DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY

Dr. Hongtao Yu, Professor and Chair
P. O. Box 17910
Phone: (601) 979-2171
Fax: (601) 979-3674
Email: hongtao.yu@jsums.edu

Faculty
Dr. A. Yerramilli, Visiting Professor
Dr. Z. Arslan, Associate Professor
Dr. N. Campbell, Associate Professor
Dr. R. Gao, Associate Professor
Dr. A. Hamme, Associate Professor
Dr. G. Hill, Associate Professor
Dr. M. Hossain, Assistant Professor
Dr. M. Huang, Professor
Dr. K. Lee, Professor
Dr. W. Lester, Adjunct Professor
Dr. J. Leszczynski, Presidential Distinguished Prof.
Dr. Y. Liu, Professor
Dr. E. Noe, Professor
Dr. P. Ray, Associate Professor
Dr. R. Sullivan, Professor Emeritus
Dr. H. Tachikawa, Professor
Dr. R. Venkatraman, Associate Professor
Dr. J. D. Watts, Professor
Dr. J. Zubkowski, Professor

Program Description
The Department of Chemistry offers both a Doctor of Philosophy (Ph.D.) and a Master of Science (M.S.) degree in Chemistry. The Ph.D. degree in chemistry requires evidences of high quality scientific research leading to peer-reviewed publications with classroom teaching, laboratory supervising, and proposal and manuscript writing experiences. The program covers all modern areas of chemistry including analytical, biochemistry, computational, environmental, inorganic, organic, and physical chemistry and interdisciplinary areas in material, energy, environmental, and biomedical research. The intensive graduate training includes formal lecture courses, hands-on laboratory and theoretical research experiences, teaching experiences, independent proposal development, preparation of manuscripts and preparation of research thesis/dissertation for publication.

Program Mission
The Department of Chemistry will provide a comprehensive graduate education in all areas of modern chemistry and related fields for a diverse student body aiming for national and international distinction and produce high quality chemists for education institutions, governmental agencies, and industrial and business entities.

Program Objectives

- To provide the best education and career opportunity for all students including those from the underrepresented minority groups with the best cultural and nurturing environment conducive to learning and scholarly activities.
- To prepare students for development of methods of independent and systematic investigations leading to scientific discoveries.
- To prepare students for a successful career at academic institutions, industrial and business entities, and governmental agencies.
- To promote professional development and growth of the faculty.

Time Limits
For full-time students working toward an **M.S. degree**, the degree requirements should be completed by the end of the second year following the first semester of study. Students beyond their second year of full-time study will be reviewed by their thesis committee for satisfactory progress every semester. A report of unsatisfactory will result in dismissal from the program. Under special circumstances, MS students must graduate in three years in fulltime status. Part time students are considered separately.

For full-time students working toward a **Ph.D. degree**, we recommend that the final defense be completed within five years. Under special circumstances, Ph.D. students must graduate in eight years in fulltime status. Part time students are considered separately. Students beyond their fifth year of full-time study will be reviewed by their dissertation committee for satisfactory progress every semester. A report of unsatisfactory will result in dismissal from the program. The student will be allowed to apply for a Masters degree in this case.

Doctoral Program in Chemistry

Learning Outcomes
1. To train professionals with in-depth knowledge in one main chemistry field with sufficient background in two related fields through advanced course work and laboratory research.
    - Students will have a good understanding of subjects in one field of chemistry by receiving at least "B" for the core course in this field.
    - Students will accomplish a working knowledge of the subject chemistry area by reading scientific papers and performing research in this area.
    - Students will have a good understanding of subjects in two additional chemistry areas by receiving at least "B"s for two other courses relevant to these fields.

- Students will pass comprehensive exams for the student's research area and 1-2 additional areas of chemistry.

2. To produce doctoral professionals who can carry out independent chemical research with competency in research design, data gathering and interpretation, and communication of research results through scientific publication and presentation.
   - Conduct a thorough literature review and provide a properly referenced written report.
   - Master advanced laboratory techniques and computer programs commonly used in scientific research.
   - Demonstrate the ability to conduct laboratory or computational experiments whose results are unknown.
   - Able to analyze results of laboratory or computational research activities.
   - Able to organize and complete an appropriate written research dissertation including all necessary laboratory and library research aspects.
   - Able to prepare manuscripts for publications
3. To prepare doctoral scientists for competitive professional employment in academia, industry, consulting, government, and teaching at the college level.
   - Understand current needs of potential employers
   - Attend professional meetings and make oral or poster presentations
   - Secure internships in governmental labs and/or in industry
   - Successful passing of Chemistry Teaching Course (CHEM750) as teaching assistants and tutoring undergraduate students
4. To train students with an understanding and awareness of professional, ethical and safety applications of their knowledge.
   - Develop and understand the ethical and social dimension of science and the role and responsibility of chemistry for advancement of society.
   - Learn and put into practice the expectations for responsible conduct in professional field.
   - Participate in professional meetings and workshops.

Admission Requirements
In addition to the requirements of the Division of Graduate Studies, applicants must have the following:

- A B.S. degree in chemistry or a closely related field with passing grades 'C' or better for the following courses with labs:
- 2 semesters of General Chemistry
- 2 semesters of Organic Chemistry
- 1 semester of Analytical Chemistry
- 1 semester of Physical Chemistry
- 1 semester of Inorganic Chemistry
- GRE Score*
- Three Letters of Recommendation
- A Statement of Purpose for Graduate Study

(**Students who have difficulty taking the GRE can take the Department's entrance exam instead*)

Retention Requirements
In addition to satisfying the basic requirements of the Division of Graduate Studies, students are required to maintain a chemistry GPA of 3.00 or higher every semester. Seminar courses, dissertation courses, and other non-chemistry elective courses are excluded from the calculation of the chemistry GPA. Students whose chemistry GPA is below 3.00 will be placed on probation for 1-2 semesters to fix the deficiencies.

During the time a student's only course work is to carry out thesis/dissertation research, an unsatisfactory progress in research during any semester, judged by the faculty advisor and the Graduate Advisory Committee, will trigger probationary status. A consecutive unsatisfactory progress will result in dismissal of the student from the program.

Repeating a Course
If a student receives a grade of "C" or lower in a chemistry core course or a course in the student's major field of study, that course must be retaken and the student must earn a grade of "B" or better.

Degree Candidacy Requirements
After completing the lecture and seminar course requirements, students need to take and pass the comprehensive examination and defend an independent research proposal in order to become an official Ph.D. candidate. The comprehensive examination of 3 subjects must be taken and passed during the second year of study and the written independent research proposal must be prepared and defended during the third year of study or at least one year before graduation.

Graduation Requirements
The minimum number of credit hours for the Ph.D. degree in Chemistry is 60 credit hours.

- 18 credit hours from graduate Chemistry lecture courses
- 2 credit hours for Seminars
- 40 credit hours for Dissertation Research
- Teach at least 2 semesters of undergraduate courses as a teaching assistant.
- Pass Area Comprehensive Examination in three subject areas.
- Write and defend an Independent Research Proposal.
- Defend dissertation before the Dissertation Committee and public audience.
- Submit an approved dissertation for publication of five bond copies, one each to the Division of

Graduate Studies, the Department, the University Library, the Faculty Advisor, and the student.

The 18 credit hours of lecture courses must include at least three out of the following five core courses for a total of at least 9 credit hours. Under special circumstances, with recommendation of the faculty advisor and approval by the program director, an elective course critical for the student's subject of study can be used to replace one of the three core courses.

CHEM 723	Advanced Analytical Chemistry
CHEM 731	Advanced Biochemistry
CHEM 736	Physical Organic Chemistry
CHEM 741	Advanced Inorganic Chemistry
CHEM 758	Quantum Chemistry

Students entering the Ph.D Program with a M.S. Degree in Chemistry: Students who earned a M.S. degree from another institution are allowed to transfer up to three (3) lecture courses or 9 credit hours if these courses are equivalent to the JSU chemistry doctoral courses. Students who earned a M.S. degree from JSU chemistry will be required to take at least two more approved lecture courses instead of the required six lecture courses, and the passed comprehensive exams are waved. Other requirements are the same as for those entering the Ph.D. program with a B.S. degree.

Students earning a non-thesis M.S. Degree in Chemistry: Students on the Ph.D. program are given an option to obtain a non-thesis M.S. degree upon completion of the requirements for the degree candidacy for the Ph.D. program (details see "Requirements for Non-Thesis Master's Degree"). Upon receiving the non-Thesis M.S. degree, students will continue on their Ph.D. program without interruption. All credits earned thus far will be counted toward their Ph.D. degree.

Master's Program in Chemistry

Learning Outcomes

1. To train students with in-depth knowledge in one main chemistry field with sufficient background in two related fields through advanced course work and laboratory research.
2. To train students with competency in modern chemical research through data gathering and interpretation and communication of research results through oral and written presentations.
3. To train students for professional employment including industry, teaching at community college and secondary levels, and doctoral programs and professional schools.
4. To train students with an understanding and awareness of the professional, ethical and safety applications of their knowledge.

Admission Requirements

In addition to the requirements of the Division of Graduate Studies, applicants must have the following:

1. A B.S. degree in chemistry or a closely related field with passing grades ("C" or better) in the following courses with labs:
   - 2 semesters of General Chemistry
   - 2 semesters of Organic Chemistry
   - 1 semester of Analytical Chemistry
   - 1 semester of Physical Chemistry
   - 1 semester of Inorganic Chemistry
2. Three Letters of Recommendation
3. A Statement of Purpose for Graduate Study

Retention Requirements

In addition to satisfying the basic requirements of the Division of Graduate Studies, students are required to maintain a chemistry GPA of 3.00 or higher every semester. Seminar courses, dissertation courses, and other non-chemistry elective courses are excluded from the calculation of the chemistry GPA. Students whose chemistry GPA is below 3.00 will be placed on probation for one semester to fix the deficiencies.

Degree Requirements

A student pursuing a M.S. degree in Chemistry is required to complete a minimum of 30 hours with a thesis in Chemistry.

1. Within the 18 credit hours of lecture courses, students must complete at least three (3) of five (5) core courses for a total of nine (9) hour. It is possible to take some courses in related fields upon recommendation of the advisor. The core courses are:

   CHEM 523 Advanced Analytical Chemistry
   CHEM 541 Advanced Inorganic Chemistry
   CHEM 531 Biochemistry
   CHEM 558 Quantum Chemistry
   CHEM 536 Physical Organic Chemistry

   Students will fulfill the remaining 12 hours from Chemistry electives with no more than 11 hours in CHEM 580-Thesis Research.
2. Students are required to take two semesters of chemistry seminar for one (1) credit hour.
3. Pass the Graduate Area Comprehensive Examination in three chemistry areas.
4. The student must participate as a teaching assistant in the chemistry department for at least one semester.
5. Defend a thesis before the Thesis Committee and public audience.
6. Submit an approved thesis for publication of five bond copies, one each to the Division of Graduate Studies, the Department, the University Library, the Faculty Advisor, and the student.

Non-Thesis Master's Degree

Ph.D. students who fulfill the following requirements will be awarded a Non-Thesis Master's degree in Chemistry if the students apply.

1. A minimum of 36 credit hours, including at least 18 hours of approved graduate level lecture courses and two hours of seminar with a GPA of 3.00 or better. The graduate lecture courses should include at least three of the five core courses: Advanced Analytical Chemistry, Advanced Inorganic Chemistry, Biochemistry, Quantum Chemistry, and Physical Organic Chemistry.
2. Pass the Graduate Area Comprehensive Examination in three areas.
3. Pass an oral defense covering the student's research before a committee of four faculty members.

DESCRIPTION OF COURSES

Master-Level Courses

CHEM 511 Chemistry Seminar. (1 Hour) Presentation and discussion of current chemical topics and research by students, faculty and visiting speakers. Prerequisite: Permission of instructor.

CHEM 523 Advanced Analytical Chemistry. (3 Hours) Prerequisites: Courses in Analytical Chemistry and Physical Chemistry. Principles and application of selected analytical methods including electro-chemistry, spectroscopy and selected topics of current interest.

CHEM 526 Electroanalytical Chemistry. (3 Hours) Prerequisite: Advanced Analytical Chemistry. Discussion of potentiometric, conductometric, polarographic, amperometric, coulometric, controlled potential and stepping analysis and related techniques. Emphasis is also placed on theoretical considerations and applications to studies of chemical and charge transfer equilibria and kinetics.

CHEM 531, 532 Biochemistry. (3 Hours) Prerequisite: One year of Organic Chemistry. The chemical composition of living matter and the chemical mechanics of life processes.

CHML 531, 532 Biochemistry Laboratory. (1 Hour) Prerequisite: Chemistry 531 and 532. Basic purification and characterization techniques in Biochemistry.

CHEM 536 Physical Organic Chemistry. (3 Hours) Prerequisites: Physical Chemistry and Organic Chemistry. A study of organic molecular structure, Woodward Hoffmann Rules, substituents effects, intra- and intermolecular forces, kinetics and stereochemistry.

CHEM 541 Advanced Inorganic Chemistry. (3 Hours) Prerequisite: An undergraduate course in Physical Chemistry. A study of inorganic compounds with the application of Physical Chemistry principles to thermodynamic, kinetic and structural problems.

CHEM 553 Thermodynamics. (3 Hours) Prerequisite: Physical Chemistry. Principles of thermodynamics and their application to chemical and phase equilibria.

CHEM 558 Quantum Chemistry. (3 Hours) Prerequisite: Physical Chemistry. Principles and applications of quantum theory.

CHEM 580 Thesis Research. (Variable 1-6 Hours) Prerequisite: Permission of adviser. Selected topics arranged in consultation with the staff; includes literature, research, and laboratory investigation of a problem.

Doctoral-Level Courses

CHEM 711 Seminar (0.5 Hour) Presentation and discussion of current chemical topics and research by visiting speakers, faculty and students. General topics by the instructor or invited guests will be given on scientific ethics, writing, and presentation, and chemical careers. Students are required to prepare a manuscript style research report each semester.

CHEM 721 Advanced Instrumental Analysis (3 Hours). Prerequisite: Analytical Chemistry and Physical Chemistry (two semesters). Theoretical principles and laboratory techniques involved in characterization of chemical systems using instrumental methods on following topics: absorption and emission spectrometry, mass spectrometry, liquid and gas chromatography, and electrophoresis. A laboratory series on spectrophotometry, fluorometry, atomic absorption spectrometry, inductively coupled plasma atomic emission spectrometry, FT-IR, gas chromatography-mass spectroscopy, and high performance liquid chromatography is included.

CHEM 723 Advanced Analytical Chemistry (3 hours) Prerequisite: Analytical Chemistry and Physical Chemistry (two semesters). Theory of chemical equilibria relevant to acid-base, metal-ligand complexes, solubility of precipitates, and biochemical reactions; theory, instrumentation, and application of electroanalytical methods, absorption, emission, ICP-MS, and chromatographic methods; Current trend and recent developments in analytical and bioanalytical chemistry using recent publications; Assignments of advanced laboratory experiments in spectroscopic, electroanalytical, and chromatographic analyses.

CHEM 726 Electroanalytical Chemistry (4 hours) Prerequisite: Advanced Analytical Chemistry. Principles and application of all modern electrochemical methods such as voltammetrics, chronoamperometry, spectroelectrochemistry, and thin layer electrochemistry etc. Electrode kinetics and mass transfer are discussed in detail.

CHEM 729 Spectroscopic Methods for Structural Determination (3 hours). Prerequisite: Analytical and Organic Chemistry. Using of modern spectroscopic methods, mainly Nuclear Magnetic Resonance, Mass Spectrometry, X-Ray Crystallography, and Infrared Spectroscopy for elucidation of simple to complex structures of chemical compounds. Topics on new developments in modern NMR, X-Ray, MS, and IR will be updated and included.

CHEM 731 Advanced Biochemistry I (3 hours) Prerequisite: Biochemistry 431. Introductory topics on proteins, enzymology, bioenergetics, chemistry and intermediary metabolism of carbohydrates, lipids,

proteins and nucleic acids; Advanced topics on storage, transmission, and expression of genetic information, molecular immunology, membrane transport and hormone action.

CHEM 732 Experimental Biochemistry (3 hour) Biochemistry 431. Advanced techniques will be covered for the analysis of cellular function including cell culture and related microscopic techniques, cytotoxicity and cytostatic assays, characterization of kinase activity using immunostaining and electrophoretic methods. This course is consist of 1 hour lectures and 3 hours of laboratory work.

CHEM 733 Advanced Molecular Biology (3 hours) Molecular mechanisms involved in replication, expression and regulation of prokaryotic genes. Topics include: DNA replication, repair, recombination, restriction-modification, recombinant DNA technology, plasmids and transposons, RNA transcription, processing and message splicing.

CHEM 734 Physical Biochemistry (3 hours) Characterization of macromolecules, hydrodynamic methods, multiple equilibria, maromolecule-ligand interactions.

CHEM 736 Physical Organic Chemistry (3 hours) Prerequisite: Organic Chemistry (two semesters). A study of organic molecular structure, reactive intermediates, molecular recognition, substituent effects, intra- and intermolecular forces, kinetics, catalysis, stereochemistry, and photochemistry.

CHEM 738 Organic Synthesis (3 hours) Prerequisite: Organic Chemistry (two semesters). The course covers the formation of carbon-carbon and carbon-heteroatom bonds, functionalization and interconversion of functional groups, reactions of organic reagents, protective groups, total synthesis and asymmetric synthesis in organic synthesis.

CHEM 741 Advanced Inorganic Chemistry (3 hours) Prerequisite: Inorganic Chemistry (CHEM 340). A study of symmetry and group theory, bonding and structures of inorganic compounds, coordination chemistry and acid-base chemistry.

CHEM 743 Structural Inorganic Chemistry (3 hours). A study included concepts of the solid state as explored by crystallography. It covers symmetry, polyhedral, sphere packing, tetrahedral and octahedral structures of inorganic compounds.

CHEM 747 Inorganic Reaction Mechanisms (3 hours) Prerequisite: Consent by Instructor. The topics include mechanism of reactions of inorganic compounds, stereochemical changes in complexes, redox reactions, homogeneous and heterogeneous catalysts.

CHEM 749 Organometallic Chemistry (3 hours) Prerequisite: Physical Organic Chemistry (CHEM 736) or equivalent. A study of formation, stability and reactivity of metal-carbon bond of main group and transition metals and the usage of organometallics in organic synthesis and catalysis.

CHEM 752 Atomic and Molecular Spectroscopy (3 hours) Prerequisite: Physical Chemistry (two semesters). A comprehensive course covering concepts and methods of modern atomic and molecular spectroscopy. Subjects covered include electric phenomena, absorption and emission of radiation, atomic spectroscopy, rotational spectroscopy, vibrational spectroscopy, electronic spectroscopy, and magnetic resonance spectroscopy.

CHEM 753 Thermodynamics (3 hours) Prerequisite: Physical Chemistry (two semesters). Laws of thermodynamics and their chemical applications. Introduction to chemical kinetics and statistical mechanics.

CHEM 754 Kinetics (3 hours) Prerequisite: Physical Chemistry (two semesters). Mechanics of chemical reactions, cross sections, and rate constants. Elastic, inelastic, and rearrangement channels are discussed, using quantum and semiclassical techniques.

CHEM 755 Mechanisms of Organic Chemistry (3 hours) Prerequisite: Organic Chemistry (two semesters). A study of mechanistic aspects of organic reactions included the rate theory, and reaction mechanism, experimental methods and treatment of data.

CHEM 758 Quantum Chemistry (3 hours) Prerequisite: Physical Chemistry (two semesters). Important concepts of quantum chemistry at the intermediate level, including angular momentum, perturbation theory, electronic structure of molecules, and radiation matter interaction. Applications will vary from year to year.

CHEM 763 Statistical Mechanics (3 hours) Prerequisite: Physical Chemistry (two semesters) A study of statistical mechanical ensembles, partition functions and their relationship to thermodynamics, lattice statistics, molecular distribution and correlation functions, the theories of liquids and solutions, phase transitions, and cluster theory.

CHEM 768 Molecular Quantum Mechanics (3 hours) Prerequisite: Quantum Chemistry or equivalent. Theoretical, algorithmic, and practical aspects of the methods of molecular quantum mechanics and their applications to chemical systems. Topics covered include Hartree-Fock theory, perturbation theory, configuration interaction, coupled-cluster theory, and density-functional theory.

CHEM 780 Dissertation - (1 - 9 hours). This course involves original research in one of the sub-disciplines of Chemistry of the chemistry faculty. Enrollment in the course must be continuous until the student produces, presents, and defends a written Dissertation of the approved quality. The research topic will be selected by the graduate advisor and approved by the dissertation committee.

CHEM 782 Special Topics in Analytical Chemistry - (3 hours) Selected topics not covered in regularly scheduled courses, and current research topics in analytical chemistry.

CHEM 783 Special Topics in Biochemistry - (3 hours) Selected topics not covered in regularly scheduled courses, and current research topics in biochemistry.

CHEM 784 Special Topics in Organic Chemistry - (3 hours) A course in a specific area of organic chemistry such as structure determination in organic

chemistry, or current research subject not covered in regularly scheduled courses presented to fit the interests of advanced students.

CHEM 785 Special Topics in Inorganic Chemistry - (3 hours) Topics include subjects of current research in inorganic chemistry, but not covered in regularly scheduled courses.

CHEM 786 Special Topics in Physical Chemistry - (3 hours) Topics vary from year to year will include subjects such as photochemistry, solid state, surface chemistry, and radiation chemistry.

CHEM 787 Nanoscience and Nanotechnology (3 hours) Prerequisites: Physical Chemistry (CHEM 342) and Organic Chemistry (CHEM 242). A comprehensive course provides an introduction to the rapidly developing field of Nanoscience and Nanotechnology with special emphasis on general and material chemistry, environmental science, biotechnology and modeling**.** The topics include properties of individual nanoparticles, bulk nanostructures, carbon nanotubes, quantum wells, wires and dots; the tools and methods for measuring these properties; methods for growing and synthesizing nanomaterials; applications in biological materials and the fabrication of nanomachines and devices.