Chemistry and Biochemistry

General Information

Degrees and Areas of Concentration

The Department of Chemistry and Biochemistry offers courses leading to the following baccalaureate degrees:

- B.A. in Chemistry
- B.A. in Chemistry with a Biochemistry Emphasis
- B.S. in Chemistry (with a Chemistry or Biochemistry Option)
- B.S. Ed. in Secondary Education with Emphasis in Chemistry (in cooperation with the College of Education)
- B.A. or B.S. in Chemistry with Master's Level Coursework for Secondary Teacher Certification (in cooperation with the College of Education)

The B.S. degree offered by the department is certified by the American Chemical Society. Students completing the B.S. degree (chemistry or biochemistry option) are certified by the American Chemical Society. The B.S. degree is the professional degree in chemistry, and students who earn the B.S. degree are well prepared for a career in the chemical industry or for graduate work in chemistry. The department provides opportunities for undergraduates to become involved in ongoing research projects. The B.A. degree with an emphasis in biochemistry is especially suited for pre-health students such as pre-medical, pre-dental, or pre-pharmacy students.

The department also offers graduate work leading to the M.S. or Ph.D. degree in chemistry with most graduate courses being scheduled in the evening. A student may earn a M.S. degree with or without a thesis. The non-thesis option provides a convenient way for students who are employed full-time to earn an advanced degree. The department also offers a non-thesis M.S. with a professional science emphasis. This option includes 9 credit hours of business courses and an internship practicum.

Research leading to a M.S. thesis or Ph.D. dissertation may be conducted in one of five emphasis areas, namely, analytical chemistry, inorganic chemistry, organic chemistry, physical chemistry, or biochemistry. The nature of the graduate program allows each student to receive individualized attention from his/her research mentor, and to develop hands-on experience with major instrumentation in the department.

Fellowships, Scholarships and Awards

The following scholarships, fellowships and awards are available to undergraduate chemistry majors:

- The John J. Taylor Scholarship is given to a full-time student with high financial need, pursuing a chemistry degree and currently enrolled either of junior or senior status.
- The Friends and Alumni Scholarship is given to a full-time student with high financial need and pursuing a chemistry degree.
- The Monsanto Scholarship in Biochemistry and Biotechnology is open to full-time Sophomore, Junior or Senior students at the University pursuing a Bachelor of Science degree in Biochemistry and Biotechnology. This scholarship is administered by the Biochemistry and Biotechnology program.
- William and Erma Cooke Chemistry Scholarships are given annually to outstanding full-time chemistry majors who are at least sophomores and have financial need.
- The Lawrence Barton Scholarship is awarded to a junior, preferably a first generation college student.
- The Barbara Willis Brown Scholarship for Women in Chemistry is given annually to a female chemistry major who is at least 25 years of age. The student is encouraged to enroll in undergraduate research (CHEM 3905), however research is not requirement for this award. Student financial need is a consideration.
- The Eric G. Brunngraber Memorial Scholarship is given to a chemistry major based on GPA, statement of research interests, and performance in completed course work.
- Aid to Education Scholarships are given to junior or senior chemistry majors annually. Faculty select awardees on the basis of merit.
- The Gary S. and Kathy A. Jacob Endowed Scholarship is awarded to a full-time undergraduate student interested in pursuing a degree in Chemistry and Biochemistry or in Biochemistry and Biotechnology.
- Charles W. Armbruster Scholarship: These scholarships are awarded to outstanding transfer students. The recipients are selected on the basis of need and merit and they must be enrolled in at least 9 credit hours.
- Hal and Mary Harris Endowed Scholarship in Chemistry: Recipients must be juniors seeking a degree in chemistry with a minimum GPA of 3.0 and enrolled in a minimum of 12 credit hours.
- Stephen S. Lawrence Endowed Scholarship in Chemistry: Recipients will be junior or senior chemistry majors who demonstrate financial need, are enrolled in a minimum of 9 credit hours and maintain a cumulative GPA of at least 2.8. Awardees will have demonstrated a good record of departmental citizenship which may include tutoring, teaching, activity in the chemistry club, or other departmental volunteer activities.
- The Rath Family Scholarship: The scholarship shall be awarded to a full-time, undergraduate student who is interested in pursuing a degree in the STEM disciplines at UMSL. Preference may be given to a student who is majoring in Chemistry/Biochemistry who demonstrates financial need and in addition to students from first generation populations from the Indian Subcontinent/South Asia where possible. A GPA of 3.0 or better and a minimum ACT score of 24 (ACT is only applicable for US students) is required. Award recipients will be encouraged to participate in peer-mentoring, tutoring, or similar programs in the STEM disciplines.
- The Nicholas Chickos Endowed Memorial Scholarship: Recipients must be undergraduate students majoring in chemistry or biochemistry and in good academic standing. Preference may be given to a Veteran student.

Several undergraduate awards are given each year to outstanding students. An award is given to an outstanding student in introductory chemistry. The Outstanding Sophomore Chemistry Major award is made to the top sophomore chemistry student. The American Chemical Society Division of Analytical Chemistry Award is given to the outstanding student in analytical chemistry. Similarly awards are given to the top students in Inorganic, Organic and Physical Chemistry. The American Chemical Society-St. Louis Section, Outstanding Junior Chemistry Major Award is given to the outstanding junior chemistry major, and the outstanding senior receives the Alan F. Berndt Outstanding Senior Award.

The following scholarships, fellowships and awards are available to graduate students in chemistry:

- The M. Thomas Jones Fellowship is given each semester to the graduate student who is deemed by his/her peers to have presented the best research seminar.
- Ceil DeGutis Award for Research Excellence. senior graduate student (meaning typically a fourth or fifth year graduate student) enrolled in one of UMSL's graduate programs in Biology, Chemistry, or Physics for outstanding research performance.
- The Graduate Research Accomplishment Prize is given annually. The recipient is chosen based on his/her publications, presentations at professional meetings, and seminars given at UMSL.
- The Jack L. Coombs Award for outstanding performance as a Graduate Teaching Assistant. It is given each year based on faculty nomination for outstanding performance as a Graduate Teaching Assistant.
- Alumni Graduate Research Fellowships are available for summer study for selected chemistry graduate students.
- Rudolph E. K. Winter Graduate Scholarship. This scholarship will provide one or more stipend supplements for worthy incoming PhD students, as determined by a decision of the appropriate chemistry faculty committee. Preference will be given to students majoring in some aspect of organic chemistry and the award may be renewable for one year if recipient remains in good academic standing.

Departmental Honors

The Department of Chemistry and Biochemistry will award departmental honors to those B.A. and B.S. degree candidates in chemistry with an overall grade point average of 3.2. They must also successfully complete CHEM 3905, Chemical Research, and must present an acceptable thesis.

Career Outlook

The St. Louis metropolitan area has long been a major center for industrial chemistry, and in the past decade it has become a focus for the establishment of life sciences research and development. A bachelor's degree in chemistry provides a student with the professional training needed to play a part in this ever-changing industry.

A major in chemistry provides excellent preprofessional training in the health sciences, and major in biochemistry and biotechnology is often chosen by premedical and predental students and those interested in graduate work in biochemistry and biology. A minor in chemistry provides the minimum qualification and training for a position as a laboratory technician in industry, hospital laboratories, etc.

A Master's degree in chemistry is often required for further advancement in the chemical industry, whereas a doctoral degree opens the door to many opportunities, including careers in the academic world, industrial research and development, and in government laboratories.

Degrees

Chemistry BA

- Biochemistry Emphasis

Chemistry BS

Chemistry MS

- Professional Science Emphasis

Chemistry MS Accelerated Master's Program

Chemistry MS, Accelerated Master's Program for Chemistry BA with Biochemistry Emphasis

Chemistry PhD

Minor

Chemistry Minor

Certificates

Analytical Chemistry Graduate Certificate

Biochemistry Graduate Certificate

Inorganic Chemistry Graduate Certificate

Organic Chemistry Graduate Certificate

Affiliated Interdisciplinary Programs

Biochemistry and Biotechnology BS

Biochemistry and Biotechnology MS

- Professional Science Emphasis

Biochemistry and Biotechnology BS/MS 2+3 Program

Courses

CHEM 1000 Chemistry: The Central Science: 1 semester hour
This course introduces chemistry majors to the broad nature of the chemical enterprise, including career areas for chemists, trends in chemistry related opportunities in research and industry, and provides an overview of the relevance of chemistry as a discipline. The course reviews the chemistry curriculum and the role of chemistry as a central science and includes presentations from selected current faculty and departmental alumni about research opportunities and other resources within the department. The course is required of all chemistry majors, and is to be taken no later than their second semester of enrollment as a chemistry major at UMSL.

CHEM 1021 Beer Brewing: Chemical and Biochemical Principles: 3 semester hours
This course examines the process of beer brewing as it relates to general topics of chemistry, biochemistry and biology. Each aspect of the brewing process will be examined in detail and the underlying scientific principles identified and discussed. The course is designed for non-science, non-engineering and non-allied health majors and can be used to fulfill a general education requirement for undergraduate degrees. The course consists of two hours of lecture and three hours of lab per week.

CHEM 1052 Chemistry for the Health Professions (MOTR CHEM 100HP): 4 semester hours
An introduction to general, nuclear, structural organic, organic reactions and biochemistry. This course is designed primarily for students in nursing and related health professions, and should not be taken by students majoring in the physical or biological sciences. Chemistry majors may include neither CHEM 1052 or CHEM 1062 in the 120 hours required for graduation. Four hours of lecture per week.

CHEM 1062 Organic and Biochem for the Health Professions: 2 semester hours
Prerequisites: Any college Chemistry course. An introduction to organic reactions and biochemistry. CHEM 1062 is offered during the second half of the semester. Four hours of lecture per week.

CHEM 1111 Introductory Chemistry I (MOTR CHEM 150L): 5 semester hours
Prerequisite: MATH 1030 (or a score of 26 or higher on either the Math ACT or the Missouri Math Placement Test) and MATH 1035 (MATH 1035 may be taken concurrently). Presents an introduction to the fundamental laws and theories of chemistry. Laboratory experiments are designed to demonstrate some aspects of qualitative and quantitative analysis and to develop skills in laboratory procedures. Chemistry majors may not include both CHEM 1011 and CHEM 1111 in the 120 hours required for graduation. Three hours of lecture, one and one-half hours of workshop, and three hours of laboratory per week.

CHEM 1111A CHEM 1111A-Introductory Chemistry 1 - Modular Format: 1 semester hour
Prerequisites: MATH 1030 (or a score equivalent to completion of MATH 1030 on the UMSL mathematics placement assessment). These courses (1111A-1111L) are identical in content to CHEM 1111 but are offered in a modular format. Each credit hour deals with the lecture or laboratory material covered in CHEM 1111. Completion of all five modules with a grade in each of C- or above is equivalent to completion of CHEM 1111. CHEM 1111A covers the first quarter of lecture material covered in CHEM 1111.

CHEM 1111B CHEM 1111B-Introductory Chemistry 1 - Modular Format: 1 semester hour
Prerequisites: CHEM 1111A. Concurrent registration with CHEM 1111A is permitted. CHEM 1111B covers the second quarter of lecture material covered in CHEM 1111.

CHEM 1111C CHEM 1111C-Introductory Chemistry 1 - Modular Format: 1 semester hour
Prerequisites: CHEM 1111B. Concurrent registration with CHEM 1111B is permitted. CHEM 1111C covers the third quarter of lecture material covered in CHEM 1111.

CHEM 1111D CHEM 1111D-Introductory Chemistry 1 - Modular Format: 1 semester hour
Prerequisites: CHEM 1111C. Concurrent registration with CHEM 1111C is permitted. CHEM 1111D covers the final quarter of lecture material covered in CHEM 1111.

CHEM 1111L CHEM 1111L-Introductory Chemistry 1 - Modular Format: 1 semester hour
Prerequisites: CHEM 1111D. Concurrent registration with CHEM 1111D is permitted. CHEM 1111L covers laboratory portion of CHEM 1111.

CHEM 1121 Introductory Chemistry II: 5 semester hours
Prerequisite: CHEM 1111 or advanced placement. Lecture and laboratory are a continuation of CHEM 1111. Three hours of lecture, one and one-half hours of workshop and three hours laboratory per week.

CHEM 1134 Special Topics in Introductory Chemistry: 1-5 semester hours
Prerequisite: Consent of instructor. A lecture and/or laboratory course to assist transfer students to complete the equivalent of CHEM 1111 and CHEM 1121. Students enrolling in this course should contact the instructor prior to the first day of class for guidelines on course requirements, to choose a lab or workshop section, and to request enrollment in the course website.

CHEM 2010 Introduction to Inquiry Approaches to STEM Education (STEP I): 1 semester hour
Same as BIOL 2010, PHYSICS 2010, MATH 2010, and SEC ED 2010. Prerequisites: Concurrent enrollment BIOL 1821, BIOL 1831, CHEM 1111, CHEM 1121, PHYSICS 2111, PHYSICS 2112, MATH 1800, or MATH 1900 or have a declared STEM major. Students who want to explore teaching careers become familiar with lesson plan development by writing, teaching and observing lessons in a local school class. Students build and practice inquiry-based lesson design skills and become familiar with and practice classroom management in the school setting. As a result of the STEP I experiences students should be able to decide whether to continue to explore teaching as a career and ultimately finishing the remainder of the WE TEACH MO curriculum leading to teacher certification. The classroom observations and teaching represent a major field component and requires at least one two hour block of free time during the school day once a week.

CHEM 2011 Designing Inquiry-Based STEM Experiences (STEP II): 1 semester hour
Same as BIOL 2011, PHYSICS 2011, MATH 2011, and SEC ED 2011. Prerequisites: BIOL 2010, CHEM 2010, PHYSICS 2010, MATH 2010, or SEC ED 2010. Students explore teaching careers, become familiar with STEM school setting through observing and discussing the school environment and by developing and teaching inquiry-based lessons.

CHEM 2223 Quantitative Analysis in Chemistry: 3 semester hours
Prerequisites: CHEM 1121. This course covers basic analytical chemistry theory and techniques, principles of experimental error analysis, and the application of statistics to data treatment. A significant proportion of the laboratory experiments emphasize quantification of unknown samples.

CHEM 2612 Organic Chemistry I: 3 semester hours
Prerequisite: CHEM 1121 (may be taken concurrently). An introduction to the structure, properties, synthesis, and reactions of aliphatic and aromatic carbon compounds. Three hours of lecture per week.

CHEM 2622 Organic Chemistry II: 3 semester hours
Prerequisite: CHEM 2612. A systematic study of organic reactions and their mechanisms; organic synthetic methods. Three hours of lecture per week.

CHEM 2633 Organic Chemistry Laboratory: 2 semester hours
Prerequisite: CHEM 2612. An introduction to laboratory techniques and procedures of synthetic organic chemistry including analysis of organic compounds. One hour of lecture and four and one-half hours of laboratory per week.

CHEM 3022 Introduction to Chemical Literature: 1 semester hour
Prerequisites: CHEM 2622 (CHEM 2622 may be taken concurrently). This course will familiarize the student with the literature of chemistry and its use. One hour of lecture per week.

CHEM 3302 Physical Chemistry for The Life Sciences: 3 semester hours
Prerequisites: CHEM 2612 and MATH 1800 or MATH 1100, and PHYSICS 1012. Principles and applications of physical chemistry appropriate to students pursuing degree programs in the life sciences. Topics will include thermodynamics, equilibria, kinetics, and spectroscopy. This course is intended for undergraduates seeking the B.S. degree in Biochemistry and Biotechnology and does not fulfill the physical chemistry required for other Chemistry B.A. and B.S. degree programs.

CHEM 3312 Physical Chemistry I: Thermodynamics and Kinetics: 3 semester hours
Prerequisites: CHEM 1121 and MATH 2000 (MATH 2000 may be taken concurrently), and PHYSICS 2111. This course discusses the principles of physical chemistry, focusing on thermodynamics, theory of gases, phase equilibria, solution behavior, and kinetics.

CHEM 3322 Physical Chemistry II: Quantum Chemistry and Spectroscopy: 3 semester hours
Prerequisites: CHEM 3312 and MATH 2000. This course discusses the principles of physical chemistry, focusing on topics that may include, atomic and molecular structure, spectroscopy, and quantum mechanics.

CHEM 3333 Physical Chemistry Laboratory I: 2 semester hours
Prerequisites: CHEM 2223 and CHEM 3312 (CHEM 3312 may be taken concurrently). This course involves experiments designed to illustrate principles introduced in CHEM 3312.

CHEM 3412 Basic Inorganic Chemistry: 3 semester hours
Prerequisites: CHEM 2622. This course reviews the principles of atomic structure and studies covalent and ionic bonding. Topics may include properties of the elements and synthesis, reactions and bonding aspects of important main group and transition metal compounds.

CHEM 3643 Advanced Organic Chemistry Laboratory: 2 semester hours
Prerequisites: CHEM 2223, CHEM 2622, CHEM 2633, and CHEM 3022 (may be taken concurrently). Identification of organic compounds by classical and spectroscopic methods; advanced techniques in synthesis and separation of organic compounds. One hour of lecture and four and one-half hours of laboratory per week. Not for graduate credit.

CHEM 3905 Chemical Research: 1-10 semester hours
Prerequisite: Consent of instructor. Independent laboratory and library study, in conjunction with faculty member, of fundamental problems in chemistry. A written report describing the research is required.

CHEM 4212 Instrumental Analysis: 3 semester hours
Prerequisites: CHEM 3312 and CHEM 3322. This course studies the principles and applications of modern methods of instrumental analysis for analytical chemistry measurements. Topics may be selected from the areas of electrochemistry, absorption and emission spectroscopy, chromatography, mass spectrometry, surface analysis, and nuclear magnetic resonance.

CHEM 4233 Laboratory in Instrumental Analysis: 2 semester hours
Prerequisites: CHEM 4212, CHEM 3333. Experiments designed to illustrate the principles and practices of instrumental analysis, involving the use of modern instrumentation in analytical chemistry applications. One hour of discussion and four and one-half hours of laboratory per week.

CHEM 4343 Physical Chemistry Laboratory II: 2 semester hours
Prerequisites: CHEM 2223 and CHEM 3322 (CHEM 3322 may be taken concurrently). This course involves experiments designed to illustrate principles introduced in CHEM 3322.

CHEM 4412 Advanced Inorganic Chemistry: 3 semester hours
Prerequisites: CHEM 3322 (may be taken concurrently), CHEM 3412, and CHEM 2622. This course introduces the chemistry of the elements, including atomic and molecular structure, acids and bases, the chemistry of the solid state, and main group and transition metal chemistry. Three hours of lecture per week. Students may not receive credit for both CHEM 4412 and CHEM 5412.

CHEM 4433 Inorganic Chemistry Laboratory: 2 semester hours
Prerequisites: CHEM 3333, CHEM 3643, and CHEM 4412 (CHEM 3643 may be taken concurrently). The more sophisticated techniques of physical and analytical chemistry will be used to study inorganic compounds and their reactions. One hours of lecture and four and one half hours of laboratory per week. Not for graduate credit.

CHEM 4602 Introduction to Physical Organic Chemistry: 3 semester hours
Prerequisites: CHEM 2622 and CHEM 3322. This course covers the mechanism and theory of organic chemistry. Topics may include kinetics, transition state theory, reaction intermediates, and stereochemical analysis. Three hours of lecture per week. Credit cannot be earned for both CHEM 4602 and CHEM 5602.

CHEM 4622 Introduction to Reactions and Mechanisms in Organic Chemistry: 3 semester hours
Prerequisites: CHEM 2622. This course will examine a variety of organic transformations typically utilized in organic synthesis. Topics may include carbon-carbon bond formation, pericyclic reactions, oxidation, reduction, and functional group interconversions. Mechanism and stereochemistry will also be emphasized. Three hours of lecture per week. Credit cannot be earned for both CHEM 4622 and CHEM 5622.

CHEM 4662 Introduction to Macromolecular, Supramolecular, and Nanoscale Chemistry: 1 semester hour
Prerequisites: CHEM 2622, CHEM 3412, and CHEM 3312. This course introduces students to macromolecular, supramolecular, and nanoscale chemistry. Structure, synthesis and/or preparation, characterization, and physical properties of these systems will be introduced. Credit cannot be earned for both CHEM 4662 and CHEM 5662.

CHEM 4712 Biochemistry: 3 semester hours
Prerequisites: CHEM 2622. This course examines the chemistry and function of cell constituents, and the interaction and conversions of intracellular substances. Students may not receive credit for both BIOL 4732 and CHEM 4712.

CHEM 4722 Advanced Biochemistry: 3 semester hours
Prerequisite: CHEM 4712. This course covers selected advanced topics in the chemistry of life processes. Students may not receive credit for both CHEM 4722 and CHEM 5722.

CHEM 4733 Biochemistry Laboratory: 2 semester hours
Prerequisites: CHEM 4712 (may be taken concurrently), and CHEM 2223. Laboratory study of biochemical processes in cellular and subcellular systems with emphasis on the isolation and purification of proteins (enzymes) and the characterization of catalytic properties. One hour of lecture and four and one-half hours of laboratory per week.

CHEM 4772 Physical Biochemistry: 3 semester hours
Prerequisites: CHEM 3312 or CHEM 4712 or BIOL 4732. This course is designed to acquaint students with concepts and methods in biophysical chemistry. Topics that will be discussed include protein and DNA structures, forces involved in protein folding and conformational stability, protein-DNA interactions, methods for characterization and separation of macromolecules, and biological spectroscopy. Students may not receive credit for both CHEM 4772 and CHEM 5772.

CHEM 4774 Introduction to Bioinformatics: 3 semester hours
Prerequisites: CHEM 4712 or equivalent. This course introduces modern approaches in bioinformatics and computational biochemistry. Topics covered include a survey of biological databases, predictions from protein and DNA sequences, sequence alignment and sequence database searches, building phylogenetic trees, three-dimensional protein structure prediction, molecular modeling and simulation, and computational genomics. Students may not receive credit for both CHEM 4774 and CHEM 5774.

CHEM 4797 Biochemistry and Biotechnology Seminar: 1 semester hour
Same as CHEM 4797. Prerequisites: Senior standing in the Biochemistry and Biotechnology program and consent of faculty advisor. This course will focus on selected publications related to biochemistry and biotechnology from both refereed journals and news sources. Students are expected to participate in discussions and to prepare oral and written presentations. Completion of the Major Field Achievement Test in Biochemistry & Biotechnology is a course requirement. May not be taken for graduate credit.

CHEM 4814 Special Topics in Chemistry: 1-10 semester hours
A reading and seminar course in selected advanced topics.

CHEM 4897 Seminar in Chemistry: 2 semester hours
Prerequisites: CHEM 3022 and senior standing. This course will provide students with the opportunity to listen to talks presented by students, faculty, and invited speakers. Students must complete a comprehensive examination before the end of the course. Chemistry majors should enroll during the semester in which they intend to graduate, or during their next-to-last semester before graduation.

CHEM 5180 Regulatory Science: 3 semester hours
Prerequisites: Graduate standing. This course covers laws, regulations and agencies involved in the registration of conventional, biotechnology and biological crops, crop protectants and growth regulators. US and International laws and regulations will be discussed from technical proof of concept through commercial release. Offered online only through GP-IDEAS Consortium in the fall.

CHEM 5212 Advanced Instrumental Analysis: 3 semester hours
Prerequisites: Graduate standing and consent of instructor. This course covers the principles and applications of modern methods of instrumental analysis for analytical chemistry measurements. Topics may be selected from, but are not limited to, the areas of electrochemistry, absorption and emission spectroscopy, chromatography, mass spectrometry, surface analysis, and nuclear magnetic resonance. Additional independent study and work are required. Students may not receive credit for both CHEM 4212 and CHEM 5212.

CHEM 5280 Advanced Regulatory Science: 3 semester hours
Prerequisites: CHEM 5180. This course builds on CHEM 5180 and provides hands-on exercises concerning agriculture regulatory topics. It introduces laws, regulations and agencies involved in fertilizer, animal and waste management as well as the role of public policy in the regulatory process. Offered online only through GP-IDEAS Consortium in the spring.

CHEM 5294 Special Topics in Analytical Chemistry: 1-3 semester hours
Prerequisites: Consent of instructor. This course covers topics in analytical chemistry that may change from semester to semester, and more than one course or topic may be offered in a given semester. Topics may be selected from the areas of chromatography, mass spectrometry, analytical spectroscopy, thermal analysis, X-ray diffraction, surface analysis, magnetism, ion-exchange, size-exclusion chromatography, or other topics in modern analytical chemistry. The course may be taken more than once for credit provided that topic(s) are different in each case.

CHEM 5302 Foundations of Physical Chemistry: 3 semester hours
Prerequisites: Consent of Instructor. A survey of fundamental and advanced topics in physical chemistry including thermodynamics, kinetics, quantum chemistry, and spectroscopy. Three hours of lecture per week. Additional independent study work is required. Students may not receive credit for both CHEM 4302 and CHEM 5302.

CHEM 5394 Special Topics in Physical Chemistry: 1-3 semester hours
Prerequisite: Consent of instructor. The topic for this course may change from semester to semester, and more than one course or topic can be offered in a given semester. The course may be taken more than once for credit provided that the topic is different in each case. The course can have more than one instructor.

CHEM 5396 Directed Readings in Physical Chemistry: 1-3 semester hours
Prerequisites: Consent of Physical Chemistry Faculty. A series of readings of monographs, review papers, and/or research publications for a particular student directed at providing that student with appropriate background preparation for experimental or theoretical Ph.D.-level research in an area of physical chemistry. The particular readings will be selected by the physical chemistry staff. Potential topics include but are not limited to advances in Electrochemistry, Surface Chemistry, Thermodynamics, Molecular Spectroscopy, Quantitative Absorption Spectroscopy using new Methodologies, Applications of Group Theory in Spectroscopy, and Computational Chemistry. Assessment may be in various forms including by assignments and seminars. Students may take this course more than once for credit through the particular topic must be different in each case.

CHEM 5412 Advanced Graduate Inorganic Chemistry: 3 semester hours
Prerequisites: Graduate standing and consent of instructor. An introduction to the chemistry of the elements, including atomic and molecular structure, acids and bases, the chemistry of the solid state, and main group and transition metal chemistry. Additional independent study work is required. Three hours of lecture per week. Students may not receive credit for both CHEM 4412 and CHEM 5412.

CHEM 5462 Organometallic Chemistry of the Transition Elements: 3 semester hours
Prerequisites: CHEM 4412 or an equivalent course. A study of transition metal compounds containing metal-carbon bonds and related metal-element bonds, including their synthesis, structure and bonding, and reactions. Applications in organic synthesis and catalysis will also be presented. Three hours of lecture per week.

CHEM 5494 Special Topics in Inorganic Chemistry: 1-3 semester hours
Prerequisite: Consent of instructor. The topic for this course may change from semester to semester, and more than one course or topic can be offered in a given semester. The course may be taken more than once for credit provided that the topic is different in each case. The course can have more than one instructor.

CHEM 5602 Advanced Organic Chemistry I - Physical Organic: 3 semester hours
Prerequisites: CHEM 2622 and CHEM 3322. This course covers the mechanism and theory of organic chemistry. Topics may include kinetics, transition state theory, reaction intermediates, and stereochemical analysis. Three hours of lecture per week. Credit cannot be earned for both CHEM 4602 and CHEM 5602.

CHEM 5622 Advanced Organic Chemistry II - Reactions And Synthesis: 3 semester hours
Prerequisite: CHEM 2622. This graduate level course will examine a variety of organic transformations typically utilized in organic synthesis. Topics may include, carbon-carbon bond formation, pericyclic reactions, oxidation, reduction, and functional group interconversions. Mechanism and stereochemistry will also be emphasized. Three hours of lecture per week. Credit cannot be earned for both CHEM 4622 and CHEM 5622.

CHEM 5652 Spectroscopic Identification of Organic Compounds: 3 semester hours
Prerequisites: Graduate standing or CHEM 3643. An applied approach to the use of spectroscopic techniques in organic chemistry. Topics to include integrated applications of infrared and Raman spectroscopy, ^{13}C and ^{1}H nuclear magnetic resonance spectroscopy and mass spectroscopy for the purpose of elucidating the structure and dynamics of organic compounds. Three hours of lecture per week.

CHEM 5662 Macromolecular, Supramolecular, and Nanoscale Chemistry: 1 semester hour
Prerequisites: CHEM 2622, CHEM 3412, and CHEM 3312. This graduate level course introduces students to macromolecular, supramolecular, and nanoscale chemistry. Structure, synthesis and/or preparation, characterization, and physical properties of these systems will be introduced. Credit cannot be earned for both CHEM 4662 and CHEM 5662.

CHEM 5694 Special Topics in Organic Chemistry: 1-3 semester hours
Prerequisite: Consent of instructor. The topic for this course may change from semester to semester, and more than one course or topic can be offered in a given semester. The course may be taken more than once for credit provided that the topic is different in each case. The course can have more than one instructor.

CHEM 5722 Advanced Graduate Biochemistry: 3 semester hours
Prerequisites: CHEM 4712 or BIOL 4732. Selected advanced topics in the chemistry of life processes. Three hours of lecture per week. Students may not receive credit for both CHEM 4722 and CHEM 5722.

CHEM 5772 Advanced Physical Biochemistry: 3 semester hours
Prerequisites: CHEM 3312 or CHEM 4712 or BIOL 4732. Designed to acquaint students with concepts and methods in biophysical chemistry. Topics that will be discussed include protein and DNA structures, forces involved in protein folding and conformational stability, protein-DNA interactions, methods for characterization and separation of macromolecules, and biological spectroscopy. Three hours of lecture per week. Students may not receive credit for both CHEM 4772 and CHEM 5772.

CHEM 5774 Bioinformatics: 3 semester hours
Prerequisites: CHEM 4712 or equivalent. This course introduces modern approaches in bioinformatics and computational biochemistry. Topics to be covered include a survey of biological databases, predictions from protein and DNA sequences, sequence alignment and sequence database searches, building phylogenetic trees, three-dimensional protein structure prediction, molecular modeling and simulation, and computational genomics. Additional independent study work is required. Students may not receive credit for both CHEM 4774 and CHEM 5774.

CHEM 5794 Special Topics in Biochemistry: 1-3 semester hours
Prerequisites: Consent of instructor. The topic for this course may change from semester to semester, and more than one course or topic can be offered in a given semester. The course may be taken more than once for credit provided that the topic is different in each case. The course can have more than one instructor.

CHEM 5798 Practicum in Science in Business: 1-2 semester hours
Same as: BIOL 5798. Prerequisites: Graduate standing and enrollment in a Professional Science emphasis in Chemistry, Biochemistry & Biotechnology, or Biology. Students will integrate and apply their scientific expertise to a practical, business-related problem. The course will emphasize interdisciplinary team-work as well as both written and oral communication skills.

CHEM 5799 Internship in Science in Business: 1-2 semester hours
Same as: BIOL 5799. Prerequisites: Graduate standing and enrollment in a Professional Science emphasis area in Chemistry, Biochemistry & Biotechnology, or Biology. The internship will consist of period of on-the-job training at a local company. Credit hours will be determined by the number of hours the student works each week and in consultation between the intern's supervisor and the course instructor. Internship assignments will be commensurate with the education and experience of the student, with an emphasis on work at the interface between the scientific and business components of the company. A written report describing the internship project is required.

CHEM 6487 Problem Seminar in Inorganic Chemistry: 1 semester hour
Prerequisite: Consent of the inorganic chemistry staff. Problems from the current literature, presentations and discussions by faculty, students and visiting scientists. Ph.D. students may take more than once for credit. Up to three credits may be applied to the M.S. degree program.

CHEM 6687 Problem Seminar in Organic Chemistry: 1-3 semester hours
Prerequisite: Consent of the organic chemistry staff. Problems from the current literature, presentations and discussions by faculty, students and visiting scientists. PH.D. Students may take more than once for credit. Up to three credits may be applied to the M.S. degree programs.

CHEM 6787 Problem Seminar in Biochemistry: 1 semester hour
Prerequisite: Consent of the biochemistry staff. Problems from the current literature, presentations and discussions by faculty, students and visiting scientists. Ph.D. students may take more than once for credit. Up to three credits may be applied to the M.S. degree program.

CHEM 6812 Introduction to Graduate Study in Chemistry: 1 semester hour
Prerequisite: Consent of graduate advisor. Topics to be covered include: techniques of teaching of chemistry in colleges and universities, methods of instruction and evaluation; role and responsibilities of the Graduate Teaching Assistant in laboratory instruction; safety in the undergraduate laboratory, safety practices, emergency procedures; selection of a research project and thesis advisor.

CHEM 6822 Introduction to Graduate Research in Chemistry: 1 semester hour
Prerequisite: Consent of instructor. Topics to include: safety in the research laboratory, safety practices, emergency procedures, hazardous materials, waste disposal, radiation safety; research ethics, chemistry information retrieval, computer assisted information retrieval, types of databases, searching bibliographic data bases.

CHEM 6832 Strategies for Independent Research Proposal Development: 1 semester hour
Prerequisites: CHEM 6822 and consent of graduate advisor. Topics include: strategies for identification of research topics in chemistry and biochemistry, techniques for database literature search, critical analysis of existing research knowledge, introduction to standard grant proposal formats, technical aspects in preparation of a research plan and accompanying sections, use of bibliographical software, and overview and practice of the peer review process.

CHEM 6887 Graduate Student Seminar in Chemistry: 1 semester hour
Prerequisites: Graduate standing. Scientific presentations by students. One hour per week.

CHEM 6897 Chemistry Colloquium: 1 semester hour
This course consists of presentations of papers by faculty and invited speakers. It meets for one hour per week.

CHEM 6905 Graduate Research in Chemistry: 1-10 semester hours
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