

# CHEMISTRY (CHEM)

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## CHEM 500

### Advanced Analytical Chemistry

An overview of analytical chemistry with discussions of complex ionic equilibria, electro analytical techniques including potentiometric, voltametric, coulometric and conductometric methods, ion chromatography, capillary electrophoresis and sensor technology.

**Lecture: 3 Lab: 0 Credits: 3**

## CHEM 501

### Capstone Project

This course will educate students in the area of quality process and quality manufacturing. Student will work with the instructor to plan and conduct research on a project that is relevant to the analytical chemistry program of study. The project must be approved by the Master of Chemistry in Analytical Program Director.

**Lecture: 1 Lab: 3 Credits: 2**

## CHEM 503

### Survey of Analytical Chemistry

This course covers modern aspects of chemical analysis. It is designed to give the student a solid conceptual ground to understand how a given analytical technique works including its limits and advantages. The emphasis is on solutions analysis and the course is roughly divided into: (i) Basic measurements and concepts; (ii) spectroscopy; and (iii) chromatography and mass spectrometry. Upon completion of this course, the student will be able to: describe the basic setup and operation of separation, mass spectrometric, and spectroscopic instrumentation; interpret spectra from various instruments as a means for qualitative and quantitative analysis; apply basic knowledge of separation technique, mass spectrometry, and spectroscopy for practical problem solving; relate the use of separation technique, mass spectrometry, and spectroscopy to his or her own research interests; and compile, present, and explain modern techniques for analytical research. Topics includes high-performance liquid chromatography, gas chromatography, atomic spectrometry, molecular spectrometry, UV/vis spectrometry, molecular luminescence, infrared spectrometry, mass spectrometry, radio chemistry, raman spectrometry, nuclear magnetic resonance spectrometry, etc.

**Lecture: 3 Lab: 0 Credits: 3**

## CHEM 505

### Spectroscopic Methods I

Theories of spectroscopic transitions and their applications in structural elucidations and quantitative analysis. Topics include ultraviolet/visible, infrared, Raman and nuclear magnetic resonance spectroscopy and mass spectrometry.

**Lecture: 3 Lab: 0 Credits: 3**

## CHEM 506

### Sampling and Sample Preparation

Techniques and devices for sampling in diverse media will be treated, followed by a discussion of sample treatment prior to analysis including isolation, concentration, and fractionation of analytes and classes of analytes.

**Lecture: 3 Lab: 0 Credits: 3**

## CHEM 508

### Analytical Methods Development

A seminar course presenting analytical methods in complex matrices with emphasis on methods development and validation.

**Lecture: 2 Lab: 0 Credits: 2**

## CHEM 509

### Physical Methods of Characterization

A survey of physical methods of characterization including x-ray diffraction and fluorescence surface techniques including SEM, TEM, AES and ESCA, thermal methods and synchrotron radiation methods.

**Lecture: 3 Lab: 0 Credits: 3**

## CHEM 510

### Electronics and Interfacing

Elementary circuit analysis, operational amplifiers, digital electronics, signal processing and interfacing of instruments using modern computer software and hardware.

**Lecture: 2 Lab: 0 Credits: 2**

## CHEM 512

### Spectroscopic Methods II

A continuation of the study of optical methods covering atomic absorption spectroscopy, atomic and flame emission spectroscopy, chemiluminescence, fluorescence, phosphorescence, light scattering and refractometry.

**Lecture: 2 Lab: 0 Credits: 2**

## CHEM 513

### Chemometrics and Statistics in Chemistry

This course is carefully designed to provide a vigorous training on statistical methods to graduate students and industry professionals for analysis of real life projects so they can function effectively as part of an innovative and scientific community. The topics include, but not limited to, advanced error analysis, statistical inference, hypothesis testing, probability density functions, sampling estimation, applied regression and multivariable methods, non-parametric analysis, outlier identification methods, and optimization and experimental design. In this course, an advanced statistical software program is introduced with example problems for comprehensive analysis of data and interpretation of the results. The course also discusses various topics for scientific interpretation of data set for chemical, environmental, and biological engineering disciplines.

**Lecture: 3 Lab: 0 Credits: 3**

## CHEM 515

### Gas Chromatography -- Theory and Practice

This course will cover theory and concepts of gas chromatographic analysis and its practical application in solving analytical problems. Topics include basic theory of chromatographic separation, separation dynamics, instrumentation, column selection, quantitative techniques, and practical applications.

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 516****Liquid Chromatography -- Theory and Practice**

This course will cover the operating principles and applications of state-of-the-art LC/HPLC instrumentation and analysis. Topics include basic theory of liquid chromatography, instrumentation, optimization of LC separation, quantitative techniques, and the diverse range of analytical applications amenable to LC analysis.

**Prerequisite(s):** CHEM 515 with min. grade of C

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 518****Understanding the International Conference on Harmonization Guidelines**

The International Conference on Harmonization (ICH) was revolutionized in the 1980's to provide a forum for the pharmaceutical industry to discuss regulatory requirements for registration of new chemical entity. These guidelines have been significantly influenced the content of FDA draft guidelines to develop the scientific information and manufacturing controls. Thus, proper understanding of these guidelines is essential in the drug development process. This course will be designed to focus exclusively on guidelines associated with the registration of small molecules. Completing this course, students will understand the expectations set forth in various FDA and ICH quality topics in order to implement these guidelines and/or engage the regulatory agencies in dialogue in order to provide justification of data or present clear scientific rationale.

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 519****Good Manufacturing Practices**

This course provides an introduction to current good manufacturing practices (GMP) regulations and their implementation to different areas of the manufacturing process such as laboratory records, equipment, personnel, facilities, etc. The course will help students to recognize the regulatory actions and financial risks for non-compliance.

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 520****Advanced Inorganic Chemistry**

Selective treatment of the chemistries of main group and transition elements with emphasis on coordination complexes, organometallic compounds and inorganic cages and clusters. Discussions of molecular symmetry, stereochemistry, bonding, electronic spectra, magnetic properties, reactions, kinetics and reaction mechanisms are included.

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 521****Structural Inorganic and Materials Chemistry**

This course covers structure and bonding and structure-property relationships in inorganic molecules and solids. Descriptions of crystal structures, spectroscopic and x-ray diffraction techniques for structure determination and properties of solids are included.

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 522****Efficient Chemical and Materials Synthesis**

The design and development of environmentally benign chemical pathways: challenges and opportunities. High-yield and zero-waste chemical processes. Representative processes.

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 524****Synthesis and Intellectual Property Management**

This course focuses on the management of intellectual property. Professionals will lead discussions on the control and dissemination of materials concerning intellectual property. This will be combined with the technical presentations by the students in the classroom. Topics of discussion will include invention disclosures, intellectual property rights, proprietary materials, justification for patents, types of patents, the terms of a patent, patents procedure, licensing procedure and security considerations. Access to patented materials and disclosure of materials under patent process will be covered.

**Lecture: 2 Lab: 0 Credits: 2**

**CHEM 526****Graduate Chemistry Laboratory**

An advanced laboratory with emphasis on synthesis and characterization of inorganic and organometallic compounds.

**Lecture: 1 Lab: 7 Credits: 3**

**CHEM 530****Organic Reaction Mechanisms**

A study of important mechanism classes and their relationship to the major reactions of organic chemistry. Emphasis will be placed on the study of reaction intermediates and on the methods used to characterize reaction pathways. Topics will include chemical bonding, aromaticity, stereochemistry, substitution, elimination, carbanion chemistry, free radical reactions, photochemistry and concerted reactions.

**Prerequisite(s):** CHEM 455 with min. grade of C

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 531****Tactics in Organic Synthesis**

A study of modern synthetic strategies used in the preparation of complex organic molecules. Synthetic planning using the disconnection approach and the selection of reagents to solve regiochemical and stereochemical problems will be the underlying themes. Synthetic strategies to be discussed include tandem reactions, template and chelation effects, biomimetic tactics and the use of chiral terpenes, carbohydrates and amino acids in enantioselective syntheses. Target molecules will include natural products, pharmaceuticals and smart organic materials.

**Prerequisite(s):** CHEM 530 with min. grade of C

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 534****Advanced Spectroscopic Methods**

Characterization and analysis by mass, vibrational, nuclear magnetic resonance, and electronic spectroscopy. Structure spectra correlations applied to organic and inorganic compounds with examples drawn from diverse areas, e.g., pollutants, toxic materials, polymers, etc.

**Lecture: 3 Lab: 4 Credits: 4**

**CHEM 535****Polymer Synthesis**

This course will cover the basics of polymer synthesis including traditional polymerization techniques, such as free-radical and ionic chain polymerizations, and step-growth polymerization. Newer methods of polymer synthesis, such as ring-opening metathesis and controlled free-radical polymerizations, will also be discussed. Students will be introduced to the methods of preparation of advanced polymer structures, such as block, star and brush copolymers, dendrimers, and hyperbranched polymers.

**Prerequisite(s):** CHEM 239 with min. grade of C

**Lecture:** 3 **Lab:** 0 **Credits:** 3

**CHEM 537****Polymer Chemistry Laboratory**

This course will include the synthesis of a variety of polymers and their characterization using instrumental methods. Emphasis will be placed on factors that control polymer formation, methods for obtaining molecular weights and distributions of polymers, as well as thermal and mechanical characteristics of polymers.

**Prerequisite(s):** CHEM 470 with min. grade of C

**Lecture:** 1 **Lab:** 6 **Credits:** 3

**CHEM 538****Physical Biochemistry**

The course will cover the principles and techniques of physical chemistry applied to biological macromolecules. Topical concepts include thermodynamics, kinetics, and quantum chemistry. Applications to areas such as interpretation of entropy and enthalpy driven processes, biochemical equilibrium, phase transitions in lipid, bilayers and membranes, enzyme kinetics, intra- and intermolecular interactions, and spectroscopy of proteins and nucleic acids will be introduced.

**Prerequisite(s):** CHEM 239 with min. grade of C and CHEM 344 with min. grade of C

**Lecture:** 3 **Lab:** 0 **Credits:** 3

**CHEM 539****Introduction to Pharmaceutical Chemistry**

Fundamental concepts will be discussed, including modern principles of drug design; drug absorption, distribution and metabolism; theories of drug-receptor interactions; approaches to structure-activity relationships; chemical, physicochemical and structural considerations. The various classes of therapeutic agents will be surveyed with emphasis on possible modes of action. Methods of synthesis will be considered.

**Prerequisite(s):** CHEM 239 with min. grade of C

**Lecture:** 3 **Lab:** 0 **Credits:** 3

**CHEM 542****Polymer Characterization and Analysis**

This course will provide an overview of the common techniques for polymer characterization, studying structure-property relationships, and polymer morphology. The course will focus on thermal and mechanical characterization of polymers as well as polymer rheology. Examples and uses of major commercial polymers and advanced functional polymers will be introduced.

**Lecture:** 3 **Lab:** 0 **Credits:** 3

**CHEM 543****Analytical Chemistry in Pharmaceutical Laboratories**

This course is designed to compliment the current curriculum of the professional master degree in analytical chemistry. It is a review of the requirements a student may face as a professional chemist in a regulated industry. The course focus is on the requirements and common topics facing today's pharmaceutical industry. While individual agencies have specific regulations, the fundamental ideas of these regulations are largely consistent across the board. For example, an analytical chemist versed in Good Laboratory Practices (GLP) under FDA can quickly pick up the GLP's required by EPA.

**Lecture:** 2 **Lab:** 0 **Credits:** 2

**CHEM 544****Colloids and Colloid Analysis**

This course will begin a general overview of colloid science. This part of the course will introduce various types of colloids, touch on factors and conditions leading to their stability or instability, consider their evolution and will include a very limited discussion of the conditions under which they can form. The second part of the course will consist of a series of discussions of specific analytical techniques used to characterize colloidal systems, with particular emphasis on the physical characterization of the dispersed phase.

**Lecture:** 2 **Lab:** 0 **Credits:** 2

**CHEM 548****Electrochemical Methods**

Thermodynamics and potential, charge-transfer kinetics and mass transfer. Potential step and potential sweep methods, including hydrodynamic methods. Bulk electrolysis methods. Electrode reactions coupled with homogeneous chemical reactions. Double-layer structure and adsorbed intermediates in electrode processes. Digital simulation of electrochemical processes. Students are expected to have some background in the physical chemistry of solutions and electroanalytical chemistry at the level of CHEM 500.

**Lecture:** 3 **Lab:** 0 **Credits:** 3

**CHEM 550****Chemical Bonding**

Review of the postulatory basis of quantum mechanics and application to 1-D and 3-D systems. Hydrogenic and symmetry-adapted spin orbitals and bond formation. Ground and excited states. Commonly used semiempirical molecular orbital methods.

**Prerequisite(s):** CHEM 344 with min. grade of C

**Lecture:** 3 **Lab:** 0 **Credits:** 3

**CHEM 552****Chemical Kinetics**

Types of reactions, reaction order, activation energy, transition states, isotope effects and the mechanism of reactions. Determination of the rates of free radical reactions. Primary processes in thermal, photochemical and other radiation-induced reactions.

**Prerequisite(s):** CHEM 553 with min. grade of C and CHEM 550 with min. grade of C

**Lecture:** 3 **Lab:** 0 **Credits:** 3

**CHEM 553****Chemical Statistical Thermodynamics and Molecular Simulation**

Statistical interpretation of the fundamental properties and laws of thermodynamics. Ensembles, partition functions, and principles of molecular simulation. Applications to chemical and phase equilibria including case studies from contemporary literature.

**Prerequisite(s):** CHEM 343 with min. grade of C and CHEM 344 with min. grade of C

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 560****Advanced Chemistry Projects**

Advanced chemistry projects to be carried out under the direction of a faculty member. These projects may involve computational, theoretical, experimental work or a combination of these. Projects based on experimental work may be carried out in the research lab of the instructor. Topics of the advanced projects will be selected by the faculty member offering the course and will not necessarily be related to the dissertation topic of the student. May be taken more than once and up to 12 credit hours.

**Credit: Variable**

**CHEM 561****Laboratory Rotations**

This course requires each student to complete research rotations in three different laboratories, 4 weeks in each lab. It allows students to explore various areas of chemical research before committing to a single lab to conduct thesis research. The course intends to give students an opportunity to learn what research topics excite them, what techniques they favor and what lab environment is a good fit. At the same time, rotations provide faculty the mechanism for evaluating students as candidates to join their lab. Submission of a report is required upon the completion of each rotation.

**Lecture: 0 Lab: 9 Credits: 3**

**CHEM 584****Graduate Seminar in Chemistry**

To foster scientific communications skills, students are required to present seminars based on the scientific literature. Required of all first year M.S. and PhD students.

**Lecture: 0 Lab: 1 Credits: 1**

**CHEM 585****Chemistry Colloquium**

Lectures by invited scientists in areas of chemistry generally not covered in the department. Must be taken two time by M.S. students and four time by PhD. students.

**Lecture: 0 Lab: 1 Credits: 1**

**CHEM 591****Research and Thesis**

(Credit: Variable)

**Credit: Variable**

**CHEM 594****Special Problems**

Designed for non-thesis M.S. only. (Credit: Variable)

**Credit: Variable**

**CHEM 596****Chemistry for Teachers-Elementary**

Certification as chemistry teacher or approval of instructor. An in-service workshop for pre-college teachers emphasizing the phenomenological approach to the teaching of chemical science. (Credit: variable)

**Credit: Variable**

**CHEM 597****Reading and Special Problems**

Independent study to meet the special needs of graduate students in department-approved graduate degree programs. Requires the written consent of the instructor. May be taken more than once. Receives a letter grade. (Credit: Variable)

**Credit: Variable**

**CHEM 598****Chemistry for High School Teachers**

Certification as teacher or approved of instructor. An in-service workshop for pre-college teachers emphasizing the phenomenological approach to teaching of chemical science at the high school level. (Credit: variable)

**Credit: Variable**

**CHEM 600****Continuation of Residence**

**Lecture: 0 Lab: 0 Credits: 1**

**CHEM 610****Special Topics in Analytical Chemistry**

Topics of current interest in analytical chemistry including advanced electro-chemistry, surface spectroscopy of electrode surfaces, separations, laboratory automation and new spectroscopic techniques.

**Lecture: 2 Lab: 0 Credits: 2**

**CHEM 611****Special Topics in Analytical Chemistry**

Topics of current interest in analytical chemistry including advanced electro-chemistry, surface spectroscopy of electrode surfaces, separations, laboratory automation and new spectroscopic techniques.

**Lecture: 2 Lab: 0 Credits: 2**

**CHEM 620****Special Topics in Inorganic Chemistry**

Topics of current interest in inorganic chemistry, including organometallic chemistry, homogeneous catalysis, inorganic reaction mechanisms, inorganic stereochemistry, materials chemistry, x-ray crystallography, synthetic and physical methods in inorganic and materials chemistry and chemical applications of group theory.

**Lecture: 2 Lab: 0 Credits: 2**

**CHEM 621****Special Topics in Inorganic Chemistry**

Topics of current interest in inorganic chemistry, including organometallic chemistry, homogeneous catalysis, inorganic reaction mechanisms, inorganic stereochemistry, materials chemistry, x-ray crystallography, synthetic and physical methods in inorganic and materials chemistry and chemical applications of group theory.

**Lecture: 2 Lab: 0 Credits: 2**

**CHEM 630****Special Topics in Organic Chemistry**

Topics of current interest in organic chemistry including photochemistry, fluorine chemistry, heterocyclic chemistry, pharmaceutical chemistry and electro optical organic chemistry.

**Prerequisite(s):** CHEM 455 with min. grade of C

**Lecture: 2 Lab: 0 Credits: 2**

**CHEM 631****Special Topics in Organic Chemistry**

Topics of current interest in organic chemistry including photochemistry, fluorine chemistry, heterocyclic chemistry, pharmaceutical chemistry and electro optical organic chemistry.

**Prerequisite(s):** CHEM 455 with min. grade of C

**Lecture: 2 Lab: 0 Credits: 2**

**CHEM 635****Heterocyclic Chemistry**

Of the vast array of structures which organic compounds adopt, many contain ring systems as a component. When the ring is made up of carbon and at least one other element, the compound is classified as a heterocycle. The aims of this course are to identify the effects that the presence of such ring systems have on the chemistry of a molecule; to show how the rings can be made, and to describe some of the uses of the compounds in organic synthesis, in medicine and in other contexts. The chemistry of aromatic five-, six- and seven-membered ring compounds with one or more nitrogen, oxygen and/or sulfur atoms will be emphasized.

**Prerequisite(s):** CHEM 239 with min. grade of C and CHEM 455 with min. grade of C

**Lecture: 3 Lab: 0 Credits: 3**

**CHEM 650****Special Topics in Physical Chemistry**

Topics of current interest in physical chemistry, including atmospheric chemistry, ion molecule reactions, laser chemistry, theories of gas phase reactions, scattering theory, interaction of radiation with matter and time-dependent relaxation methods.

**Lecture: 2 Lab: 0 Credits: 2**

**CHEM 651****Special Topics in Physical Chemistry**

Topics of current interests in physical chemistry, including atmospheric chemistry, ion molecule reactions, laser chemistry, theories of gas phase reactions, scattering theory, interaction of radiation with matter and time-dependent relaxation methods.

**Lecture: 2 Lab: 0 Credits: 2**

**CHEM 684****Graduate Seminars in Chemistry**

To foster scientific communications skills, students are required to present seminars based on the scientific literature. Required of all Ph.D. students who have passed the written qualifying examination.

**Lecture: 1 Lab: 0 Credits: 1**

**CHEM 685****Chemistry Colloquium**

Lectures by invited scientists in areas of chemistry generally not covered in the department.

**Prerequisite(s):** CHEM 585 with min. grade of C

**Lecture: 0 Lab: 1 Credits: 1**

**CHEM 691****Research and Thesis Ph.D.**

(Credit: Variable) Instructor permission required.

**Credit: Variable**

**CHEM 700****Practical Laboratory for Analytical Chemistry**

In this one-week intensive course, students will gain hands-on experience using analytical instruments. A brief review of theory of instrumentation will be covered. Students will carry out practical problems and will present their findings.

**Lecture: 2 Lab: 4 Credits: 2**