences for the major.* • *Individual course instructors use feedback to modify their classes.*

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education (continued)*	*LLL. Be able to identify and solve chemical problems and explore new areas of research.* *MMM. Find gainful employment in industry or government, be accepted at graduate or professional schools, or find employment in school systems as instructors or administrators.* **Learning outcomes published:** • *www.acs.org/cpt* • *Course syllabi* • *www-chem.ucsd.edu/* • *Articulation agreements with California Community Colleges (Project IMPAC)*	• *(A) Understand bond formation and bond energies, and predict which bonds are weak and which are strong. (CHEM 140A)* • *(A) Extend valence shell repulsion theory to treat strain (CHEM 140A)* • *(A) Use a simplified crystal field theory to rationalize structure and reactivity of transition metal complexes and their colors when dissolved in water (CHEM 6C)* • *(A) Use ligand field theory and other quantum methods to predict the molecular structures of transition metal complexes and extend this to organometallics (CHEM 120B)* • *(A, C) Solve the Schroedinger Equation for a 1-d harmonic oscillator to derive eigenvalues and eigenfunctions. Note the equal-spaced energy levels (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger equation for a 1-d square well and for a rigid rotor, noting that energy levels become more widely spaced at high energies (CHEM 126, CHEM 133)* • *(A, C) Solve the Schroedinger Equation for a Coulomb potential, noting that energy levels are spaced more closely at high energies (CHEM 126, CHEM 133)* • *(A, C) Explain energies and transitions for simple atoms at an intermediate level (CHEM 126, CHEM 133)* • *Develop a proper quantum interpretation of bonding for simple molecules (CHEM 126, CHEM 133)* • *(C) Use and be able to interconvert among the several ways of denoting solutions concentrations (CHEM 6A)* • *(A, C) Use the four colligative properties to calculate concentrations or molar masses, depending on known information (CHEM 6A)* • *(A, B) State the 4 great laws of thermodynamics and explain why they are considered great (CHEM 6B)* • *(A) Distinguish state functions from such non-quantities as heat and work (CHEM 6B)* • *(A, C) Manipulate partial derivatives of state quantities using relations such as the Maxwell relations (CHEM 127, CHEM 131)* • *(B, C) Calculate the idealized maximum efficiency of a heat engine or a refrigerator as deduced from a reversible Carnot cycle (CHEM 127, CHEM 131)* • *(B, C) Calculate the maximum efficiency of a less-than-ideal reversible cycle, such as those of Otto or Diesel (CHEM 127, CHEM 131)* • *(A, C) Identify the fallacy in the creationists' erroneous assertion that evolution is inconsistent wit the Second Law (CHEM 6B)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education (continued)*		• *(A) Explain why it is that reactions that heat their surroundings are likely to be spontaneous and why it is that even some that cool their surroundings can be spontaneous. (CHEM 6B)* • *(A, B, C) Use Hess's Law to combine thermal energies for chemical reactions when one combines consecutive atomic combinations (CHEM 6B)* • *(A, B, C) Use tables of free energies to compute equilibrium constants (CHEM 6B)* • *(A, C) Evaluate equilibrium constants from information about concentrations or partial pressures; or use equilibrium constants to deduce concentrations or partial pressures at equilibrium, given some initial condition (CHEM 6B)* • *(A, B) Distinguish strong and weak acids and bases (CHEM 6B)* • *(B, C) Convert between the pH scale and concentrations of protons or proton acceptors in aqueous solution (CHEM 6B)* • *(C, D, E, F, G) Carry out titrations to determine the pH of an unknown aqueous solution to acceptable accuracy and precision. (CHEM 6B, CHEM 6BL)* • *(B, C) Generalize the concept of a titration to any chemical or biochemical measurement (CHEM 114A, CHEM 112A)* • *(B, D, E, G) Desire and prepare a pH buffer of required pH and ionic strength (CHEM 6B. CHEM 100A)* • *(A) Compare and contrast Arrhenius, Bronsted, and Lewis acids (CHEM 6B)* • *(A, B, C) Write balanced equations for oxidation-reduction reactions, including the participation of solvent water (CHEM 6C)* • *(A, B) Use redox tables to predict the spontaneous direction for reactivity in redox reactions, and have some intuitive notions even without a table of potentials (CHEM 6C)* • *(C) Calculate the reversible emf expected for an arbitrary redox reaction, using tables, for any combination of concentrations of solutes and pressures of gasses (CHEM 6C)* • *(A, C) Deduce reaction rate laws and rate constants from initial rate data (CHEM 6C)* • *(C) Transform data from measurements of kinetic processes to produce a linear plot and deduce reaction order and rate constants from such plots (CHEM 6C)* • *(A) Explain the role of catalysts in a reaction and give some examples (CHEM 6C)* • *(A, B) Distinguish addition polymers from condensation polymers and give examples of each (CHEM 6C)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education (continued)*		• *(A, B) Distinguish homogeneous and heterogeneous catalysis, and write reaction schemes for each (CHEM 120B, CHEM 231)* • *(A, B) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A, CHEM 127)* • *(C, D, E, F, G) Apply the principles of gravimetry to determine the amount of analyte in an unknown sample (CHEM 6BL)* • *(C, D, E, F, G) Titrate a weak acid with a strong base to determine the molar mass, pKa, and identity of the acid (CHEM 6BL)* • *(C, D, E, F) Determine the specific heat of a metal, the heat of fusion of water, and the heat of neutralization of an acid-base reaction via coffee-cup calorimetry (CHEM 6BL)* • *(C, D, E, F, G) Use oxidation-reduction titration to determine the oxalate content in the iron oxalate complex (CHEM 6BL)* • *(D, E, F) Synthesize an iron (III) oxalate complex (CHEM 6BL)* • *(C, D, E, F, G) Use spectrophotometry to determine the iron content in the iron oxalate complex (CHEM 6BL)* • *(C, D, E, F) Understand and follow a semimicro qualitative analysis scheme to characterize a mixture of common metal ions (CHEM 6BL)* • *(E, F) Investigate the atomic emission spectra of various elements (CHEM 6BL)* • *(E, H) Maintain a clearly written lab notebook as a permanent record of experimental results (CHEM 6BL)* • *(I) Write a simple report in standard format emulating publication in a science journal (CHEM 6BL)* • *(F) Demonstrate skill using a computer spreadsheet (CHEM 100A)* • *(F, I) Demonstrate proficiency with computer graphing (CHEM 100A)* • *(D, E, F, I) Characterize reaction kinetics in a laboratory (CHEM 100A)* • *(C, D, E, F, G, I) Measure chemical equilibria in solution (CHEM 100A)* • *(C, D, E, F, G, I) Use electrochemical techniques and ion selective electrodes to determine ion concentrations (CHEM 100A)* • *(C, D, E, F, G, H, I) Use column chromatography to separate components of a mixture (CHEM 100A)* • *(B, C, D, E, F, G, H, I, J, K) Use gas chromatography to separate mixtures, using several different detection strategies, including mass spectrometry (CHEM 100A)* • *(B, C, D, E, F, G, H, I, J, K) Use high performance liquid chromatography to separate mixtures (CHEM 100A, CHEM 100BL)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education (continued)*		• *(A, B, E, G, I, J) Demonstrate proficiency in statistical analysis and error estimation beyond what was learned in the lower labs (CHEM 105A, CHEM 100BL)* • *(A, C) Draw conformations of alkanes and cycloalkanes (Newman projections, wedge/dotted-line structures). Graph the relation between conformation and potential energy for these molecules. Predict preferred conformations, including those of substituted cyclohexanes. Calculate the ratio of conformers based on relative energies (CHEM 140A)* • *(A, B) Explain how conformations around bonds translate into global shape changes and dictate the overall structure of big molecules, emphasizing relevancy for biological structures (CHEM 140B)* • *(A, C) Recognize strain in various conformations and predict effect on stability and as a driving force for reactivity and rearrangements (CHEM 140B)* • *(A) Define and recognize stereoisomer, enantiomer, diastereomer, conformation, configuration, meso, epimer, resolution. Recognize inversion, retention and racemization. All these for any molecule (CHEM 140A)* • *(A) Sketch a molecule with a chiral center so as to show unambiguously the configuration using both Fischer projection and perspective drawing. Determine the configuration (R or S) of any chiral center from a perspective drawing (CHEM 140A)* • *(C) Calculate "specific rotation" from the experimental optical rotation and concentration (CHEM 140B)* • *(A) Determine the configuration (E or Z) of any double bond (CHEM 140A)* • *(A, C) Describe the formation and relative stabilities of carbocations as related to hyperconjugation (CHEM 140A)* • *(H) Convert IUPAC names of simple molecules to chemical structures (CHEM 140A, CHEM 140B)* • *(A, C) Write contributor structures to a resonance hybrid for simple molecules and rate the importance of each contributor (CHEM 140A)* • *(A) Analyze inter and intramolecular forces and estimate solubility, melting point and boiling point. Describe the molecular events occurring during the processes of dissolving, melting and boiling (CHEM 140A)* • *(A, B) Explain the unique role of water as a solvent (CHEM 6A)* • *(A, B) Use the unique solvation properties of water to predict or retrodict organic molecular structure with emphasis on molecules of biochemical interest (CHEM 140A, CHEM 140C)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education (continued)*		• *(A, B, C) Estimate relative acidities and basicities of organic compounds based on estimation of the stabilities of their conjugate base and acid. Calculate the pH of a solution of a weak acid or base from the analytical concentration and Ka. Calculate the proportions of protonated and non-protonated species at a given pH (CHEM 140A, CHEM 140B)* • *(A) Locate reactive sites within a molecule and draw correct electron-pushing arrows for reactions based on electronic properties and structure instead of rote memorization of mechanisms. (CHEM 140A, CHEM 140B)* • *(A) Explain by words and equations the factors affecting the rate of a chemical reaction, including temperature. Analyze kinetic data and determine the order of a reaction. Validate reaction mechanisms by comparison with kinetic data (CHEM 140A, CHEM 140B)* • *(A) Distinguish between kinetic and thermodynamic products of reactions. Explain reasons for obtaining one product rather than the other (CHEM 140B)* • *(A) Use the concepts of delocalization and resonance for estimation of bond lengths, electronic distribution, stability, aromaticity, basicity, acidity and reactivity (CHEM 140A)* • *(A, C) Draw conclusions about a reaction mechanism from the stereochemistry of the products. Given a proposed mechanism for a reaction, predict the stereochemistry (CHEM 140B, CHEM 140C, CHEM 154)* • *(C, D, E) Define and recognize regioselective, stereoselective and stereospecific reactions. Describe resolution of a racemic mixture by converting it to a diastereomeric mixture (CHEM 140A)* • *(B) Understand and explain the importance of chiral recognition in biological systems (CHEM 140A, CHEM 140C)* • *(A) Distinguish nucleophiles from electrophiles and list examples of each. Write chemical equations to describe the currently accepted mechanism(s) for major reactions: radical, SN1, SN2, E1, E2, electrophilic addition, electrophilic substitution, conjugate addition, addition-elimination, pericyclic. Explain how each mechanism is deduced from experimental kinetic data and stereochemistry of the products. Be able to specify structures and energetics of intermediates in multistep reactions. (CHEM 140A, CHEM 140B)* • *(A) Describe how the terms oxidation and reduction are used in organic chemistry (CHEM 140A)* • *(A) Recognize and predict rearrangements of carbocations (CHEM 140A)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education (continued)*		• *(A) Identify all major functional groups and the reactivity of each (CHEM 140A, CHEM 140B)* • *(B) Identify the functional groups prominent in reactions that biomolecules undergo (CHEM 140C)* • *(D, E, F, G) Conduct a retrosynthetic analysis of a given compound and outline the forward steps and reagents that are required (CHEM 140B, CHEM 140C)* • *(B, K) Be aware of the pervasiveness of organic substances in the environment (CHEM 140A, CHEM 149B)* • *(B, K) Identify and discuss some of the common polymers and macromolecules, at a level more soils than in C (CHEM 140C)* • *(F) UV-VIS: Use the terms chromophore, molar absorptivity, wavelength at maximum, transition, pi - pi*, n - pi* (CHEM 140B)* • *(C, E, F) UV-VIS: Use UV-VIS data to calculate concentrations and assist in determining chemical structure (CHEM 6BL, CHEM 100A, CHEM 140B)* • *UV-VIS: Explain the effect of conjugation on the absorption wavelength by sketching the molecular orbitals and relative energies (CHEM 140B)* • *(A) IR: Describe the molecular transitions responsible for the infrared absorption (CHEM 140B)* • *(C, E, G) IR: Use the characteristic absorption frequencies (data provided) of functional groups to assist in determining the structure of an unknown compound (CHEM 143A, CHEM 143C)* • *(A, C, F) IR: Predict how electronic and structural factors affect the infrared absorption of functional groups, particularly carbonyls (CHEM 140B, CHEM 143A)* • *(B, K) IR: Explain the connection between infrared absorption and the "greenhouse effect" (CHEM 140A, CHEM 149A)* • *(C, F, G) NMR: Magnetic resonance of protons and carbon: Identify the number of non-equivalent protons and carbons in a given molecule based on symmetry. Assign peaks of an NMR spectrum to likely chemical environments. Identify the relative numbers of protons of an unknown using integration. Identify the presence of neighboring protons from splitting patterns and coupling constants. Use NMR spectrum to elucidate the structure of an unknown compound (CHEM 140B)* • *(C, F, G) NMR: Predict the NMR spectrum from a structure (number of peaks, multiplicity and chemical shift) (CHEM 140B)* • *(C, F, G) NMR: Use the proton decoupled ^{13}C NMR spectrum to assist in the determination of the structure of an unknown compound (CHEM 140B)* • *(G) NMR: Distinguish solvent and reference NMR signals from that of the sample (CHEM 140B)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education (continued)*		• *(A, F, G) NMR: Understand and explain conformational averaging in NMR spectra (CHEM 140AB)* • *(A, E, F) Characterize reaction products by spectroscopic methods, as available (CHEM 143A, CHEM 143B)* • *(E, F) Document data and observation accurately (CHEM 6BL, CHEM 143A)* • *(D, E) Lab: Carry out a task with a proficient and confident manner while working alone (CHEM 6BL, CHEM 143A)* • *(D, E, F, G, H, I, J, K) Lab: Work as a member of team in an efficient manner toward a common goal (CHEM 105A, CHEM 143D)* • *(D, E) Lab: Maintain safe practices for oneself and others (CHEM 6BL)* • *(D, E) Lab: Minimize waste and dispose of waste legally and correctly (CHEM 6BL, CHEM 143A)* • *(A, E, F) Lab: Relate laboratory procedures, whether synthetic or analytical, to underlying theory (CHEM 105A, CHEM 143A)* • *(D, E, F) Lab: Demonstrate and use subsequently: Recrystallization, extraction, evaporation, TLC, column chromatography, distillation (CHEM 143A)* • *(D, E) Lab: Demonstrate when and how to reduce hazards by using hoods, glove boxes, or oxygen-free techniques (CHEM 6BL, CHEM 143A)* • *(E, I, J) Lab: Document procedures and results completely, accurately, and with complete honesty in notebooks kept to professional standards (CHEM 6BL, CHEM 100A, CHEM 143A)* • *(D, E, F, G) Operate a variety of laboratory instruments and apparatus for synthesis and for analysis, with explicit direction or, eventually, following written manuals (CHEM 100A, CHEM 105A, CHEM 143A)* • *(E, G, H, I) Analyze experimental data, using proper statistical methods and construction of graphs that re effective in communicating results to others (CHEM 6BL, CHEM 100A)* • *(E, G, I, J) Distinguish precision and accuracy. Distinguish systematic from random error and blatant mistakes. Identify these in reports and present quantitative limits on error when it is possible to do so (CHEM 100AL, CHEM 105A)* • *(D, E, H) Search and retrieve chemical information from various databases (CHEM 105A, CHEM 143C)* • *(H, K) Read, analyze and critically evaluate journal papers in various subfields of chemistry (CHEM 6BL, Et al.)*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education (continued)*		• *(I, K) Write scientific reports in a concise, organized and effective style (CHEM 6BL, CHEM 100A, CHEM 143A/B)* • *(I, K) Report scientific findings and inferences in oral presentations in clear and organized fashion, using visual tools, mostly PowerPoint® computer methods (CHEM 105A)* • *(A, C, K) Explain the theory of origin of life (CHEM 114A)* • *(A, B) Describe the difference between eukaryotic and prokaryotic cells (CHEM 114A)* • *(A) Recognize the 20 amino acids and explain the differences in their chemical properties (CHEM 114A)* • *(A) Explain and sketch the periodic arrangements of secondary structures within a protein fold (CHEM 114A)* • *(A) Understand the packing of secondary structure units to form a tertiary fold (CHEM 114A)* • *(A) Identify the packing of tertiary folds to form specific quaternary structures (CHEM 114A)* • *(A) Use analysis of hydrophobic interactions and properties of water and how they influence protein folding in solution and in membranes (CHEM 114A)* • *(A) Distinguish and explain negative and positive cooperativity and allosteric interactions (CHEM 114A)* • *(A) Describe the organization of the membranes and the influence of specific chain properties on the fluidity of the membrane (CHEM 114A)* • *(A) Know that specific classes of proteins called enzymes are catalysts of chemical reactions (CHEM 114A)* • *(C) Recognize and use Michaelis-Menten kinetic scheme (CHEM 114A)* • *(A, C) Review the properties of buffers and concept of pH and explain how solution pH can influence protein stability and enzyme kinetics (CHEM 114A)* • *(A, C) Distinguish competitive, non-competitive, and uncompetitive inhibitors affect observed rates of reactions (CHEM 114A)* • *(A) Explain how inhibitors can be used as drugs (CHEM 114A)* • *(A) Describe the structure and properties of DNA in terms that take advantage of insights provided by organic chemistry (CHEM 114A)* • *(A, C, G, H, I, J, K) Develop an understanding of the epistemology associated with the learning and teaching of chemistry and other sciences at the pre-college and early college level. Implement theories of learning and classroom interaction in a practical chemical education environment. Meet outcome goals defined by the Department of Education Studies.*		

Department: *Chemistry & Biochemistry* **Major:** *B.S. in Chemistry/ Chemical Education (continued)*		• *(B, K) Augment knowledge and understanding of chemistry with modest but well grounded understanding or related disciplines, notably biology, geology, and earth and environmental science, to the satisfy learning goals of those departments (BILD 1, ES 101, ES 102, ES 103)* • *(I, J, K) Demonstrate the ability to use content-specific materials and standards-based methods to teach (apprentice) grades 9-12 physical sciences (chemistry, physics, earth science, biology, and mathematics) to the satisfaction of the objectives set by the Department of Education Studies (ES 129C)* • *Apprentice teaching is encouraged (CHEM 195)* • *(D, E, H, I, J, L) Independent research is encouraged but not required (CHEM 199)*		