

# CHEMISTRY (CHE)

## College of Letters & Science

### CHE 001 – Preparation for General Chemistry (3 units)

*Course Description:* Preparation for the general chemistry series (CHE 002ABC & CHE 004ABC); unit conversion, dimensional analysis, periodic table, chemical equations, stoichiometry, and gases.

*Learning Activities:* Lecture 2 hour(s), Discussion 1 hour(s).

*Enrollment Restriction(s):* Concurrent enrollment in CHE 002A or CHE 004A not allowed.

*Credit Limitation(s):* Not open for credit to students who have completed CHE 002A or CHE 004A with a grade of C- or better.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

### CHE 001V – Preparation for General Chemistry (3 units)

*Course Description:* Preparation for the general chemistry series (CHE 002ABC & CHE 004ABC); unit conversion, dimensional analysis, periodic table, chemical equations, stoichiometry, and gases.

*Learning Activities:* Web Virtual Lecture 3 hour(s), Web Electronic Discussion 1 hour(s).

*Enrollment Restriction(s):* Concurrent enrollment in CHE 002A or CHE 004A not allowed.

*Credit Limitation(s):* Not open for credit to students who have completed CHE 002A or CHE 004A with a grade of C- or better.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

### CHE 002A – General Chemistry (5 units)

*Course Description:* Periodic table, stoichiometry, chemical equations, physical properties and kinetic theory of gases, chemical equilibrium, acids and bases. Laboratory experiments in stoichiometric relations, properties and collection of gases, atomic spectroscopy, introductory quantitative analysis and acids and bases.

*Prerequisite(s):* High school chemistry and physics, and concurrent enrollment in mathematics at or above the level of MAT 012 strongly recommended; must earn a qualifying score of 24 or better on the Chemistry Placement Exam or complete CHE 001V with a C- or higher; more information about the Chemistry Placement Requirements to ensure enrollment in CHE 002A can be found at <https://chemistry.ucdavis.edu/undergraduate/general-chemistry-series/chemistry-placement-requirements>.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 4 hour(s).

*Credit Limitation(s):* Only three units of credit for students who have completed CHE 004A; not open for credit for students who have completed CHE 002AH or CHE 004B.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

### CHE 002AH – Honors General Chemistry (5 units)

*Course Description:* Limited enrollment course with a more rigorous treatment of material covered in CHE 002A. Students completing CHE 002AH can continue with CHE 002BH or CHE 002B.

*Prerequisite(s):* Consent of instructor; high school chemistry and physics, and concurrent enrollment in mathematics at or above the level of MAT 012 strongly recommended; must earn a qualifying score of 33 or better on the Chemistry Placement Exam; more information about the Chemistry Placement Requirements to ensure enrollment in CHE 002A can be found at <https://chemistry.ucdavis.edu/undergraduate/general-chemistry-series/chemistry-placement-requirements>.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 4 hour(s).

*Credit Limitation(s):* Not open for credit to students who have taken CHE 002A.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

### CHE 002B – General Chemistry (5 units)

*Course Description:* Continuation of CHE 002A. Thermodynamics, atomic and molecular structure and chemical bonding, condensed phases and intermolecular forces, solubility. Laboratory experiments in thermochemistry, equilibria, and quantitative analysis using volumetric methods.

*Prerequisite(s):* CHE 002A C- or better.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 4 hour(s).

*Credit Limitation(s):* Only three units of credit for students who have completed CHE 004A; not open for credit for students who have completed CHE 002BH or CHE 004B.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

### CHE 002BH – Honors General Chemistry (5 units)

*Course Description:* Limited enrollment course with a more rigorous treatment of material covered in CHE 002B. Students completing CHE 002BH can continue with CHE 002CH or CHE 002C.

*Prerequisite(s):* CHE 002A or CHE 002AH C or better; MAT 021B (can be concurrent); or consent of instructor; CHE 002A with consent of instructor.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 4 hour(s).

*Credit Limitation(s):* Not open for credit to students who have taken CHE 002B.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

### CHE 002C – General Chemistry (5 units)

*Course Description:* Continuation of CHE 002B. Kinetics, electrochemistry, spectroscopy, structure and bonding in transition metal compounds, application of principles to chemical reactions. Laboratory experiments in selected analytical methods and syntheses.

*Prerequisite(s):* CHE 002B C- or better or CHE 002BH C- or better or CHE 004B C- or better.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 4 hour(s).

*Credit Limitation(s):* Not open for credit to students who have taken CHE 002CH.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

**CHE 002CH – Honors General Chemistry (5 units)**

*Course Description:* Limited enrollment course with a more rigorous treatment of material covered in CHE 002C.

*Prerequisite(s):* CHE 002B or CHE 002BH C or better; MAT 021C (can be concurrent); or consent of instructor; CHE 002B with consent of instructor.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 6 hour(s).

*Credit Limitation(s):* Not open for credit to students who have taken CHE 002C.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

**CHE 003A – Chemistry for Life Sciences: Determining Structure & Predicting Properties (5 units)**

*Course Description:* Integrated General and Organic Chemistry intended for majors in the life sciences. Core concepts of chemical composition, structure and properties. Includes phase changes, separation methods, composition, spectroscopy, atomic & molecular structure, periodicity, bonding, charge distribution, intermolecular forces, and physical properties.

*Prerequisite(s):* High school chemistry and physics strongly recommended; satisfactory score on the Chemistry and Mathematics Placement Examinations or satisfactory completion of the ALEKS Summer Chemistry Prep Course; a satisfactory grade in WKL 041C ('P' or 'C' or better) will suffice in lieu of a satisfactory Chemistry Placement Examination score.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s), Laboratory 3 hour(s).

*Enrollment Restriction(s):* Concurrent enrollment with CHE 002A, CHE 002B, CHE 002C, CHE 002AH, CHE 002BH, CHE 002CH prohibited; not open for enrollment to students who have completed CHE 002C or 002CH with a C- or better.

*Credit Limitation(s):* Only 3 units credit for students who have completed CHE 002A or CHE 002AH with a C- or better; only 1 unit of credit to students who have completed CHE 002B or CHE 002BH with a C- or better.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

**CHE 003B – Chemistry for Life Sciences: Predicting & Characterizing Chemical Change (5 units)**

*Course Description:* Continuation of CHE 003A covering core concepts of characterization of chemical processes and predicting chemical changes. Includes modeling chemical reactions, understanding proportions/stoichiometry, tracking energy, activation energy, reaction kinetics, thermodynamics, and equilibrium.

*Prerequisite(s):* CHE 003A C- or better; note: C- or better in CHE 002A or 002AH does not satisfy the prerequisite requirement.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s), Laboratory 3 hour(s).

*Enrollment Restriction(s):* Concurrent enrollment with CHE 002A, CHE 002B, CHE 002C, CHE 002AH, CHE 002BH, CHE 002CH prohibited.

*Credit Limitation(s):* Only 3 units credit for students who have completed CHE 002B or CHE 002BH with a C- or better.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

**CHE 003C – Chemistry for Life Sciences: Controlling Processes & Synthetic Pathways (5 units)**

*Course Description:* Continuation of CHE 003B covering core concepts of harnessing energy, controlling reaction extent, and organic chemistry synthetic pathways. Includes acids and bases, thermodynamics, chemical equilibria, organic chemistry terminology and mechanisms.

*Prerequisite(s):* CHE 003B C- or better; note: C- or better in CHE 002B or 002BH does not satisfy the prerequisite requirement.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s), Laboratory 3 hour(s).

*Enrollment Restriction(s):* Concurrent enrollment with CHE 002A, CHE 002B, CHE 002C, CHE 002AH, CHE 002BH, CHE 002CH prohibited.

*Credit Limitation(s):* Only 3 units credit for students who have completed CHE 002C or CHE 002CH with a C- or better.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

**CHE 004A – General Chemistry for the Physical Sciences & Engineering (5 units)**

*Course Description:* General chemistry course with a more rigorous treatment of material covered in CHE 002A, intended for students majoring in the physical sciences and engineering.

*Prerequisite(s):* MAT 021A (can be concurrent); must earn a qualifying score of 28 or better on the Chemistry Placement Exam or complete CHE 001V with a C- or higher; high school chemistry and physics strongly recommended; more information about the Chemistry Placement Requirements to ensure enrollment in CHE 004A can be found at <https://chemistry.ucdavis.edu/undergraduate/general-chemistry-series/chemistry-placement-requirements>.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 4 hour(s).

*Credit Limitation(s):* Only 3 units of credit for students who have completed CHE 002A; not open for credit for students who have completed CHE 002AH or 002B.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

**CHE 004B – General Chemistry for the Physical Sciences & Engineering (5 units)**

*Course Description:* General chemistry course with a more rigorous treatment of material covered in CHE 002B, intended for students majoring in the physical sciences and engineering.

*Prerequisite(s):* MAT 021B (can be concurrent); (CHE 004A C- or better or CHE 002AH C- or better); or consent of instructor.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 4 hour(s).

*Credit Limitation(s):* Only three units of credit for students who have completed CHE 002A; not open for credit for students who have completed CHE 002B or 002BH.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

### CHE 004C – General Chemistry for the Physical Sciences & Engineering (5 units)

*Course Description:* General chemistry course with a more rigorous treatment of material covered in CHE 002C, intended for students majoring in the physical sciences and engineering.

*Prerequisite(s):* MAT 021C (can be concurrent); (CHE 004B C- or better or CHE 002B B or better or CHE 002BH B or better); or consent of instructor.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 4 hour(s).

*Credit Limitation(s):* Not open for credit for students who have completed CHE 002C or 002CH.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

### CHE 008A – Organic Chemistry: Brief Course (2 units)

*Course Description:* With CHE 008B, an introduction to the nomenclature, structure, chemistry, and reaction mechanisms of organic compounds. Intended for students majoring in areas other than organic chemistry.

*Prerequisite(s):* CHE 002B C- or better or CHE 002BH C- or better or CHE 004B C- or better.

*Learning Activities:* Lecture 2 hour(s).

*Credit Limitation(s):* No credit to students who have completed CHE 118A or 128A.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

### CHE 008B – Organic Chemistry: Brief Course (4 units)

*Course Description:* Laboratory concerned primarily with organic laboratory techniques and the chemistry of the common classes of organic compounds. Lecture portion a continuation of CHE 008A.

*Prerequisite(s):* CHE 008A or CHE 118A or CHE 128A.

*Learning Activities:* Lecture 3 hour(s), Laboratory 3 hour(s).

*Credit Limitation(s):* Varying credit hours according to courses taken previously and corresponding expected workload for this course; full credit to students who complete CHE 118A or 128A; 3 units credit to students who have completed CHE 128A and CHE 129A (students who have completed CHE 129A are exempt from the laboratory portion of CHE 008B); 2 units credit to students who have completed CHE 128B; 1 unit credit to students who have completed CHE 118B or CHE 128B and CHE 129A (students who have completed CHE 118B are exempt from the laboratory portion of CHE 008B).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

### CHE 010 – Concept of Chemistry (4 units)

*Course Description:* Survey of basic concepts and contemporary applications of chemistry. Designed for non-science majors and not as preparation for CHE 002A.

*Learning Activities:* Lecture 4 hour(s).

*Credit Limitation(s):* Not open for credit to students who have had CHE 002A; but students with credit for CHE 010 may take CHE 002A for full credit.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Scientific Literacy (SL).

### CHE 098 – Directed Group Study (1-5 units)

*Course Description:* Primarily for lower division students.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Variable.

*Grade Mode:* Pass/No Pass only.

### CHE 099 – Special Study for Undergraduates (1-5 units)

*Course Description:* Special study for undergraduates. May be taught abroad.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Variable.

*Grade Mode:* Pass/No Pass only.

### CHE 100 – Environmental Water Chemistry (3 units)

*Course Description:* Practical aspects of water chemistry in the environment, including thermodynamic relations, coordination chemistry, solubility calculations, redox reactions and rate laws. Computer modeling of the evolution in water chemistry from contact with minerals and gases.

*Prerequisite(s):* CHE 002C or CHE 002CH or CHE 004C.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 103A – Chemistry for Life Sciences: Determining Organic Structures & Properties (5 units)

*Course Description:* Continuation of CHE 003C. Core concepts of organic structure, nomenclature, functional groups, organic acids and bases, resonance and delocalization, aromaticity, intermolecular forces, three-dimensional structure and conformational analysis, spectroscopy.

*Prerequisite(s):* CHE 002C C- or better or CHE 002CH C- or better; (CHE 008A or CHE 118A or CHE 128A).

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s), Laboratory 3 hour(s).

*Enrollment Restriction(s):* Not open for enrollment to students who have completed CHE 008B, CHE 118B, CHE 118C, CHE 128B, CHE 128C with a C- or better.

*Credit Limitation(s):* Only 3 Units of credit for students who have completed CHE 008A with a C- or better; only 2 units of credit for students who have completed CHE 118A or CHE 128A with a C- or better; not open for credit to students who have completed CHE 008B, CHE 118B, CHE 118C, CHE 128B, CHE 128C with a C- or better.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Scientific Literacy (SL).

### CHE 103B – Chemistry for Life Sciences: Predicting & Controlling Organic Pathways (5 units)

*Course Description:* Continuation of CHE 103A. Core concepts of functional group transformations, synthesis, mechanisms, sustainable chemistry, structure and function of biomolecules, organic reactions in biological systems, molecular design, detection, separation, and identification of organic molecules.

*Prerequisite(s):* CHE 103A C- or better.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s), Laboratory 3 hour(s).

*Enrollment Restriction(s):* Not open for enrollment to students who have completed CHE 008B, CHE 118B, CHE 118C, CHE 128B, or CHE 128C with a C- or better.

*Credit Limitation(s):* Not open for credit to students who have completed CHE 008B, CHE 118B, CHE 118C, CHE 128B, or CHE 128C.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Scientific Literacy (SL).

### **CHE 104 – Forensic Applications of Analytical Chemistry (3 units)**

*Course Description:* Theory and application of standard methods of chemical analysis to evidentiary samples. Use and evaluation of results from screening tests, FTIR, GC and GCMS to various sample types encountered in forensics.

*Prerequisite(s):* CHE 002C or CHE 002CH or CHE 004C.

*Learning Activities:* Lecture 2 hour(s), Laboratory 3 hour(s).

*Grade Mode:* Letter.

### **CHE 105 – Analytical & Physical Chemical Methods (4 units)**

*Course Description:* Fundamental theory and laboratory techniques in; analytical and physical chemistry, errors and data analysis methods, basic electrical circuits in instruments, advanced solution equilibria, potentiometric analysis, chromatographic separations, UV-visible spectroscopy, lasers.

*Prerequisite(s):* CHE 110A (can be concurrent) or CHE 107B (can be concurrent).

*Learning Activities:* Lecture 2 hour(s), Laboratory 6 hour(s).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Scientific Literacy (SL).

### **CHE 107A – Physical Chemistry for the Life Sciences (3 units)**

*Course Description:* Physical chemistry intended for majors in the life science area. Introductory development of classical and statistical thermodynamics including equilibrium processes and solutions of both non-electrolytes and electrolytes. The thermodynamic basis of electrochemistry and membrane potentials.

*Prerequisite(s):* (CHE 002C or CHE 002CH or CHE 004C); (MAT 016C or MAT 017C or MAT 021C); (PHY 007C or PHY 009C or PHY 009HC).

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

### **CHE 107B – Physical Chemistry for the Life Sciences (3 units)**

*Course Description:* Continuation of CHE 107A. Kinetic theory of gases and transport processes in liquids. Chemical kinetics, enzyme kinetics and theories of reaction rates. Introduction to quantum theory, atomic and molecular structure, and spectroscopy. Application to problems in the biological sciences.

*Prerequisite(s):* CHE 107A.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

### **CHE 108 – Molecular Biochemistry (3 units)**

*Course Description:* Chemical principles and experimental methods applied to the biological sciences to understand the molecular structure and function of proteins, nucleic acids, carbohydrates, and membrane lipids.

*Prerequisite(s):* CHE 128C or CHE 118C.

*Learning Activities:* Lecture 3 hour(s).

*Enrollment Restriction(s):* Pass One open to Chemistry majors.

*Grade Mode:* Letter.

### **CHE 110A – Physical Chemistry: Introduction to Quantum Mechanics (4 units)**

*Course Description:* Introduction to the postulates and general principles of quantum mechanics. Approximations based on variational method and time independent perturbation theory. Application to harmonic oscillator, rigid rotor, one-electron and many-electron atoms, and homo-and hetero-nuclear diatomic molecules.

*Prerequisite(s):* (PHY 007C or PHY 009C or PHY 009HC); (CHE 002C or CHE 002CH or CHE 004C); (MAT 016C or MAT 017C or MAT 021C); completion of MAT 021D, MAT 022A, MAT 022AL; PHY 009C or PHY 009HC, strongly recommended.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL).

### **CHE 110B – Physical Chemistry: Properties of Atoms & Molecules (4 units)**

*Course Description:* Group theory. Application of quantum mechanics to polyatomic molecules and molecular spectroscopy. Intermolecular forces and the gas, liquid and solid states. Distributions, ensembles and partition functions. Transport properties.

*Prerequisite(s):* CHE 110A.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

### **CHE 110C – Physical Chemistry: Thermodynamics, Equilibria & Kinetics (4 units)**

*Course Description:* Development and application of the general principles of thermodynamics and statistical thermodynamics. Chemical kinetics, rate laws for chemical reactions and reaction mechanisms.

*Prerequisite(s):* CHE 110B.

*Learning Activities:* Lecture 3 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

### **CHE 115 – Instrumental Analysis (4 units)**

*Course Description:* Intermediate theory and laboratory techniques in analytical and physical chemistry. Advanced data analysis methods and goodness-of-fit criteria. Fourier-transform spectroscopic methods and instrumentation. Mass spectrometry. Electrochemistry. Liquid chromatography.

*Prerequisite(s):* CHE 105; (CHE 110B (can be concurrent) or (CHE 107A, CHE 107B)).

*Learning Activities:* Lecture 2 hour(s), Laboratory 6 hour(s).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Writing Experience (WE).



### CHE 118A – Organic Chemistry for Health & Life Sciences (4 units)

*Course Description:* The 118A-C series is for students planning professional school studies in health and life sciences. Rigorous, in-depth presentation of basic principles with emphasis on stereochemistry and spectroscopy and preparations and reactions of nonaromatic hydrocarbons, haloalkanes, alcohols and ethers.

*Prerequisite(s):* CHE 002C C- or better or CHE 002CH C- or better or CHE 004C C- or better.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 1.50 hour(s).

*Credit Limitation(s):* Only 2 units credit for students who have completed CHE 008A; not open for credit to students who have completed CHE 008B or CHE 128A.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Scientific Literacy (SL).

### CHE 118B – Organic Chemistry for Health & Life Sciences (4 units)

*Course Description:* Continuation of CHE 118A, with emphasis on spectroscopy and the preparation and reactions of aromatic hydrocarbons, organometallic compounds, aldehydes and ketones.

*Prerequisite(s):* CHE 118A or CHE 128A.

*Learning Activities:* Lecture 3 hour(s), Laboratory 3 hour(s).

*Credit Limitation(s):* Only 1 unit of credit to students who completed CHE 128B.; not open for credit to students who have completed 8 or more units of CHE 128 and CHE 129.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Scientific Literacy (SL).

### CHE 118C – Organic Chemistry for Health & Life Sciences (4 units)

*Course Description:* Continuation of CHE 118B, with emphasis on the preparation, reactions and identification of carboxylic acids and their derivatives, alkyl and acyl amines,  $\beta$ -dicarbonyl compounds, and various classes of naturally occurring, biologically important compounds.

*Prerequisite(s):* CHE 118B or (CHE 128B, CHE 129A).

*Learning Activities:* Lecture 3 hour(s), Laboratory 3 hour(s).

*Enrollment Restriction(s):* Open to students changing from the CHE 128 course sequence only if they have completed prior organic laboratory work (at least course CHE 129A).

*Credit Limitation(s):* Not open for credit to students who have completed CHE 128C.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Scientific Literacy (SL).

### CHE 121 – Introduction to Molecular Structure & Spectra (4 units)

*Course Description:* Modern theoretical and experimental methods used to study problems of molecular structure and bonding; emphasis on spectroscopic techniques.

*Prerequisite(s):* CHE 110B.

*Learning Activities:* Lecture 4 hour(s).

*Grade Mode:* Letter.

### CHE 122 – Chemistry of Nanoparticles (3 units)

*Course Description:* Chemical and physical aspects of inorganic nanoparticles. Topics include synthesis, structure, colloidal behavior, catalytic activity, size and shape dependency of physical properties, analytical methods and applications.

*Prerequisite(s):* CHE 110C (can be concurrent) or CHE 107B (can be concurrent).

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 124A – Inorganic Chemistry: Fundamentals (3 units)

*Course Description:* Symmetry, molecular geometry and structure, molecular orbital theory of bonding (polyatomic molecules and transition metals), solid state chemistry, energetics and spectroscopy of inorganic compounds.

*Prerequisite(s):* CHE 002C or CHE 002CH or CHE 004C.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

### CHE 124B – Inorganic Chemistry: Main Group Elements (3 units)

*Course Description:* Synthesis, structure and reactivity of inorganic and heteroorganic molecules containing the main group elements.

*Prerequisite(s):* CHE 124A.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 124C – Inorganic Chemistry: D & F Block Elements (3 units)

*Course Description:* Synthesis, structure and reactivity of transition metal complexes, organometallic and bioinorganic chemistry, the lanthanides and actinides.

*Prerequisite(s):* CHE 124A.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 124L – Laboratory Methods in Inorganic Chemistry (2 units)

*Course Description:* The preparation, purification and characterization of main group and transition metal inorganic and organometallic compounds.

*Prerequisite(s):* CHE 124B or CHE 124C (can be concurrent).

*Learning Activities:* Laboratory 6 hour(s).

*Grade Mode:* Letter.

### CHE 125 – Advanced Methods in Physical Chemistry (4 units)

*Course Description:* Advanced theory and laboratory techniques in analytical and physical chemistry. Advanced spectroscopic methods. Thermodynamics. Kinetics. Chemical literature. Digital electronics and computer interfacing. Laboratory measurements and vacuum techniques.

*Prerequisite(s):* CHE 110C (can be concurrent); CHE 115.

*Learning Activities:* Lecture 2 hour(s), Laboratory 6 hour(s).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE); Quantitative Literacy (QL); Writing Experience (WE).

**CHE 128A – Organic Chemistry (3 units)**

*Course Description:* Introduction to the basic concepts of organic chemistry with emphasis on stereochemistry and the chemistry of hydrocarbons. Designed primarily for majors in chemistry. Chemistry majors should enroll in CHE 129A concurrently. May be taught abroad.

*Prerequisite(s):* CHE 002C C or better or CHE 002CH C or better or CHE 004C C- or better.

*Learning Activities:* Lecture 3 hour(s).

*Credit Limitation(s):* Only 2 units credit allowed for students who have completed CHE 008A; not open for credit to students who have completed CHE 008B or 118A.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

**CHE 128B – Organic Chemistry (3 units)**

*Course Description:* Continuation of CHE 128A with emphasis on the chemistry of alcohols, ethers, their sulfur analogs, and carbonyl compounds. Introduction to the application of spectroscopic methods to organic chemistry. Introduction to synthesis of moderately complex organic molecules. May be taught abroad.

*Prerequisite(s):* CHE 128A; or consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Credit Limitation(s):* Full credit to students who completed CHE 008B or CHE 118A; not open for credit to students who have completed CHE 118B.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

**CHE 128C – Organic Chemistry (3 units)**

*Course Description:* Continuation of CHE 128B with emphasis on enolate condensations and the chemistry of amines, phenols, and sugars; selected biologically important compounds. May be taught abroad.

*Prerequisite(s):* CHE 128B.

*Learning Activities:* Lecture 3 hour(s).

*Credit Limitation(s):* Full credit to students who completed CHE 118B; Not open for credit to students who have completed CHE 118C.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

**CHE 129A – Organic Chemistry Laboratory (2 units)**

*Course Description:* Introduction to laboratory techniques of organic chemistry. Emphasis on methods used for separation and purification of organic compounds. May be taught abroad.

*Prerequisite(s):* (CHE 002C C or better or CHE 002CH C or better or CHE 004C C- or better); CHE 128A (can be concurrent).

*Learning Activities:* Lecture 1 hour(s), Laboratory 3 hour(s).

*Credit Limitation(s):* Full credit to students who completed CHE 008B; not open for credit to students who have completed CHE 118B.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

**CHE 129B – Organic Chemistry Laboratory (2 units)**

*Course Description:* Continuation of CHE 129A. Emphasis on methods used for synthesis and isolation of organic compounds.

*Prerequisite(s):* CHE 129A; CHE 128B (can be concurrent).

*Learning Activities:* Laboratory 6 hour(s).

*Credit Limitation(s):* Not open for credit to students who have completed CHE 118C.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

**CHE 129C – Organic Chemistry Laboratory (2 units)**

*Course Description:* continuation of PHE 129B.

*Prerequisite(s):* CHE 128C (can be concurrent); CHE 129B.

*Learning Activities:* Laboratory 6 hour(s).

*Grade Mode:* Letter.

**CHE 130A – Principles of Medicinal Chemistry (3 units)**

*Course Description:* Examination of the design principles and experimental methods used in pharmaceutical and medicinal chemistry. May be taught abroad.

*Prerequisite(s):* CHE 118C or CHE 128C.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 130B – Computational Drug Design (3 units)**

*Course Description:* Continuation of CHE 130A with emphasis on case studies of various drugs and the use of computational methods in drug design. May be taught abroad.

*Prerequisite(s):* CHE 130A (can be concurrent).

*Learning Activities:* Lecture 2 hour(s), Lecture/Lab 1 hour(s).

*Grade Mode:* Letter.

**CHE 130C – Case Studies in Medicinal Chemistry (1 unit)**

*Course Description:* Seminar. Exploration of medicinal and pharmaceutical chemistry topics through seminars presented by professional chemists (and allied professionals). Designed to highlight career opportunities for students with a degree in pharmaceutical chemistry.

*Prerequisite(s):* CHE 130A (can be concurrent); CHE 130B (can be concurrent).

*Learning Activities:* Seminar 2 hour(s), Independent Study.

*Grade Mode:* Pass/No Pass only.

**CHE 131 – Modern Methods of Organic Synthesis (3 units)**

*Course Description:* Introduction to modern synthetic methodology in organic chemistry with emphasis on retrosynthetic analysis, reaction mechanisms, and application to multistep syntheses of pharmaceuticals and natural products.

*Prerequisite(s):* CHE 128C or CHE 118C.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

**CHE 135 – Drug Development Laboratory (3 units)**

*Course Description:* Separation, purification, identification and biological evaluation of organic compounds using modern methods of synthesis, computational chemistry and instrumentation. Emphasis on pharmaceutical and medicinal substances.

*Prerequisite(s):* CHE 130B (can be concurrent).

*Learning Activities:* Lecture 1 hour(s), Laboratory 6 hour(s).

*Grade Mode:* Letter.

**CHE 145 – Good Quality Practices (3 units)**

*Course Description:* Preparation for work in GQP laboratories in both research and industry. Context within GQP-Good Quality Practices (GMP Good Manufacturing Practice, GCP Good Clinical Practices). Lab practice in GQP skills.

*Prerequisite(s):* CHE 118B or CHE 129B.

*Learning Activities:* Discussion 1 hour(s), Laboratory 6 hour(s).

*Enrollment Restriction(s):* Open to Chemistry and science majors.

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

**CHE 150 – Chemistry of Natural Products (3 units)**

*Course Description:* Chemistry of terpenes, steroids, acetogenins, and alkaloids: isolation, structure determination, biosynthesis, chemical transformations, and total synthesis. May be taught abroad.

*Prerequisite(s):* CHE 118C or CHE 128C.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

*General Education:* Science & Engineering (SE).

**CHE 155 – Scientific Programming for Chemistry (3 units)**

*Course Description:* Chemical applications of computer programming with Python. Numpy, Scipy, Matplotlib libraries. Multidimensional arrays, data visualization, linear algebra routines. Force fields and molecular dynamics simulations. Numerical integration of differential equations with applications to chemical kinetics. Least squares fitting of experimental data.

*Prerequisite(s):* ECS 032A recommended.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 168 – Chemical & Engineering Principles in Whisky & Fuel Alcohol Production (3 units)**

*Course Description:* Chemical & engineering principles underlying the manufacture of whisky & fuel alcohol. Biochemistry of malting. Assessment of grain modification & diastatic power, and of the phenol content of peated malt. Lautering as a problem of fluidized bed compaction. Fermentation and its assessment. Fractional distillation and the Rayleigh equation. The fate of congeners in pot and column distillation. Chemical reactions affecting flavor from kilning to maturation.

*Prerequisite(s):* CHE 128A; CHE 128B (can be concurrent); or consent of instructor.

*Learning Activities:* Laboratory 3 hour(s), Discussion 1 hour(s).

*Enrollment Restriction(s):* Limited to students aged 21 years or older; open to seniors in chemical engineering and seniors in chemistry; non-majors require consent of instructor.

*Cross Listing:* ECH 168.

*Grade Mode:* Letter.

**CHE 192 – Internship in Chemistry (1-6 units)**

*Course Description:* Supervised internship in chemistry; requires a final written report.

*Prerequisite(s):* Upper division standing; project approval by faculty sponsor prior to enrollment.

*Learning Activities:* Internship 3-18 hour(s).

*Repeat Credit:* May be repeated 6 unit(s).

*Grade Mode:* Pass/No Pass only.

**CHE 194HA – Undergraduate Honors Research (2 units)**

*Course Description:* Original research under the guidance of a faculty advisor, culminating in the writing of an extensive report.

*Prerequisite(s):* Open only to chemistry majors who have completed 135 units and who qualify for the honors program.

*Learning Activities:* Independent Study 2 hour(s).

*Grade Mode:* Letter.

**CHE 194HB – Undergraduate Honors Research (2 units)**

*Course Description:* Original research under the guidance of a faculty advisor, culminating in the writing of an extensive report.

*Prerequisite(s):* Open only to chemistry majors who have completed 135 units and who qualify for the honors program.

*Learning Activities:* Independent Study 2 hour(s).

*Grade Mode:* Letter.

**CHE 194HC – Undergraduate Honors Research (2 units)**

*Course Description:* Original research under the guidance of a faculty advisor, culminating in the writing of an extensive report.

*Prerequisite(s):* Open only to chemistry majors who have completed 135 units and who qualify for the honors program.

*Learning Activities:* Independent Study 2 hour(s).

*Grade Mode:* Letter.

**CHE 195 – Careers in Chemistry (1 unit)**

*Course Description:* Designed to give Chemistry undergraduate students an in-depth appreciation of career opportunities with a bachelors degree in chemistry. Professional chemists (and allied professionals) describe research and provide career insights.

*Prerequisite(s):* Junior or senior standing in Chemistry.

*Learning Activities:* Seminar 2 hour(s).

*Grade Mode:* Pass/No Pass only.

**CHE 197 – Projects in Chemical Education (1-4 units)**

*Course Description:* Participation may include development of laboratory experiments, lecture demonstrations, autotutorial modules or assistance with laboratory sessions.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Discussion/Laboratory.

*Repeat Credit:* May be repeated 12 unit(s).

*Grade Mode:* Pass/No Pass only.

**CHE 198 – Directed Group Study (1-5 units)**

*Course Description:* Directed group study. May be taught abroad.

*Prerequisite(s):* Consent of instructor based upon adequate preparation in chemistry, mathematics and physics.

*Learning Activities:* Variable.

*Grade Mode:* Pass/No Pass only.

**CHE 199 – Special Study for Advanced Undergraduates (1-5 units)**

*Course Description:* Special study for advanced undergraduates. May be taught abroad.

*Prerequisite(s):* Consent of instructor based upon adequate preparation in chemistry, mathematics, and physics.

*Learning Activities:* Variable.

*Grade Mode:* Pass/No Pass only.

### **CHE 201 – Chemical Uses of Symmetry & Group Theory (3 units)**

*Course Description:* Symmetry elements and operations, point groups, representations of groups. Applications to molecular orbital theory, ligand field theory, molecular vibrations, and angular momentum. Crystallographic symmetry.

*Prerequisite(s):* CHE 124A; CHE 110B; or consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### **CHE 204 – Mathematical Methods in Chemistry (3 units)**

*Course Description:* Introduction to mathematical and numerical methods in chemistry. Real and complex functions. Methods of integration. Differential equations. Linear algebra and matrices. Special functions. Integral transforms. Statistics.

*Prerequisite(s):* CHE 110C.

*Learning Activities:* Lecture 3 hour(s).

*Enrollment Restriction(s):* Graduate standing in Chemistry.

*Grade Mode:* Letter.

### **CHE 205 – Symmetry, Spectroscopy, & Structure (3 units)**

*Course Description:* Vibrational and rotational spectra; electronic spectra and photoelectron spectroscopy; magnetism; electron spin and nuclear quadrupole resonance spectroscopy; nuclear magnetic resonance spectroscopy; other spectroscopic methods.

*Prerequisite(s):* CHE 201; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### **CHE 209 – Special Topics in Physical Chemistry (3 units)**

*Course Description:* Advanced topics in physical chemistry, biophysical chemistry or chemical physics chosen from areas of current research interest.

*Prerequisite(s):* CHE 210A; CHE 211A.

*Learning Activities:* Lecture 3 hour(s).

*Enrollment Restriction(s):* Graduate standing in Chemistry.

*Repeat Credit:* May be repeated when topics differ.

*Grade Mode:* Letter.

### **CHE 210A – Quantum Chemistry: Introduction & Stationary-State Properties (3 units)**

*Course Description:* Stationary-state quantum chemistry: postulates of quantum mechanics, simple solutions, central field problems and angular momenta, hydrogen atom, perturbation theory, variational theory, atoms and molecules.

*Prerequisite(s):* CHE 110B; CHE 110C; or consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### **CHE 210B – Quantum Chemistry: Time-Dependent Systems (3 units)**

*Course Description:* Matrix mechanics and time-dependent quantum chemistry: matrix formulation of quantum mechanics, Heisenberg representation, time-dependent perturbation theory, selection rules, density matrices, and miscellaneous molecular properties.

*Prerequisite(s):* CHE 210A.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### **CHE 210C – Quantum Chemistry: Molecular Spectroscopy (3 units)**

*Course Description:* Molecular spectroscopy: Born-Oppenheimer approximation, rotational, vibrational and electronic spectroscopy, spin systems, and molecular photophysics.

*Prerequisite(s):* CHE 210B.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### **CHE 211A – Advanced Physical Chemistry: Statistical Thermodynamics (3 units)**

*Course Description:* Principles and applications of statistical mechanics; ensemble theory; statistical thermodynamics of gases, solids, liquids, electrolyte solutions and polymers; chemical equilibrium.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### **CHE 211B – Statistical Mechanics (3 units)**

*Course Description:* Statistical mechanics of nonequilibrium systems, including the rigorous kinetic theory of gases, continuum mechanics transport in dense fluids, stochastic processes, brownian motion and linear response theory.

*Prerequisite(s):* CHE 211A.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### **CHE 212 – Chemical Dynamics (3 units)**

*Course Description:* Introduction to modern concepts in chemical reaction dynamics for graduate students in chemistry. Emphasis will be placed on experimental techniques as well as emerging physical models for characterizing chemical reactivity at a microscopic level.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### **CHE 215 – Theoretical & Computational Chemistry (3 units)**

*Course Description:* Mathematics of wide utility in chemistry, computational methods for guidance or alternative to experiment, and modern formulations of chemical theory. Emphasis will vary in successive years.

*Prerequisite(s):* CHE 211A; CHE 210B; or consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Repeat Credit:* May be repeated.

*Grade Mode:* Letter.



**CHE 216 – Magnetic Resonance Spectroscopy (3 units)**

*Course Description:* Quantum mechanics of spin and orbital angular momentum, nuclear magnetic resonance, theory of chemical shift and multiplet structures, electron spin resonance, theory of g-tensor in organic and transition ions, spin Hamiltonians, nuclear quadrupolar resonance, spin relaxation processes.

*Prerequisite(s):* CHE 210A; CHE 210B (can be concurrent).

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 217 – X-Ray Structure Determination (3 units)**

*Course Description:* Introduction to x-ray structure determination; crystals, symmetry, diffraction geometry, sample preparation and handling, diffraction apparatus and data collection, methods of structure solution and refinement, presentation of results, text, tables and graphics, crystallographic literature.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 218 – Macromolecules: Physical Principles (3 units)**

*Course Description:* Relationship of higher order macromolecular structure to subunit composition; equilibrium properties and macromolecular dynamics; physical chemical determination of macromolecular structure.

*Prerequisite(s):* CHE 110A; CHE 110B; CHE 110C; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 219 – Spectroscopy of Organic Compounds (3 units)**

*Course Description:* Identification of organic compounds and investigation of stereochemical and reaction mechanism phenomena using spectroscopic methods—principally NMR, IR and MS.

*Prerequisite(s):* CHE 128C; or equivalent.

*Learning Activities:* Lecture 3 hour(s), Laboratory 2.50 hour(s).

*Grade Mode:* Letter.

**CHE 219L – Laboratory in Spectroscopy of Organic Compounds (1 unit)**

*Course Description:* Practical application of NMR, IR and MS techniques for organic molecules.

*Prerequisite(s):* CHE 219 (can be concurrent).

*Learning Activities:* Laboratory 2.50 hour(s).

*Enrollment Restriction(s):* Restricted to Chemistry graduate students only or consent of instructor.

*Grade Mode:* Letter.

**CHE 221A – Special Topics in Organic Chemistry (3 units)**

*Course Description:* Selected topics of current interest in organic chemistry. Topics will vary each time the course is offered, and in general will emphasize the research interests of the staff member giving the course.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 221B – Special Topics in Organic Chemistry (3 units)**

*Course Description:* Selected topics of current interest in organic chemistry. Topics will vary each time the course is offered, and in general will emphasize the research interests of the staff member giving the course.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 221C – Special Topics in Organic Chemistry (3 units)**

*Course Description:* Selected topics of current interest in organic chemistry. Topics will vary each time the course is offered, and in general will emphasize the research interests of the staff member giving the course.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 221D – Special Topics in Organic Chemistry (3 units)**

*Course Description:* Selected topics of current interest in organic chemistry. Topics will vary each time the course is offered, and in general will emphasize the research interests of the staff member giving the course.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 221E – Special Topics in Organic Chemistry (3 units)**

*Course Description:* Selected topics of current interest in organic chemistry. Topics will vary each time the course is offered, and in general will emphasize the research interests of the staff member giving the course.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 221F – Special Topics in Organic Chemistry (3 units)**

*Course Description:* Selected topics of current interest in organic chemistry. Topics will vary each time the course is offered, and in general will emphasize the research interests of the staff member giving the course.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 221G – Special Topics in Organic Chemistry (3 units)**

*Course Description:* Selected topics of current interest in organic chemistry. Topics will vary each time the course is offered, and in general will emphasize the research interests of the staff member giving the course.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 221H – Special Topics in Organic Chemistry (3 units)**

*Course Description:* Selected topics of current interest in organic chemistry. Topics will vary each time the course is offered, and in general will emphasize the research interests of the staff member giving the course.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 222 – Chemistry of Nanoparticles (3 units)**

*Course Description:* Chemical and physical aspects of inorganic nanoparticles, including synthesis, purification, reactivity, characterization, and applications for technology. Emphasis is on problems from the current literature.

*Prerequisite(s):* CHE 110C; or equivalent.

*Learning Activities:* Lecture/Discussion 3 hour(s).

*Credit Limitation(s):* Not open for credit to students who have taken CHE 122.

*Grade Mode:* Letter.

**CHE 226 – Principles of Transition Metal Chemistry (3 units)**

*Course Description:* Electronic structures, bonding, and reactivity of transition metal compounds.

*Prerequisite(s):* CHE 124A; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 228A – Bio-inorganic Chemistry (3 units)**

*Course Description:* Defines role of inorganic chemistry in the functioning of biological systems by identifying the functions of metal ions and main group compounds in biological systems and discussing the chemistry of model and isolated biological compounds. Offered every third year.

*Prerequisite(s):* CHE 226; or consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 228B – Main Group Chemistry (3 units)**

*Course Description:* Synthesis, physical properties, reactions and bonding of main group compounds. Discussions of concepts of electron deficiency, hypervalency, and non-classical bonding. Chemistry of the main group elements will be treated systematically. Offered every third year.

*Prerequisite(s):* CHE 226; or consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 228C – Solid-State Chemistry (3 units)**

*Course Description:* Design and synthesis, structure and bonding of solid-state compounds; physical properties and characterization of solids; topics of current interest such as low-dimensional materials, inorganic polymers, materials for catalysis. Offered every third year.

*Prerequisite(s):* CHE 124A; CHE 110B; CHE 226; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 228D – Homogeneous Catalysis (3 units)**

*Course Description:* Overview of homogeneous catalysis and related methods, with emphasis on kinetics, mechanisms, and applications for organic synthesis. The related methods may include cluster, colloid, phase transfer, enzymatic, heterogeneous and polymer-supported catalysis. Offered every third year.

*Prerequisite(s):* CHE 226.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 228E – Magnetochemistry (3 units)**

*Course Description:* Covers the basic principles and concepts of magnetism, methods used for characterization of magnetic properties, as well as specific state-of-the-art magnetic materials and topics from the recent chemistry literature.

*Prerequisite(s):* CHE 124A or CHE 201; or an equivalent class from either Physics or Chemical Engineering and Materials Science.

*Learning Activities:* Lecture 2 hour(s), Discussion 1 hour(s).

*Grade Mode:* Letter.

**CHE 231A – Organic Synthesis: Methods & Strategies (4 units)**

*Course Description:* Current strategies and methods in synthetic organic chemistry. Focus on construction of carbon frameworks, control of relative and absolute stereochemistry and retrosynthetic strategies. Use of databases and molecular modeling software in multistep strategies.

*Prerequisite(s):* CHE 128C; or equivalent.

*Learning Activities:* Lecture 3 hour(s), Discussion/Laboratory 3 hour(s).

*Grade Mode:* Letter.

**CHE 231B – Advanced Organic Synthesis (3 units)**

*Course Description:* Current strategies and methods in synthetic organic chemistry. Continuation of CHE 231A. Organic synthesis of complex target molecules. Stereochemical considerations and asymmetric synthesis. Organometallics for selective transformations. Carbocyclic and heterocyclic ring formation.

*Prerequisite(s):* CHE 231A.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 233 – Physical-Organic Chemistry (3 units)**

*Course Description:* Introduction to elementary concepts in physicalorganic chemistry including the application of simple numerical techniques in characterizing and modeling organic reactions.

*Prerequisite(s):* CHE 128A; CHE 128B; CHE 128C; CHE 110A; CHE 110B; CHE 110C; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

**CHE 234 – Chemical & Molecular Neuroscience (3 units)**

*Course Description:* Basic principles in chemistry and molecular biology applied to questions in neuroscience. Chemical and molecular tools driving innovative work in chemical and molecular biology.

*Prerequisite(s):* CHE 128C; BIS 102; or equivalent courses.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 235 – Organometallic Chemistry in Organic Synthesis (3 units)

*Course Description:* Current trends in use of organometallics for organic synthesis; preparations, properties, applications, and limitations of organometallic reagents derived from transition and/or main group metals.

*Prerequisite(s):* CHE 128C.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 236 – Chemistry of Natural Products (3 units)

*Course Description:* Advanced treatment of chemistry of naturally occurring compounds isolated from a variety of sources. Topics will include isolation, structure determination, chemical transformations, total synthesis, biological activity, and biosynthesis. Biosynthetic origin will be used as a unifying theme.

*Prerequisite(s):* CHE 128C; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 237 – Bio-Organic Chemistry (3 units)

*Course Description:* Structure and function of biomolecules; molecular recognition; enzyme reaction mechanisms; design of suicide substrates for enzymes; enzyme engineering; design of artificial enzymes and application of enzymes in organic synthesis.

*Prerequisite(s):* Graduate standing in Chemistry or consent of instructor.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 238 – Introduction to Chemical Biology (3 units)

*Course Description:* Synthesis of complex molecules in nature. Use of biosynthetic pathways in synthesis of new chemical entities. Applications of small molecules in chemical genetics and structural biology. Solving biological problems using synthetic biomolecules.

*Prerequisite(s):* CHE 118C or CHE 128C; or equivalent; CHE 130A, CHE 130B and BIS 102, BIS 103, and BIS 104, or the equivalents recommended.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 240 – Advanced Analytical Chemistry (3 units)

*Course Description:* Numerical treatment of experimental data; thermodynamics of electrolyte and non-electrolyte solutions; complex equilibria in aqueous and non-aqueous solutions; potentiometry and specific ion electrodes; mass transfer in liquid solutions; fundamentals of separation science, including column, gas and liquid chromatography.

*Prerequisite(s):* CHE 110A; CHE 115; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 241A – Surface Analytical Chemistry (3 units)

*Course Description:* Concepts of surfaces and interfaces: physical properties, unique chemistry and electronic effects. Focus on gas-solid interfaces, with some discussion of liquid-solid interfaces.

*Prerequisite(s):* CHE 110C; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 241B – Laser & X-ray Spectroscopy (3 units)

*Course Description:* Concepts and mechanisms of light-matter interactions. Chemical applications of modern spectroscopic methods, including multiphoton spectroscopy, time-resolved laser and x-ray photolysis, and phase-contrast x-ray imaging.

*Prerequisite(s):* CHE 110B; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Repeat Credit:* May be repeated.

*Grade Mode:* Letter.

### CHE 241C – Mass Spectrometry (3 units)

*Course Description:* Mass spectrometry and related methods with emphasis on ionization methods, mass analyzers, and detectors. Related methods may include ion-molecule reactions, unimolecular dissociation of organic and bio-organic compounds, and applications in biological and environmental analysis.

*Prerequisite(s):* CHE 110C; CHE 115; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 241D – Electroanalytical Chemistry (3 units)

*Course Description:* Electroanalytical chemistry with consideration of mass transfer and electrode kinetics for polarizable electrodes. Current-potential curves for a variety of conditions, including both potentiostatic and galvanostatic control, and their application in chemical analysis.

*Prerequisite(s):* CHE 110C; CHE 115; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 241E – Microscopy & Imaging Techniques (3 units)

*Course Description:* Introduction to modern microscopy and imaging techniques: scanning tunneling, atomic force, far-field optical, fluorescence, scanning near-field optical, and scanning electron microscopy. Application to nanoscience and analytical and bioanalytical chemistry. Some laboratory demonstrations.

*Prerequisite(s):* CHE 110C; CHE 115; or equivalent.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 245 – Mechanistic Enzymology (3 units)

*Course Description:* Advanced topics in chemical kinetics relevant to enzymes, enzyme kinetics, theory of enzyme catalysis, and the analysis of a selection of organic enzyme reaction mechanisms by the tools introduced in the first part of the course.

*Learning Activities:* Lecture 3 hour(s).

*Grade Mode:* Letter.

### CHE 261 – Current Topics in Chemical Research (2 units)

*Course Description:* Designed to help chemistry graduate students develop and maintain familiarity with the current and past literature in their immediate field of research and related areas.

*Prerequisite(s):* Graduate standing in Chemistry or consent of instructor.

*Learning Activities:* Lecture 2 hour(s).

*Repeat Credit:* May be repeated when topic differs.

*Grade Mode:* Letter.

**CHE 262 – Introduction to Chemistry Research (1 unit)**

*Course Description:* Group and individual discussion of research activities in the Department and research topic selection. Designed for incoming graduate students preparing for higher degrees in chemistry.

*Learning Activities:* Lecture/Discussion 2 hour(s).

*Enrollment Restriction(s):* Pass One restricted to graduate students; Pass Two open to all majors.

*Grade Mode:* Satisfactory/Unsatisfactory only.

**CHE 263 – Introduction to Chemical Research Methodology (3 units)**

*Course Description:* Introduction to identification, formulation, and solution of meaningful scientific problems including experimental design and/or theoretical analyses of new and prevailing techniques, theories and hypotheses. May be repeated for credit when topic differs.

*Prerequisite(s):* CHE 293; and consent of instructor; graduate student standing in Chemistry.

*Learning Activities:* Discussion/Laboratory 9 hour(s).

*Grade Mode:* Satisfactory/Unsatisfactory only.

**CHE 264 – Advanced Chemical Research Methodology (6 units)**

*Course Description:* Applications of the methodology developed in CHE 263 to experimental and theoretical studies. Advanced methods of interpretation of results are developed. Includes the preparation of manuscripts for publication.

*Prerequisite(s):* CHE 263; or consent of instructor.

*Learning Activities:* Discussion/Laboratory 18 hour(s).

*Repeat Credit:* May be repeated when topic differs.

*Grade Mode:* Satisfactory/Unsatisfactory only.

**CHE 290 – Seminar (2 units)**

*Course Description:* Seminar.

*Prerequisite(s):* Consent of instructor.

*Learning Activities:* Seminar 2 hour(s).

*Grade Mode:* Satisfactory/Unsatisfactory only.

**CHE 294 – Presentation of Chemistry Research (1 unit)**

*Course Description:* Introduces first- and second-year Chemistry graduate students to the process of giving an effective research presentation. Advanced Ph.D. students give formal seminars describing the design and execution of their research projects.

*Prerequisite(s):* Graduate standing.

*Learning Activities:* Seminar 2 hour(s).

*Enrollment Restriction(s):* Restricted to graduate students in Chemistry who have not yet given their departmental presentation.

*Repeat Credit:* May be repeated 3 time(s).

*Grade Mode:* Satisfactory/Unsatisfactory only.

**CHE 295 – Careers in Chemistry (1 unit)**

*Course Description:* Designed to give Chemistry graduate students an in-depth appreciation of career opportunities with a M.S. or Ph.D. degree in chemistry. Professional chemists (and allied professionals) give seminars describing both research and career insights.

*Prerequisite(s):* Graduate standing in Chemistry.

*Learning Activities:* Seminar 2 hour(s).

*Repeat Credit:* May be repeated 3 time(s).

*Grade Mode:* Satisfactory/Unsatisfactory only.

**CHE 296 – Research in Pharmaceutical Chemistry (6 units)**

*Course Description:* Laboratory provides qualified graduate students with the opportunity to pursue original investigation in Pharmaceutical Chemistry and allied fields in order to fulfill the letter-graded research requirement of the Integrated B.S./M.S. Program in Chemistry (Pharmaceutical Chemistry Emphasis).

*Prerequisite(s):* CHE 130A; CHE 130B; CHE 135; CHE 233 (can be concurrent); and consent of instructor.

*Learning Activities:* Laboratory 18 hour(s).

*Enrollment Restriction(s):* Restricted to students in the Integrated B.S./M.S. Program in Chemistry.

*Repeat Credit:* May be repeated 3 time(s) when topic differs.

*Grade Mode:* Letter.

**CHE 298 – Group Study (1-5 units)**

*Course Description:* Group study.

*Learning Activities:* Variable.

*Grade Mode:* Letter.

**CHE 299 – Research (1-12 units)**

*Course Description:* The laboratory is open to qualified graduate students who wish to pursue original investigation. Students wishing to enroll should communicate with the department well in advance of the quarter in which the work is to be undertaken.

*Learning Activities:* Variable.

*Grade Mode:* Satisfactory/Unsatisfactory only.

**CHE 390 – Methods of Teaching Chemistry (2 units)**

*Course Description:* Practical experience in methods and problems of teaching chemistry. Includes analyses of texts and supporting material, discussion of teaching techniques, preparing for and conducting of discussion sessions and student laboratories. Participation in the teaching program required for Ph.D. in chemistry.

*Prerequisite(s):* Consent of instructor; graduate student standing in Chemistry.

*Learning Activities:* Lecture 1 hour(s), Discussion 1 hour(s).

*Repeat Credit:* May be repeated.

*Grade Mode:* Satisfactory/Unsatisfactory only.

**CHE 392 – Advanced Methods of Teaching Chemistry (2 units)**

*Course Description:* Advanced topics in teaching chemistry. Analysis and discussion of curricular design, curricula materials, teaching methods and evaluation. For students who are planning a career in teaching chemistry.

*Prerequisite(s):* CHE 390.

*Learning Activities:* Lecture 2 hour(s).

*Grade Mode:* Satisfactory/Unsatisfactory only.