CHEMISTRY

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COLLEGE OF SCIENCE

Bausch, Mark J., Associate Professor, Ph.D., Northwestern University, 1982; 1987. Organic radical anion basicities, radical acidities, stability of organic cations.

Beyler, Roger E., Professor, *Emeritus,* Ph.D., University of Illinois, 1949; 1959.

Caskey, Albert L., Associate Professor, *Emeritus*, Ph.D., Iowa State University, 1961; 1964.

Dave, Bakul, Associate Professor, Ph.D., University of Houston, 1993; 1996. Inorganic and organic nanocomposites, solgel based materials, bioinorganic chemistry.

Dyer, Daniel J., Associate Professor, Ph.D., University of Colorado, 1996; 1998. Design and synthesis of organic materials and polymers.

Gao, Yong, Associate Professor, Ph.D., University of Alberta, 1998; 2000. Bio-organic chemistry; medicinal chemistry; bio-materials.

Ge, Qingfeng, Associate Professor, Ph.D., Tianjing University, 1991; 2003. Physical/Materials Chemistry, computational chemistry, surface science, kinetics and catalysis, biomaterials and biocatalysis.

Goodson, Boyd M., Associate Professor, Ph.D., University of California, Berkeley, 1999; 2002. Structure and dynamics of molecules and proteins, optical/nuclear double resonance, NMR and MRI, quantum computation.

Guyon, John C., Professor, *Emeritus*, Ph.D., Purdue University, 1961; 1974.

Hadler, Herbert I., Professor, *Emeritus*, Ph.D., University of Wisconsin, 1952; 1966.

Hinckley, Conrad C., Professor, *Emeritus*, Ph.D., University of Texas, 1964; 1966.

Hou, Yuqing, Research Assistant Professor, Ph.D., Southern Illinois University Carbondale, 1997; 1998.

Huff-Hartz, Kara, Assistant Professor, Ph.D., Purdue University, 2002; 2006. Analytical.

Kinsel, Gary R., Professor and *Chair*, Ph.D., University of Colorado Boulder, 1989; 2005. Analytical Chemistry,MALDI and ESI mass spectrometry, RF plasmapolymers, biomaterials, proteomics, microfluidics, surface analysis.

Kohli, Punit, Assistant Professor, Ph.D., Michigan State University, 2000; 2004. Bio-nanoscience, transport through nanotubes, materials and surface chemistry.

Koropchak, John A., Professor, and *Vice Chancellor for Research and Dean of Graduate School*, Ph.D., University of Georgia, 1980; 1984. Analytical, atomic spectroscopy, metal speciation, separations detection, condensation nucleation light scattering detection, single molecule detection, capillary separations.

Koster, David F., Professor, *Emeritus*, Ph.D., Texas A&M University, 1965; 1967.

Lee, Brian, Assistant Professor, Ph.D., University of Maryland, 1997; 2006. Biochemistry.

McCarroll, Matthew E., Associate Professor, Ph.D., University of Idaho, 1998; 2000. Analytical, molecular spectroscopy, fluorescence sensors, chiral and molecular recognition, capillary electrophoresis.

Means, Jay C., Professor and *Dean of College of Science*, Ph.D. DABT, University of Illinois-Urbana, 1976, 2007, Toxicology and Analytical Chemistry

Meyers, Cal Y., Professor, *Emeritus*, Ph.D., University of Illinois, 1951; 1964.

Perez-Alvarado, Gabriela, Assistant Professor, Ph.D., University of Maryland, 1995; 2006. Biochemistry.

Smith, Gerard V., Professor *Emeritus*, Ph.D., University of Arkansas, 1959; 1966

Tolley, Luke T., Assistant Professor, Ph.D., University of North Carolina, 2001; 2003. Analytical Chemistry, chromatography, capillary electrophoresis, mass spectroscopy, intercellular signaling biomarkers.

Trimble, Russell F., Professor, *Emeritus*, Ph.D., Massachusetts Institute of Technology, 1952; 1954.

Tyrrell, James, Professor, *Emeritus.,* Ph.D., University of Glasgow, 1963; 1967.

Wang, Lichang, Associate Professor, Ph.D., University of Copenhagen, 1993; 2001. Physical, theoretical/computational chemistry, transition metal nanoparticles, polymers, and biomolecules.

Zang, Ling, Assistant Professor, Ph.D., Chinese Academy of Sciences, 1995; 2003. Analytical/Physical/Materials chemistry, nanoscale imaging and spectroscopy, nanostructure assembling and patterning, nanodevices for fluorescence sensing and probing.

Programs leading to the Doctor of Philosophy and Master of Science degrees may be undertaken in the general areas of analytical, materials, inorganic, organic, and physical chemistry.

The doctoral degree in chemistry is a research degree. To be awarded this degree, the student must demonstrate, to the satisfaction of the graduate committee, the ability to conduct original and independent research within some area of chemistry and must, in fact, make an original contribution to the science. The master's degree also requires a research project, but with less emphasis on originality and independence.

Admission

Each student must have a baccalaureate degree in one of the sciences, mathematics, or engineering to be considered for admission to an advanced degree program. An undergraduate major in chemistry, with the following courses, is desirable:

1. One year of organic chemistry (lecture and laboratory).

2. One year of calculus-based physical chemistry (lecture and laboratory).
3. One year of analytical chemistry including instrumental analysis.

Students with deficiencies in any area may be admitted, but such deficiencies may restrict the research areas available to the student and lead to requirements for additional courses during graduate study.

Prospective students are encouraged to contact faculty in areas of the students' research interest.

Applicants are strongly encouraged to submit Graduate Record Examination (GRE) general and chemistry test scores.

Foreign students whose native language is not English will be required to obtain at least 550 paper score, 220 computer score, on the Test for English as a Foreign Language (TOEFL).

This program requires a nonrefundable $50.00 application fee that must be submitted with the application for Admissions to Graduate Study in Chemistry and Biochemistry. Applicants may pay this fee by credit card if applying electronically. Applicants submitting a paper application must pay by personal check, cashier's check, or money order made out to SIU, and payable to a U.S. Bank.

Placement Examinations. During the week before the beginning of classes, each admitted student is given written examinations (ACS standard or equivalent examination) in the five divisions of chemistry: analytical, inorganic, organic, physical, and biochemistry. Every student is required to take at least three exams. The results of these examinations are used to advise the student regarding any deficiencies to be corrected, and to place the student in appropriate courses as determined by a Graduate Student Advisory Committee. Therefore, we strongly encourage and expect all beginning students to review the appropriate undergraduate material before taking these examinations. Failure to pass the exams will generally require that the student take some remedial coursework.

Introduction to Research Techniques. All graduate students must register for CHEM 592, Introduction to Research, during the first fall semester in residence.

Minimum Registration. All students admitted to the department will register for a minimum of 9 credit hours every semester in residence except during the first semester, summer sessions, and while registered for CHEM 601 only. In the first semester, the students must register for a minimum of 6 credit-hours, and in every summer session, a minimum of 3 credit-hours. Registration for less than this requirement is not considered satisfactory progress toward a degree.

Formal Course Work Requirement. Each student must complete the courses specified by the student's graduate committee in the program of study.

The minimum course requirement for Master's students follows the "2+1" format. All master's students must take for credit at least two courses (six semester hours) within the student's major field and at least one (three semester hours) from outside the major field. Typically 500-level courses are required to meet this requirement. Chemistry 594, special readings, cannot be used to meet this requirement. A student's graduate committee may increase any of these departmental course requirements.

The minimum course requirement for doctoral students follows the "2+2" format. All doctoral students must take for credit at least two courses (six semester hours) within the student's major field and at least two courses (six semester hours) from outside the major field. Typically 500-level courses are required to meet this requirement. Chemistry 594, special readings, cannot be used to meet this six hour requirement. Courses taken while in the master's program may be applied to these department course requirements. A student's graduate committee may increase these course requirements.

For a student working in a cross-divisional area, the committee will design an appropriate program of study in consultation with the Graduate Advisor and the faculty of the divisions involved.

Students in the doctoral program must present 3 departmental seminars for credit (CHEM 595). These include one based on a literature review, the second on the topic of an original research proposal, and the final seminar on the student's own research. Only the last 2 seminars are required of students entering the doctoral program with a recognized master's degree. Students in the master's program must present 1 departmental seminar for credit.

All students must take 1 hour of CHEM 597, Professional Training, each semester in residence.

Research Director and Graduate Committee Selection. Each student must select a research director and graduate committee preferably during the first semester, but no later than the end of the second semester in residence. The student must obtain a selection form provided by the graduate adviser and must interview at least 4 faculty members before selecting a research director and graduate committee. For a master's candidate, the committee shall consist of the research director (chair), at least 1 member of the major division other than the research director, and at least 1 member outside the major division. For a Ph.D. candidate, the committee is identical except that at least 1 member outside the department is included. The chair of the Department of Chemistry and Biochemistry, if not otherwise appointed, is an ex-officio member of every graduate committee. A division may increase this requirement.

Graduate Committee Functions. The functions of the graduate committee are listed below.

1. To plan and approve the student's program of study.
2. To review the student's progress in courses and suggest and approve changes in the program of study.
3. To evaluate the student's progress in research and to make appropriate recommendations.
4. To determine whether a student may continue toward a degree. If continuation is denied, the committee must notify in writing the department chair of the reasons for this denial.
5. To read and evaluate the student's thesis or dissertation.
6. To conduct required oral examinations.

As soon as possible after being appointed, the committee will meet to plan the student's program. At this time the progress and program form is completed and filed with the graduate adviser. The committee may require preparation of a master's thesis even if directly pursuing a Ph.D. degree has been previously approved by the faculty.

Research Tools. The department requires specific research tools, which may differ among divisions. A student's graduate committee, taking into account the student's background and the needs of the research area, may require that the student acquire one or more research tools (e.g., foreign language, computer programming, statistics, and so on). Any research tool requirement must be completed before scheduling the preliminary oral examination for doctoral degree students or the final oral examination for master's degree students.

Assistantship Support. Continuation of assistantship support is contingent upon the student making satisfactory progress toward a degree. In addition, continuation of teaching assistantship support depends upon satisfactory performance of assigned duties. The Graduate School has established time limits for financial support.

First Year Evaluation. The faculty, meeting as a committee of the whole, will review the progress of all graduate students at the end of their first year in residence. For students in the doctoral program the faculty can:

1. recommend continuation in the doctoral program.
2. recommend transfer to a terminal master's degree program.
3. request that the Graduate School terminate the student from the program (giving cause).

For students in the master's program the faculty can:

1. recommend petitioning the Graduate School to allow entry to the doctoral program (accelerated entry option). Such petition can be made any time after one semester in residence.
2. recommend continuation in the master's program with the option to petition the Graduate School to grant a master's degree equivalency. When granted, this allows the student to apply for entrance to the doctoral program without writing and defending a thesis.
3. recommend continuation in the master's program with option to petition to enter the doctoral program after completion of a master's thesis.
4. recommend continuation in a terminal master's program.
5. request that the Graduate School terminate the student from the program (giving cause).

Preliminary Examination for the Ph.D. Degree.
Each student in the doctoral program must pass a preliminary examination before being advanced to candidacy. The written portion of the preliminary examination is given cumulatively with 10 examinations scheduled each calendar year. The student must pass 4 examinations in no more than 10 consecutive trials. Students must begin cumulative examinations at the start of their second calendar year or immediately on admission to the doctoral program if one calendar year has already been completed in the master's program. After the student completes the cumulative examinations, the preparation and defense of an original research proposal will serve as the oral portion of the preliminary examination.

Summary of Ph.D. Degree Requirements. Each student must fulfill the requirements of both the Graduate School and the Department of Chemistry and Biochemistry. These requirements are:

1. to obtain three passes in placement exams.
2. to take 1 hour of CHEM 592 during the first fall semester in residence.
3. to take 1 hour of CHEM 597 each semester in residence.
4. to fulfill the divisional course requirements.
5. to earn at least 32 semester hours in research and dissertation (CHEM 598 and 600). At least 24 of these hours must be in CHEM 600.
6. to attend weekly seminars and earn 2 semester hours of CHEM 595 beyond the master's degree requirement by presenting departmental seminars.
7. to maintain at least a 3.00 grade point average.
8. to complete a course of study as determined by the graduate committee.
9. to satisfy any research tool requirement established by the student's graduate committee.
10. to pass a series of cumulative examinations which shall serve as the written portion of the preliminary examination.

11. to prepare and defend an original research proposal which shall serve as the oral portion of the preliminary examination.
12. to complete a research project and to prepare a dissertation acceptable to the student's graduate committee and the Graduate School.
13. to schedule and pass a final oral examination (defense of dissertation).

Summary of Master's Degree Requirements. Each student must fulfill the requirements of both the Graduate School and the Department of Chemistry and Biochemistry. These requirements are:

1. to obtain three passes in placement exams.
2. to take 1 hour of CHEM 592 during the first fall semester in residence.
3. to take 1 hour of CHEM 597 each semester in residence.
4. to fulfill the divisional course requirements.
5. to earn at least 30 semester hours at the 400/500 level, at least 15 of which are at the 500 level. At least 21 of the 30 hours must be graded A, B, or C.
6. to attend weekly seminars and earn 1 semester hour of CHEM 595 by presenting a departmental seminar.
7. to earn at least 8 semester hours in research and thesis (CHEM 596, 598, and 599). At least 3 of these hours must be CHEM 599.
8. to maintain at least a 3.00 grade point average.
9. to satisfy any research tool requirement established by the student's graduate committee.
10. to prepare and present a thesis on the research carried out and to schedule and pass a final oral examination.

Courses (CHEM)

All laboratory courses in chemistry and biochemistry require the student to purchase either special notebooks or workbooks, costing within the range of $1.50 to $8.50. All students enrolled in a chemistry class that includes a laboratory session will be assessed a breakage charge for all glassware broken. This policy will apply to undergraduate and graduate students.

411-3 Intermediate Inorganic Chemistry. Fundamentals of inorganic chemistry, covering bonding and structure, coordination compounds and the chemistry of some familiar and less familiar elements. Three lectures per week. Prerequisite: 456 or 462 or concurrent enrollment. Offered spring semester only.

431-3 Environmental Chemistry. Chemical principles applied to the environment and environmental problems. Chemical kinetic, thermodynamic and equilibrium concepts as they relate to the atmosphere, water and soil will be discussed to include current problems of pollutants, pollutant evaluation and pollutant remediation. Discussion of methods for the chemical analysis of environmental samples will also be included. Prerequisite: C or better in 230 and 340. Offered spring semester in even years only.

434-2 or 4 Instrumental Analytical Chemistry. Theory and practice of instrumental measurements, including emission and absorption spectroscopic, capillary electrophoretic and chromatographic methods. Two lectures and two three-hour laboratories per week for four credits. Enrollment for two credit hours is restricted to graduate students in the Department of Chemistry and Biochemistry who are advised to take instrumental analysis. Laboratory fee: $30. Prerequisite: *C* or better 230. Offered fall semester only.

439-3 Forensic Chemistry. A one semester course covering the collection, handling and analyses of forensic samples and evidence. Topics include procedures to collect, preserve, maintain custody, analyze, validate the data and report conclusions from the analyses of crime related samples. Analytical methods for the qualitative and quantitative analyses of samples by gas chromatography, mass spectroscopy, infrared spectroscopy, fluorescence spectroscopy, ultraviolet and visible spectroscopy will be covered. Other techniques such as capillary and gel electrophoresis, high-pressure liquid chromatography, thin layer chromatography, blood splattering analyses, fingerprint identification, scanning electron microscopy and light microscopy may be included as time permits. One lecture and two three-hour periods containing laboratory experiments, demonstrations, and group discussions per week. Enrollment is limited with preference given to students with high academic standings. Laboratory fee: $30. Prerequisite: C or better in 230 and previous or concurrent enrollment in 434 and instructor consent. Offered spring semester only.

444-3 Intermediate Organic Chemistry. A transitional course between introductory and graduate level chemistry. The chemistry of carbon compounds based upon a mechanistic approach will be discussed. Three lectures per week. Prerequisite: *C* or better in 340, 342. Offered fall semester only.

451-6 (3, 3) Biochemistry. (Same as Microbiology 451, Biochemistry 451 and Molecular Biology, Microbiology and Biochemistry 451) **(a)** Chemistry and function of amino acids, proteins and enzymes; enzyme kinetics; chemistry, function and metabolism of carbohydrates; citric acid cycle; electron transport and oxidative phosphorylation. **(b)** Chemistry, function and metabolism of lipids; nitrogen metabolism; nucleic acid and protein biosynthesis; metabolic regulation. Three lectures per week. Must be taken in a,b sequence. Prerequisite: one year of organic chemistry.

452-3 Structure and Function. This course will cover the structural basis of biomolecules with an emphasis on the chemical and physical aspects involved in the architecture of proteins and nucleic acids. The study of the physical properties of biomolecular interactions and assembly of biomolecules into macromolecular complexes

will be covered. Interpretation of data from atomic resolution techniques will be discusses. Prerequisites: 350 or 451a/b and 461/462 or equivalent.

456-3 Biophysical Chemistry. (Same as Biochemistry 456 and Molecular Biology, Microbiology and Biochemistry 456) A one-semester course in biophysical chemistry intended for biochemists and molecular biologists. Emphasis will be on solution thermodynamics, kinetics and spectroscopy applied to biological systems. Prerequisite: 340 and 342, 451a or concurrent enrollment, Mathematics 141 or 150.

461-3 Quantum Mechanics and Spectroscopy. An introduction to quantum mechanics and spectroscopy. Prerequisite: Mathematics 250; *C* or better in 230, 342, 343; Mathematics 221 or 305 is recommended as prerequisite or concurrent enrollment.

462-3 Classical Physical Chemistry. An introduction to chemical, statistical thermodynamics and kinetics. Prerequisite: Mathematics 250; *C* or better in 230, 342, 343; Mathematics 221 or 305 is recommended as prerequisite or concurrent enrollment. Offered spring semester only.

466-2 (1,1) Physical Chemistry Laboratory. A two-semester laboratory sequence. One three-hour laboratory per week per semester. **(a)** Experiments relating to topics covered in 462 Prerequisite: 462 or 456 or concurrent enrollment. **(b)** Experiments relating to topics covered in 461. Laboratory fee: $30. Prerequisite: 461 or concurrent enrollment. 466a offered spring semester only. 466b offered fall semester only.

468-3 Application of Symmetry to Chemistry. The concepts of symmetry elements, groups and character tables will be taught. Symmetry will be applied to molecules in order to simplify and characterize their wave functions and vibrational frequencies. Prerequisite: *C* or better in 461 or consent of instructor. Offered spring semester in odd years only.

479-3 Principles of Materials Chemistry. Introduction to fundamental concepts of materials chemistry. Synthesis, characterization, processing and applications of different materials including solids, polymers, ceramics and molecularly designed materials. Prerequisite: 411, 462 or concurrent enrollment, or consent of instructor. Offered fall semester in odd years only.

489-1 to 3 Special Topics in Chemistry. Prerequisite: consent of instructor and of chair.

511-6 (3,3) Advanced Inorganic Chemistry. (a) Principles of group theory and their application to molecular structure, ligand field theory and its application and magnetic properties of matter. **(b)** Energetics, kinetics and mechanisms of inorganic systems. Prerequisite: one year of physical chemistry, 411.

519-1 to 9 (1 to 3 per semester) Advanced Topics in Inorganic Chemistry. Metal ions in biological processes and other selected topics to be announced by the department. Maximum credit nine semester hours. Prerequisite: consent of instructor.

531-3 Introduction to Analytical Separations. An introduction to the basic principles underlying separation science, with emphasis on all major chromatographies, gel and capillary electrophoresis, isoelectric focusing, field-flow fractionation, rate and isopynic sedimentation, filtration, reverse osmosis and related methods. Prerequisite: Mathematics 250.

532-3 Analytical Chemistry Instrumentation. Introduction to analog and digital electronics and the computer control of system components. The course will focus on chemical instrumental and the use of filters, amplifiers and digital signal processing to improve sensitivity and detection limits. Two lectures and one three-hour laboratory per week. Prerequisite: 434.

533-3 Analytical Spectroscopy. Fundamental and experimental aspects of electronic and vibrational spectrometry, with a particular emphasis on the spectroscopic analysis of atomic and molecular species. Various sources of electromagnetic radiation, detectors, optical components and the optimization of experimental methods are covered in detail. Common spectroscopic techniques are covered in detail and a portion of the course covers newly emerging techniques and developments. Prerequisite: 434.

534-3 Electrochemistry. Fundamentals and applications of electrochemical methods, with emphasis on the thermodynamics and kinetics of electron transfer, electrode double-layer structures, as well as varied voltammetric techniques. Prerequisite: 462.

535-3 Advanced Analytical Chemistry. Course surveys various statistical, data-manipulative, and numerical methods as applied to analytical chemistry, including probability distributions, methods of maximum likelihood, linear and nonlinear least squares, correlation coefficients, chi-square, F and T distributions, Pearson statistics, analysis of variance, convolution, deconvolution, cross-correlation, autocorrelation, data acquisition, Nyquist theorem, aliasing, digitization errors, digital filtering, Monte Carlo methods, and finite-difference equations. Prerequisite: 434.

536-3 Principles of Mass Spectrometry. This course is an introduction to mass spectrometry with a focus on pharmaceutical and biological applications. Topics that will be covered include instrument design, ionization techniques, tandem mass spectrometry, chromatography/mass spectrometry and mass spectral interpretation. Prerequisite: 434.

537-3 Fluorescence Spectroscopy. Fundamental and experimental aspects of analytical methods based on the various phenomena of luminescence. General principles of luminescence are covered in detail, as well as analytical techniques based on fluorescence quenching, energy transfer, polarization, and time resolved methods. Aspects of source of electromagnetic radiation, detectors, and electronic/optical components are discussed specifically as they pertain to fluorescence spectroscopy. Newly emerging fluorescence based techniques are also discussed. Prerequisite: 434 and 533 (or consent of the instructor).

538-3 Nanoscale Probing and Imaging. This course covers basic principles of scanning probe microscopy and spectroscopy including STM, AFM, ACM and NSOM, and the broad applications in nanoscale probing and imaging. Topics include surface characterization and manipulation, nanolithography, nanomaterials, self-assembly, molecular electronics, optoelectronics, nanoscale electron transfer, single-molecular spectroscopy, protein structures, enzyme dynamics, and living cell imaging. Prerequisite: undergraduate physical and analytical chemistry.

539-1 to 9 (1 to 3 per semester) Advanced Topics in Analytical Chemistry. Selected topics of interest to practicing analytical chemists such as microanalytical chemistry, functional-group chemical determinations, absorption spectroscopy and electroanalytical chemistry. Maximum credit nine semester hours. Prerequisite: 434.

541-3 Organic Structure and Reactivity. Structure and reactivity of organic compounds: steric, electronic, kinetic and thermodynamic aspects and their relation to reactive intermediates. Prerequisite: Master's degree in chemistry, or a grade of *B* or better in 444, or passing grade on the organic diagnostic examination.

542-3 Mechanistic Organic Chemistry. Reaction mechanisms in organic chemistry. Electrocyclic and sigmatropic reactions, cycloadditions, free radicals, photochemistry and organometallic catalysis. Spectroscopic methods. Prerequisite: Master's degree in chemistry, or a grade of *B* or better in 444, or passing grade or the organic placement examination.

Orbital symmetry, photochemistry and the chemistry of the common transient intermediates. Prerequisite: Master's degree in chemistry, or a grade of *B* or better in 444, or passing grade on the organic placement examination.

543-3 Synthetic Organic Chemistry. Organic synthesis: classical and modern methods. Prerequisite: Master's degree in chemistry, or a grade of *B* or better in 444, or passing grade on the organic chemistry placement examination.

549-1 to 9 (1 to 3 per semester) Advanced Topics in Organic Chemistry. Specialized topics in organic chemistry. The topic to be covered is announced by the department. Maximum credit nine semester hours. Prerequisite: 542.

552-3 Biomolecular Structure and Function. This course will cover the structural basis of biomolecules with an emphasis on the chemical and physical aspects involved in the architecture of proteins and nucleic acids. The study of the physical properties of biomolecular interactions and assembly of biomolecules into macromolecular complexes will be covered. Interpretation of data from atomic resolution techniques will be discussed. Prerequsites: 350 or 451a/b and 461/462 equivalent.

559-1 to 3 Advanced Topics in Biological Chemistry. Specialized topics in biological chemistry. The topic to be covered is announced by the department. Maximum credit nine semester hours (1 to 3 per semester). Prerequisite: C or better in 350 or 451a, b or equivalent.

560-3 Introduction to Quantum Chemistry. Basic principles and applications of quantum mechanics to chemistry. Topics include operator and vector algebra, classical mechanics, angular momentum, approximate methods, hydrogen-like atoms and molecular electronic structure. Three lectures per week. Prerequisite: one year of undergraduate physical chemistry.

561-3 Molecular Orbital Theory. An introduction to molecular orbital theory. Applications and limitations of various methods. Three lectures per week. Prerequisite: one year of undergraduate physical chemistry including quantum mechanics.

562-3 Advanced Molecular Spectroscopy. Theory of rotational and vibrational spectroscopy, electronic spectroscopy of molecules. Three lectures per week. Prerequisite: 468 or consent of instructor.

564-3 Statistical Thermodynamics. Principles of statistical mechanics and applications to equilibrium and nonequilibrium systems. Topics include ideal gases, monatomic crystals, lattice statistics, the cluster method, correlation functions, Brownian motion, the Boltzmann equation and the Kubo-Green technique. Three lectures per week. Prerequisite: 461 and 462 or consent of instructor.

569-1 to 9 (1 to 3 per semester) Advanced Topics in Physical Chemistry. Topic to be announced by the department. Maximum credit nine semester hours. Prerequisite: consent of instructor.

575-3 Methods of Materials Characterization. An introduction to the structural, morphological, spectroscopic, and thermal characterization techniques commonly used in materials chemistry. Prerequisite: consent of instructor.

579-3 Topics in Advanced Materials. Design and applications of advanced materials. Special topics will focus on contemporary research areas of interest as determined by the instructor. Prerequisite: consent of instructor.

592-1 Introduction to Research. Introduction to the techniques and methods of chemical research including good laboratory practice, research ethics, record keeping, publication, patents and currently active research in this department. Graded *S*/*U* only.

594-2 to 3 Special Readings in Chemistry. Assigned library work in any of these fields of chemistry with individual instruction by a staff member. **(a)** Analytical, **(c)** Inorganic, **(d)** Organic, **(e)** Physical. Maximum credit three hours.

595-1 Advanced Seminar in Chemistry. Advanced level talks presented by graduate students. **(a)** Analytical, **(c)** inorganic, **(d)** organic, and **(e)** physical chemistry.

596-1 to 6 (1 to 3 per semester) Master's Degree Research. Graded research for Master's Degree only. Maximum 6 credit hours. Prerequisite: admission to Master's program in Chemistry and Biochemistry. Comple-

tion of at least 9 hours of graded graduate course work in the program. Permission of student's graduate advisory committee.

597-1 to 15 Professional Training. Experience in teaching of chemistry, instrument operation and special research projects. One hour required each semester in residence. Graded *S*/*U* only. Prerequisite: graduate standing.

598-1 to 50 (1 to 12 per semester) Research. Maximum credit 50 hours, except by permission of the student's graduate advisory committee. Graded *S*/*U* only. Prerequisite: consent of chair.

599-1 to 6 Thesis. Maximum credit six hours. Prerequisite: consent of chair.

600-1 to 30 (1 to 12 per semester) Dissertation—Doctoral. Requirement for Ph.D. degree, 24 hours. Maximum credit 30 hours, except by permission of the student's graduate advisory committee. Prerequisite: 598.

601-1 per semester Continuing Enrollment. For those graduate students who have not finished their degree programs and who are in the process of working on their dissertation, thesis, or research paper. The student must have completed a minimum of 24 hours of dissertation research, or the minimum thesis, or research hours before being eligible to register for this course. Concurrent enrollment in any other course is not permitted. Graded *S*/*U* or *DEF* only.