Chemistry and Biochemistry

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J. Martin E. Quirke, *Professor*
Kathleen S. Rein, *Associate Professor*
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Stephen Winkle, *Associate Professor*

Graduate Admission Requirements

1. A minimum undergraduate grade point average (GPA) of 3.0/4.0 in chemistry and cognate science courses and a GRE combined verbal and quantitative score of at least 1000 (M.S.) or 1120 (Ph.D.) are required. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.5 overall on the IELTS is required.
2. Applicants must send a statement of purpose and arrange to have sent transcripts and three letters of recommendation evaluating the applicant's potential for graduate work. Originals of these items must be sent to the FIU Graduate Admissions office as specified at http://gradschool.fiu.edu. In addition, copies of these items should be mailed directly to the Graduate Program Director (general M.S. and Ph.D. programs) or the Forensic Science Graduate Program Director (Forensic Track Ph.D.). Prospective candidates should refer to both the above website and www.fiu.edu/orgs/chemistry for details regarding the application procedure, part of which must be completed on-line.
3. Formal admission to the M.S. and Ph.D. programs is granted by the Graduate Admissions Office. Awards of teaching assistantships are granted by the Graduate Program Director. The Graduate Committee recommends admissions on the basis of a ranking of graduate applicants made by the pertinent committee (for example, the Forensic Graduate Committee for forensic track applicants). Entrance is possible at the beginning of each semester (fall, spring, summer). For consideration for a graduate assistantship, all application materials should be received at least five months prior to the desired starting date.
4. Students whose undergraduate degree is not equivalent to the American Chemical Society certified Bachelor of Science degree in chemistry may be required to make up deficiencies. For example, depending on his or her area of specialization, a student may be required to make up deficiencies in quantum mechanics, instrumental analysis, or biochemistry by successfully completing Graduate Physical Chemistry II (CHM 5426), Graduate Analytical Methods (CHM 5150), or Graduate Biological Chemistry (CHM 5305) respectively.
5. Entering graduate students must pass two proficiency exams. Proficiencies are offered in organic, physical, inorganic, analytical, and biochemistry. One pass must be in either organic or physical chemistry; the other is open. The proficiency exams will be administered to incoming graduate students in the week before the fall and spring semesters. If a student fails to receive a pass in a proficiency exam, he or she must show proficiency by completing the appropriate course with a grade of "B" (3.0/4.0) or better. These courses are Graduate Organic Chemistry (CHM 5225), Graduate Physical Chemistry (CHM 5425), Graduate Analytical Methods (CHM 5150), and Graduate Biological Chemistry (CHM 5305). Students are expected to complete proficiency requirements by the end of their first semester.
6. Graduate students must maintain a GPA of 3.0/4.0. Only courses applicable to the graduate program, excluding those for making up deficiencies or satisfying proficiencies, are counted in the GPA. If the cumulative GPA drops below 3.0 for one semester, the student will be placed on academic probation. A student who fails to raise his or her GPA to 3.0 or higher within one semester will be dismissed from the program.
7. Full-time graduate students generally serve as a Teaching Assistants (TA's) in the Department of Chemistry and Biochemistry for their first semester. Ph.D. candidates must serve as TA's for at least one year except in unusual circumstances. TA's are awarded on a competitive basis, require a minimum cumulative GPA of 3.0, and can be continued for up to two years for M.S. students and four years for Ph.D. students who maintain acceptable academic performance. A limited number of Graduate Research Assistantships (RA's) may be available.

Transfer of Credits and Financial Support

Transfer of credits. Students having an M.S. in chemistry may transfer as many as 36 credits towards their Ph.D. degree. However, no more than six of those credits will count toward fulfillment of the formal course work

requirement. More than six credits for formal course work can be transferred only with special permission of the Graduate Committee, in which case the number of additional course work credits required will depend on the student's performance in courses, the date courses were completed, and the area of Ph.D. concentration.

Financial Support. Full-time graduate students in good academic standing are eligible for financial support. Teaching and research assistantships are available on a competitive basis. Inquiries concerning application to the program and availability of financial support should be directed to the Chemistry Graduate Program Director.

Master of Science in Chemistry

Degree Requirements

1. A minimum of 32 credits of course work. A grade of "C or higher must be obtained in all courses, and a cumulative grade point average of 3.0 or higher which must be maintained. The course work must include:
   a) At least nine credits of chemistry in at least two of the five major areas of chemistry (Analytical, Biochemistry, Inorganic, Organic, and Physical) from the core listed below:

Core Courses (three credits each)

Analytical

CHM 5138	Advanced Mass Spectrometry
CHM 5156	Advanced Chromatography
CHM 5165	Chemometrics and Sampling
CHM 6157	Advanced Analytical Chemistry

Biochemistry

CHM 5325	Physical Chemistry of Proteins
CHM 5503	Physical Chemistry of Nucleic Acids
CHM 5506	Physical Biochemistry

Inorganic

CHM 5251	Organometallic Chemistry
CHM 5440	Kinetics and Catalysis
CHM 5540	Group Theory in Chemistry
CHM 5650	Physical Inorganic Chemistry

Organic

CHM 5236	Spectroscopic Techniques and Structure Elucidation
CHM 5250	Organic Synthesis
CHM 5260	Physical Organic Chemistry

Physical

CHM 5423	Atmospheric Chemistry
CHM 5490	Physical Spectroscopy
CHM 5540	Group Theory in Chemistry
CHM 5586	Computational Chemistry
CHM 6430	Advanced Thermodynamics
CHM 6461	Statistical Thermodynamics
CHM 6480	Quantum Mechanics

Courses not listed above may be counted as core course with prior departmental approval.

   b) At least six credits of additional graduate-level courses approved by the thesis committee in consultation with the Graduate Program Director with the following guidelines:
      1. The courses must be 5000 or 6000 level chemistry courses (CHM prefix) or approved cognates (up to a maximum of six credits).
      2. The following do not count toward satisfaction of this requirement: proficiency courses and courses taken to make up for undergraduate-level deficiencies in chemistry (including CHM 5150, CHM 5225, CHM 5305, CHM 5425, and CHM 5426); and courses corresponding to research, seminar, colloquium, supervised teaching, and thesis completion (CHM 6910L, CHM 6935, CHM 6936, CHM 6940, CHM 6970, and CHM 6971).
   c) Full-time graduate students are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as teaching assistants.
   d) Full-time graduate students are required to register for one credit of CHM 6935 (Graduate Seminar) or one credit of CHM 6936 (Chemistry Colloquium) each fall and spring semester.
   e) At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research at the colloquium for a letter grade in their second semester of graduate study.
   f) At least eight credits of CHM 6970 (Thesis Research) involving independent thesis research under the direction of a faculty member in the Department.
   g) At least two credits of CHM 6971 (Thesis) taken in the semester in which the M.S. thesis is to be defended.
2. Satisfactory public presentation and defense of a research thesis, evaluated by the student's Thesis Committee. The Thesis Committee will consist of the research advisor and a randomly-assigned committee member appointed by the Graduate Program Director, both from the Department's graduate faculty, and one additional member with expertise in the student's research area. At least one committee member must be tenured in the Department. The Committee may include more members, but they will be non-voting.

Combined BS/MS in Chemistry

To be considered for admission to the combined bachelor's/master's degree program, students must have completed at least 75-90 credits in the bachelor's degree program at FIU and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree program, but the application must be submitted to Graduate Admissions before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree program will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the number of credits specified by the program catalog, may be applied toward both degrees.

Admission Requirements

- Current enrollment in the Bachelor of Science program in chemistry at FIU.
- Current GPA of 3.2 or higher.
- GRE general test score of 1000 (verbal and quantitative combined), with a minimum quantitative score of 550.
- Three letters of recommendation.
- Approval of the Chemistry Graduate Committee.

Completion Requirements

Completed Bachelor of Science degree in chemistry at FIU Required:

- 9 credits (3 courses) selected from graduate chemistry core courses. Required courses must be completed with an average of "B" or higher, and only one course may receive a grade less than "B-".
- Electives: 3 courses selected from the Chemistry Graduate Elective Offerings.
- 9 credits of Thesis Research and 2 credits of Thesis. 1 credit of Colloquium.
- Overlap: Up to 3 graduate level courses (9 credits) may be used to satisfy both the Bachelor's and Master's degree requirements.

Combined BS in Chemistry/MS in Forensic Science

To be considered for admission to the combined bachelor's/master's degree program, students must have completed at least 75-90 credits in the bachelor's degree program at FIU and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree program, but the application must be submitted to Graduate Admissions before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree program will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the number of credits specified by the program catalog, may be applied toward both degrees.

Admission Requirements

- Current enrollment in the Bachelor of Science program in chemistry at FIU.
- Current GPA of 3.2 or higher.
- GRE general test score of 1000 (verbal and quantitative combined), with a minimum quantitative score of 550.
- Three letters of recommendation.
- Approval of the Chemistry Graduate Committee.

Completion Requirements

Completed Bachelor of Science degree in chemistry at FIU

Coursework

Required Courses:

BSC 5406	Forensic Biology
CHS 5542	Forensic Chemistry
CHS 5531	Forensic Analysis

- Required courses must be completed with an average of "B" or higher, and only one course may receive a grade of less than "B-".
- Electives: 5 courses selected from the Forensic Science Graduate Elective Offerings.
- 6 credits of Thesis Research and 1 credit of Thesis.
- 1 credit of Colloquium.
- Overlap: Up to 3 graduate level courses (9 credits) may be used to satisfy both the Bachelor's and Master's degree requirements.

Doctor of Philosophy in Chemistry

Degree Requirements

1. A minimum of 81 credits of course work. A grade of "C" or higher must be obtained in all courses, and a cumulative GPA of 3.0 or higher must be maintained. The course work must include:
   a. At least nine credits of chemistry courses, including courses from at least two of the five major areas of chemistry (Analytical, Biochemistry, Inorganic, Organic, and Physical) selected from the core courses listed above (see M.S. in Chemistry 1a).
   b. At least nine credits of additional graduate-level chemistry courses approved by the dissertation committee in consultation with the Graduate Program Director. The guidelines listed above in sections 1b(1) and 1b(2) for the M.S. degree also apply to these courses.
   c. Full-time graduate students are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as teaching assistants.
   d. Full-time graduate students are required to register for one credit of CHM 6935 (Graduate Seminar) or one credit of CHM 6936 (Chemistry Colloquium) each fall and spring semester
   e. At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research at the colloquium for a letter grade by the end of their third semester of graduate study.
   f. At least eight credits of CHM 7910 (Dissertation Research) involving independent dissertation research under the direction of a faculty member in the Department are required.
   g. At least 20 credits of CHM 7980 (Ph.D. Dissertation) are to be taken after the student has advanced to candidacy.
2. Satisfactory completion of cumulative examinations. The student will begin taking the cumulative examinations after completing the proficiency requirements but no later than the beginning of the student's second semester. Six examinations, each lasting three hours, will be given per year. The student must pass four out of ten consecutively-offered exams for admission to candidacy.

3. Satisfactory presentation and defense of an original research proposal (on a topic not related to the student's specific doctoral research project) and (b) satisfactory completion of a Preliminary Oral examination. The presentation and examination occur consecutively in a single session and must be completed before the end of the fifth semester (excluding summers). The examination will be conducted by the Dissertation Committee, be based on the student's dissertation research, and include questions from the student's major field and cognate fields. After fulfilling this requirement, passing the comprehensive examinations, and completing all required course work, the student advances to candidacy.
4. Satisfactory public presentation and defense of a research dissertation, evaluated by the Dissertation Committee. The student's Dissertation Committee will consist of the research advisor (a FIU graduate faculty member who holds dissertation advisor status), a member from outside the Department, or School, but within FIU, a randomly-assigned member appointed by the Graduate Program Director from the Department's graduate faculty, and at least two additional committee members with expertise in the student's research area. At least three members of the Dissertation Committee, including the major research advisor, must be graduate faculty members from the Department of Chemistry and Biochemistry, and at least two of these three members must be tenured. The Committee may include additional members, but they will be non-voting.

Doctor of Philosophy in Chemistry with a Forensic Science Track

To be admitted into the Ph.D. program in Chemistry with a Forensic track, a candidate must:

1. Hold a Bachelor's degree in chemistry, forensic science or a relevant discipline from an accredited college or university approved by the Chemistry graduate committee. The minimum requirement is a bachelors degree in a natural science with a least 7 semester courses (28 hours including labs) of chemistry courses including physical chemistry, analytical chemistry and biochemistry. Any deficiencies must be completed before being fully accepted to the Ph.D. program;
2. Have a 3.0/4.0 average or higher during the last two years of the undergraduate program or a Master's degree in a relevant discipline;
3. Have a combined score (verbal and quantitative) of 1120 or higher on the Graduate Record Exam;
4. Arrange to have three letters of recommendation sent to the Forensic Science Graduate Program Director evaluating the applicant's potential for graduate work;
5. Pass at least two proficiency exams in either analytical or biochemistry and either organic or physical chemistry – students who have not taken physical chemistry must take one semester of physical chemistry to make up the deficiency;
6. Receive approval from the Forensic Science Graduate Committee;
7. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.5 overall on the IELTS is required.

All admissions to the Chemistry Ph.D. program must be recommended by the chemistry graduate committee and signed off by the chemistry graduate program director.

Degree Requirements

1. A minimum of 81 credits or course work. A grade of "C" or higher must be obtained in all courses, and a cumulative GPA of 3.0 or higher must be maintained. Students must choose either the Analytical or the Biochemistry concentration. The course of study must include:
   a. Twelve credits of required classes that depend on the concentration (each of the following courses is worth three credits):

Analytical Chemistry/Trace Concentration

BSC 5406	Forensic Biology	3
CHS 5542	Forensic Chemistry	3
CHS 5539	Forensic Toxicology	3
CHS 5545	Chem Anl. Explosives	3
	or	
CHS 5538	Chem Anl. of Drugs	3

Biochemistry/DNA Analysis Concentration

BSC 5406	Forensic Biology	3
CHS 5542	Forensic Chemistry	3
CHS 5536	Forensic DNA Chemistry	3
PCB 5685	Population Genetics	3

   b. Two chemistry core courses chosen from the following: Advanced Chromatography (CHM 5156); Advanced Mass Spectrometry (CHM 5138); Spectroscopic Techniques (CHM 5236); Organic Chemistry of Nucleic Acids (CHM 5302); Physical Biochemistry (CHM 5506); Advanced Analytical Chemistry (CHM 6157); Chemometrics & Sampling (CHM 5165); Advanced Biological Chemistry (CHM 6982).
   c. At least one elective. The list of approved electives is maintained by the Chemistry and Forensic Graduate Committees.
   d. Full-time graduate students are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as teaching assistants.
   e. Full-time graduate students are required to register for one credit of CHM 6935 (Graduate Seminar) or one credit of CHM 6936 (Chemistry Colloquium) each fall and spring semester.
   f. At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research at the colloquium for a letter grade by the end of their third semester of graduate study.
   g. At least eight credits of CHM 7910 (Dissertation Research) involving independent dissertation research under the direction of a faculty member in the Department.
   h. At least 20 credits of CHM 7980 (Ph.D. Dissertation) is to be taken after the student has advanced to candidacy.

2. Successful completion (grade of "pass") of a comprehensive exam composed by the student's Dissertation Committee and approved by the Dissertation Advisor in consultation with the Forensic Graduate Committee.
3. Presentation and defense of an original research proposal on a forensic-related topic that is not related to the student's specific doctoral research project. The topic must be approved by the Dissertation Advisor in consultation with the Forensic Graduate Committee. After fulfilling this requirement, passing the comprehensive exam, and completing all required course work, the student advances to candidacy.
4. Satisfactory public presentation and defense of a research dissertation, evaluated by the Dissertation Committee. The composition of the Dissertation Committee is as described in section 4 for the Ph.D. in Chemistry (no track) above.

Course Descriptions

Definition of Prefixes

BCH-Biochemistry (Biophysics); CHM-Chemistry; CHS-Chemistry-Specialized
F-Fall semester offering; S-Spring semester offering; SS Summer semester offering.

BCH 6108 Biochemical Techniques (3). Introduction to theories of basic biochemical techniques commonly used in a biochemistry laboratory. Prerequisite: One semester of biochemistry.

BCH 6831 Introduction to Biochemical Research (3). An overview of the analysis of biochemical data and experimental design. Prerequisite: Graduate standing.

CHM 5138 Advanced Mass Spectrometry (3). Intensive examination of the processes and techniques involved in creating, controlling and measuring ionic species by mass spectrometry. Theory of mass spectrometry, methods of ionization, instrumental designs, quantitative mass spectrometry, meta-stable ions, and tandem mass spectrometry. Prerequisites: CHM 4130, CHM 4130L or Permission of Instructor.

CHM 5139C Mass Spectrometry Workshop (2). Basic description of processes and techniques involved in creating, controlling and measuring elemental or molecular ionic species by mass spectrometry techniques. WS designed to provide hands on experience. Prerequisite: CHM 4130.

CHM 5150 Graduate Analytical Methods (3). Analysis of analytical data, electrochemistry, spectro-analytical techniques, chromatography, survey of new analytical methods. Prerequisites: Graduate standing or permission of the instructor. (F,S)

CHM 5156 Advanced Chromatography (3). Intensive examination of the contemporary practice of chromatography including available chromatographic techniques, their selection and application. Prerequisites: CHM 4130 or permission of the instructor.

CHM 5165 Chemometrics and Sampling (3). Methods of evaluating analytical chemistry data. Planning sampling design for water, air and solids. Sample preparation and extraction techniques. Prerequisite: CHM 4130.

CHM 5181 Special Topics in Analytical Chemistry (VAR). An intensive examination of one or more areas selected by instructor and students. Core course Prerequisites: CHM 4130 or permission of the instructor.

CHM 5225 Graduate Organic Chemistry (3). Advanced topics in organic chemistry. Structure of organic molecules, reaction mechanisms, organic synthesis, and natural product chemistry. Prerequisites: Graduate standing or permission of the instructor. (F,S)

CHM 5236 Spectroscopic Techniques and Structures Elucidation (3). Advanced techniques for the spectroscopic identification of organic compounds. Interpretation of spectral information for determination of structures of various classes of organic compounds. Prerequisites: CHM 4220 and CHM 4230L.

CHM 5250 Organic Synthesis (3). Use of classical and modern reactions in the design and construction of complex organic molecules including natural products. Some topics covered will be construction reactions, refunctionalization, stereochemistry and conformational analysis. Prerequisites: CHM 4220 or permission of the instructor.

CHM 5251 Organometallic Chemistry (3). Fundamentals and applications of organometallic chemistry. Structures and bonding, ligand types, organometallic reactions, physical methods of characterization. Prerequisites: CHM 4610, CHM 3411.

CHM 5252 Asymmetric Synthesis (3). Recent advances in asymmetric synthesis for the selective design and construction of tetrahedral stereocenters. Focus on principles of configuration in transition state assemblies. Prerequisite: CHM 4220.

CHM 5260 Physical Organic Chemistry (3). A series of topics will be discussed including molecular orbital theory as it pertains to organic molecules, kinetic and thermodynamic approaches to the study of reaction mechanisms, quantitative approaches to conformational analysis, etc. Prerequisites: CHM 4220 and physical chemistry or permission of the instructor.

CHM 5280 Natural Products Chemistry and Biosynthesis (3). Studies of the chemical origins (biosynthesis), properties, and synthesis of the various classes of naturally occurring compounds: terpenes, steroids, alkaloids, acetogenins. Prerequisites: CHM 4220 or permission of the instructor.

CHM 5302 Organic Chemistry of Nucleic Acids (3). Organic chemistry of ribose sugars, nucleotide heterocyclic bases, mechanism-based inhibitors of enzymes involve in nucleic acid metabolism, and chemical synthesis of DNA. Prerequisites: CHM 4220 or permission of the instructor.

CHM 5305 Graduate Biological Chemistry (3). Structures of biological molecules; Biochemical reaction mechanisms; Enzyme kinetics; Biomolecular thermodynamics; Biomolecular spectroscopy. Prerequisites: Graduate standing or permission of instructor.

CHM 5306 Special Topics in Biological Chemistry (3). Investigation of one or more areas of biologically related chemistry. Prerequisites: CHM 4305 or permission of the instructor.

CHM 5325 Physical Chemistry of Proteins (3). Protein structures, dynamics and functions. Use of spectroscopic methods. Thermodynamics of protein folding and ligand binding. Enzyme Kinetics. Prerequisites: Biological Chemistry and Physical Chemistry or permission of instructor.

CHM 5351 Computer Modeling of Biological Molecules (3). Introduces use of computers in studying biological macromolecules. Simulations, visualization methods, software, databases. Prerequisite: CHM 3411, Biochemistry recommended.

CHM 5380 Special Topics in Organic Chemistry (VAR). An intensive examination of one or more areas selected by instructor and students. Prerequisites: CHM 4220 and physical chemistry or permission of the instructor.

CHM 5423 Atmospheric Chemistry (3). Chemical processes in atmospheres. Photochemistry, chemical kinetics, tropospheric and stratospheric chemical reactions, anthropogenic effects on the earth's atmosphere and chemistry of planetary atmospheres. Prerequisites: CHM 3411, or permission of the instructor.

CHM 5425 Graduate Physical Chemistry (4). Prequantum physics, the Schrodinger equation and its solutions, atoms and molecules, rotational, vibrational, and electronic spectroscopy. Prerequisites: Graduate standing or permission of the instructor.

CHM 5426 Graduate Physical Chemistry II (4). Gas laws; thermodynamics and equilibrium, electrochemistry, and chemical kinetics. Prerequisite: Graduate standing or permission of the instructor.

CHM 5440 Kinetics and Catalysis (3). Theory of elementary reactions, activated complex theory, mechanisms of complex reactions. Prerequisites: CHM 3411, MAP 3302.

CHM 5490 Physical Spectroscopy (3). Introduction to atomic and molecular quantum states, selection rules, and fundamental principles of spectroscopy. Introduction to group theory and to the theory of UV/visible, infrared, Raman, microwave, NMR, photo-electron, and mass spectroscopies, and the applications of these methods to the determination of fundamental physical properties and the structure of organic and inorganic molecules. Prerequisite: Physical Chemistry.

CHM 5490L Physical Spectroscopy Lab (1). The theory of spectroscopy and the use of modern instrumentation to investigate molecular structure. Prerequisites: CHM 2211, 2211L. Corequisites: PHY 4604 or CHM 5490.

CHM 5503 Physical Chemistry of Nucleic Acids (3). Physical chemistry of nucleic acids including spectroscopic determination of structures of DNAs, RNAs, and DNA protein complexes and thermodynamic and kinetic studies of nucleic acid-ligand complexes and nucleic acid structures. Prerequisites: CHM 4305 or permission of the instructor.

CHM 5506 Physical Biochemistry (3). Physical properties of biomolecules, molecular conformation; thermodynamic, kinetic, and spectroscopic properties of biomolecules. Prerequisites: CHM 4305 or permission of the instructor.

CHM 5517 Solid State (3). Crystalline form of solids, lattice dynamics, metals, insulators, semiconductors, and dielectric materials. Prerequisites: CHM 5490 or PHY 4604.

CHM 5540 Group Theory In Chemistry (3). The fundamental theory is developed with emphasis given to representations. Specific applications covered, with emphasis on molecular orbital theory and spectroscopy. Prerequisite: CHM 3411.

CHM 5581 Special Topics in Physical Chemistry (VAR). An intensive examination of one or more areas selected by instructor and students. Prerequisites: CHM 3411 or permission of the instructor.

CHM 5586 Computational Chemistry (3). Surveys computational methods for studying issues pertinent to organic and biological chemistry. Emphasis on developing an understanding of principles and putting methods to use. Includes methods for studying reaction thermodynamics, reaction mechanisms and NMR spectral properties. Prerequisites: CHM 3410, CHM 3411.

CHM 5650 Physical Inorganic Chemistry (3). Introduction to use of physical methods to determine the structure of inorganic compounds. Prerequisites: CHM 4610 or permission of the instructor.

CHM 5681 Special Topics in Inorganic Chemistry (VAR). An intensive examination of one or more areas selected by instructor and students. Prerequisites: CHM 4610 or permission of the instructor.

CHM 5765 Aquatic Chemistry (3). Redox chemistry, chemistry of sediments, organic biogeochemistry, chemodynamics, and fates or organic pollutants in aqueous environments. Prerequisites: CHM 2211, CHM 4130, or permission of the instructor.

CHM 5931 Special Topics (3). A course covering selected special topics in chemistry.

CHM 5932 Special Topics (3). A course covering selected special topics in chemistry.

CHM 5936 Special Topics in Environmental Chemistry (3). An intensive examination of one or more areas selected by the instructor and students. Prerequisite: Permission of the instructor.

CHM 6036 Advanced Biochemistry I (3). Overview of the structure and function of Biomacromolecules, i.e., proteins, enzymes, and nucleic acids emphasizing the current literature. Prerequisites: One semester of biochemistry or consent of the instructor.

CHM 6037 Advanced Biochemistry II (3). Introduction to biochemical pathways regulation and intra- and extracellular communication on the molecular level. Prerequisite: CHM 6036.

CHM 6157 Advanced Analytical Chemistry (3). Modern analytical methods, applications, and instrumentation. Topics include spectroscopy, chromatography, electrochemistry, optimization theory, and computerized instrumentation. Prerequisites: CHM 4130 or permission of the instructor.

CHM 6166 Hyphenated Analytical Techniques (3). Covers hyphenated analytical techniques required for the analysis of trace elements and organic compounds in

environmental and biomedical sciences. Prerequisites: CHM 4130 or equivalent.

CHM 6281 Environmental Organic Chemistry (3). Characteristics, origin, fate and transformation of organic compounds in air, water, sediments and biota. Prerequisites: CHM 2211, CHM 3411, or permission of the instructor.

CHM 6340 Organic Geochemistry (3). Organic geochemistry of recent and ancient environments. Characteristics, origin, and transformation of organic matter in the geosphere, including formation of crude oil. Prerequisites: CHM 2211, CHM 3411, CHM 4130, GLY 1010, or permission of the instructor.

CHM 6382 Advanced Biological Chemistry (3). In depth exploration of one or more biological chemistry areas, for example, use of multinuclear NMR in examining nuclear acids and proteins; biosynthesis of toxins, roles of porphyrins. Topics covered vary with instructor. Prerequisites: Biological Chemistry and Physical Chemistry or permission of instructor.

CHM 6430 Advanced Thermodynamics (3). The laws of classical thermodynamics and their application. Open and closed systems, irreversible processes, high and low temperature systems, solids, liquids, and gases. Core course. Prerequisites: CHM 3411 or permission of the instructor.

CHM 6449 Photochemistry (3). Fundamentals of photochemistry. Excited states, energy, and electron transfer processes, photo-oxidation, reactive species, and environmental photochemistry. Prerequisites: CHM 4220 or permission of the instructor.

CHM 6461 Statistical Thermodynamics (3). Principles of statistical thermodynamics. Ensembles, classical and quantum statistics, ideal and nonideal gases, equilibrium, crystals, liquids, and polymers. Prerequisites: CHM 3411 or permission of the instructor.

CHM 6480 Quantum Mechanics (3). Introduction to quantum mechanics. The Schrodinger equation and its solutions, approximation methods, spin, symmetry, structure of atoms and molecules. Prerequisites: CHM 3411 or permission of the instructor.

CHM 6511 Polymer Chemistry (3). A quantitative study of polymers. Mechanism of formation, configuration of polymer chains, and the relationship between physical properties and chemical constitution. Prerequisite: CHM 3411 or permission of the instructor.

CHM 6621 Inorganic Reaction Mechanisms (3). Review of kinetics and determination of mechanism. Study of mechanism of reactions of coordination complexes including electron transfer reactions, ligand substitution reactions, coordinated ligand reactions of importance in homogeneous catalysis. Prerequisite: Physical Chemistry I (Kinetics).

CHM 6624 Coordination Chemistry (3). Electronic structure of metals and transition metal complexes; redox reactions; introduction to organometallic and Bioinorganic Chemistry. Symmetry and group theory applied to Transition Metal Complexes. Physical methods in Inorganic Chemistry. Prerequisites: CHM 3410 Physical Chemistry (Kinetics), CHM 3411 Physical Chemistry II (Quantum Mechanics).

CHM 6905 Independent Study in Chemistry (1-6). Independent study and problems in an area of chemistry, under faculty supervision. May be repeated. Prerequisite: Permission of the instructor.

CHM 6910L Graduate Research in Chemistry (VAR). The student works directly with a professor on a research project. Credit is assigned on the basis of four hr/wk per credit hour. Results to be presented as a seminar. Permission of the instructor.

CHM 6935 Graduate Seminar (1). An examination of various current research topics in chemistry. Prerequisite: Graduate standing.

CHM 6936 Chemistry Colloquium (1). Analysis of current developments and topics presented by faculty members and registered students. Prerequisite: Admission to graduate program in chemistry.

CHM 6940 Supervised Teaching (1-3). Graduate student serves as lecturer and demonstrator in undergraduate laboratories coordinated and supervised by a faculty member. May be repeated. A maximum of three hours may apply to the Master's degree. Prerequisite: Good graduate standing.

CHM 6949 Industrial Internship (3). A semester of supervised work in an outside laboratory. Prerequisite: Permission of the instructor.

CHM 6970 Thesis Research (1-10). Research toward completion of Master's Thesis. Repeatable. Prerequisite: Permission of the department.

CHM 6971 Master's Thesis (1-6). Completion of thesis. Prerequisite: Permission of major professor.

CHM 7910 Dissertation Research (1-10). Research towards the completion of a doctoral dissertation. Repeatable. Prerequisite: Graduate Standing.

CHM 7980 Ph.D. Dissertation (1-12). Completion of doctoral dissertation. Prerequisite: Permission of Major Professor and Doctoral Candidacy. May be repeated.

CHS 5502 Forensic Chemistry for Teachers (3). Incorporates concepts and techniques from the application of analytical chemistry, molecular biology, biochemistry, toxicology, and microscopy to forensic casework. Exposure to teaching resources in these areas and case study format of presentation. Open to education majors only. Prerequisites: CHM 3120, CHM 3120L, CHM 2211, and CHM 2211L or permission of instructor.

CHS 5531 Forensic Analysis (3). Advanced topics on the role that physical evidence plays in their criminal justice system. Topics include crime scene methods, laboratory management and the legal framework as it relates towards physical evidence. Prerequisites: CHM 3120, CHM 3120L, CHM 2211, CHM 2211L, or permission of the instructor. (Does not count towards chemistry elective requirement).

CHS 5531L Forensic Analysis Lab (1). Laboratory to accompany Forensic Analysis CHS 5531. Prerequisites: CHM 3120, CHM 3120L, CHM 2211, CHM 2211L or permission of the instructor.

CHS 5536 Forensic DNA Chemistry (3). Chemical basis for current methodologies of DNA analysis. DNA sequencing, PCR, STR, AFLP, mass spectrometry. Prerequisites: CHM 4304 or permission of instructor.

CHS 5538C Chemistry and Analysis of Drugs (3). Introduction to the chemistry of drugs of abuse, including reactivity, synthesis and the principles of analysis from solid doses and from body fluids. Laboratory analysis through the determination of unknown samples. Prerequisites: CHM 4130, CHM 4130L, CHM 4304, CHM 4304L.

CHS 5539 Forensic Toxicology (3). Provides the basic concepts of forensic toxicology as it applies to drug and body fluid analysis. Prerequisites: CHM 2211+L, CHM 3120+L, CHM 4305+L (BCH 3033+L) or permission of instructor.

CHS 5542 Forensic Chemistry (3). Advanced analytical methods in Forensic Chemistry for application to the analysis of controlled substances, materials (ie., paint, glass, and fibers), flammable and explosives residues with an emphasis on new methods and method development.

CHS 5545 Chemistry and Analysis of Explosives (3). Chemistry and reactivity, including thermochemistry, of modern industrial and military explosives' with an emphasis on the analysis of explosives residues from post-blast debris and from samples of environmental interest. Prerequisites: CHM 4130, CHM 4130L.

CHS 6905 Independent Study in Forensic Science (1-6). Independent study and problems in an area of forensic science under faculty supervision. Prerequisite: Permission of instructor.

CHS 6946 Graduate Forensic Internship (1-6). Internship in an operational forensic laboratory, contributing in a specific manner on an assigned research project. Six hours a week minimum residence time per credit in the lab under the supervision of a host lab scientist and a faculty member is required. A final written report and presentation required. Prerequisite: Core courses in Forensic M.S. Program.