DEPARTMENT OF CHEMISTRY (GRAD)

The Department of Chemistry offers graduate programs leading to the degrees of master of arts (non-thesis), master of science (thesis), and doctor of philosophy in the fields of analytical, biological, inorganic, organic, physical, and polymer and materials chemistry. Reinforcing the broad nature of our graduate program, we have close interactions with various departments, including the Departments of Physics and Astronomy, Biochemistry and Biophysics, Environmental Science and Engineering, and the Biological and Biomedical Sciences Program.

Research Interests

Analytical

Development of instrumentation for ultra-high pressure capillary liquid chromatography, capillary electrophoresis, and combined two-dimensional separations. Applications include proteomics and measurement of peptide hormones in biological tissues. Mass spectrometry of biological, environmental, organic, and polymeric compounds; tandem MS, ion activation, ion molecule reactions; instrument development. Electrochemistry: new methods for study of biological media, neurotransmitters small spaces, redox solids, chemically modified surfaces, nanoparticle chemistry, and quantum size effects including the analytical chemistry of nanoparticles. Chemical microsystems: microfabricated fluidics technologies (i.e., lab-on-a-chip devices) to address biological measurement problems such as protein expression, cell signaling, and clinical diagnostics. Miniaturized mass spectrometers for environmental monitoring. Nanoscale fluidics devices for single molecule DNA sequencing and chemical sensing. Polymeric membranes to improve the analytical performance of in vivo sensors and enable accurate measurement of analytes in challenging milieu.

Biological

Structure-function relationships of complex biochemical processes; the molecular basis of disease; chemical biology; biophysics; mechanism of protein biosynthesis; metabolic regulation; gene organization and regulation of gene expression; biomolecular structure; protein folding; protein and RNA chemistry under physiologically relevant conditions, in-cell NMR; thermodynamics of protein-protein interactions; characterization of protein-protein and protein-DNA complexes by atomic force microscopy and single molecule fluorescence; in vitro and in vivo studies of DNA repair; RNA structure in vivo, RNA and viral genomics, transcriptome structure, assembly of biomedically important RNA-protein complexes; chemical synthesis of peptides and proteins; protein engineering through chemical synthesis and directed evolution; unnatural amino acid mutagenesis; molecular modeling of biomolecules; cell surface biophysics; fluorescence microscopy and spectroscopy; small molecule and protein microarray development; live cell fluorescence microscopy; genomics-driven natural product discovery; natural product biosynthesis and pathway engineering and design; synthetic biology; antibiotic mechanism of action; bioinformatics; metabolomics; small molecules involved in inter- and intra- species signaling.

Inorganic

Physical inorganic chemistry: electronic structure of transition metal complexes; photochemistry and electrochemistry of metal complexes; use of coordination complexes and inorganic materials for solar energy harvesting and conversion; molecular orbital theory, nuclear magnetic resonance and electron paramagnetic resonance spectroscopies; X-ray crystallography; infrared and Raman spectroscopies. Chemistry of transition metal complexes: synthesis of transition metal compounds, organometallic chemistry including metal-catalyzed organic reactions; reactions of coordinated ligands; kinetics and mechanisms of inorganic reactions; metal cluster chemistry; chiral supramolecular chemistry. Materials chemistry: molecular precursors to materials; solid state lattice design; metal-ion containing thin films; metal-polymer complexes; functional coordination polymers and metal-organic frameworks; chiral porous solids. Bioinorganic and medicinal inorganic chemistry: nanomaterials for biomedical imaging and anticancer drug delivery; reactivity of oxidized metal complexes with nucleic acids, photo-induced DNA cleavage, synthesis and characterization of model complexes for metalloenzymes.

Organic

Synthesis and biological reactions of natural products; peptide synthesis; protein engineering; structure-function studies on polypeptides and proteins; mechanistic and synthetic studies in organometallic chemistry; catalysis using organometallic complexes; nuclear magnetic resonance; kinetics; organosulfur and organophosphorus chemistry; surface effects in chemical behavior; chemistry of reactive intermediates including carbocations, carbanions, carbenes radical ions and radical pairs; photochemistry; light-driven organic catalysis; fluorescent sensors; enzyme inhibitors; new synthetic methods including asymmetric catalysis; stereochemistry and conformational analysis; design and synthesis of models for metalloenzymes; epr investigations of electronic couplings in high-spin organic molecules; spectroscopic studies of free radicals; synthesis and characterization of well-defined polymeric materials; synthesis of materials for use in microelectronics; homogeneous and heterogeneous polymerizations in supercritical fluids; synthesis of engineering polymers; molecular recognition.

Physical Chemistry

Ultrafast spectroscopy: femtosecond laser techniques to study photochemistry (e.g., energy transfer, proton coupled electron transfer) in systems including carbon nanotubes, light harvesting proteins, and several materials relevant to the production of solar fuels. Nonlinear Optics: lasers pulses with widely tunable bandwidths and frequencies with new nonlinear optical methods. Molecular interactions and dynamics in cells using optical Kerr effect and phase contrast methods. Spatial and temporal resolution of energy and charge transport within individual metal oxide nanoparticles using pump-probe microscopies. Biophysics: movements and interactions of regulatory proteins in cell nuclei using optical microscopies (e.g., FRET, FCS). Coherent quantum effects in photosynthesis using new laser spectroscopies analogous to multidimensional NMR techniques. Theoretical Chemistry: molecular dynamics simulations to study the structures and dynamics of biological membranes in addition to the properties of aqueous solutions next to such membranes. Laser spectroscopy in cooled molecular beams of transient species, ions and molecular complexes, subdoppler infrared spectroscopy, ion photodissociation studies, development of spectroscopic techniques, double resonance spectroscopy, pulsed field gradient NMR and NMR imaging. Application of optical and mass spectroscopies to study atmospheric chemistry. Quantum chemistry, density functional theory, quantum biology of neurotransmitters and pharmacological agents, energy minimization, protein dynamics, cooperativity, molecular graphics, mutagenesis, statistical mechanics of a liquid phase, structure and dynamics of aqueous solutions, kinetics in condensed phases, mechanical properties of polymers, state-to-state chemistry, reactions and energy transfer at solid surfaces. Polymer

properties: preparation of and nonlinear optical effects in polymeric systems, self-organized polymers, and liquid crystalline materials.

Polymer and Materials Chemistry

Synthesis, properties, and utilization of novel functional materials for various applications ranging from medicine and microelectronics to oil recovery and climate change. The many-pronged approach includes synthesis and molecular characterization of multifunctional monomers and polymers, computer modeling and intelligent design of molecular architectures that are able to sense, process, and response to impacts from the surrounding environment, and preparation of new engineering thermoplastics and liquid crystalline materials. Recent efforts funded by the National Cancer Institute, National Institute of Health, Advanced Energy Consortium, and Army Research Office are focused on lithographic design of organic nanoparticles for the detection, diagnosis, and treatment of diseases (especially cancer), self-healing, shape-memory, mechanocatalysis, organic solar cells, and imaging contrast agents for oil exploration. A broad variety of expertise includes imaging and probing of submicrometer surface structures by scanning probe microscopy, dynamic mechanical analysis, characterization of polymer dynamics by NMR techniques and light scattering, microfluidics and drug delivery control, measurement of molecular conductivity and energy conversion efficiency, and analytical as well as computational and numerical studies of soft materials, such as polymers, colloids, and liquid crystals.

Facilities and Equipment

Research is carried out in the William Rand Kenan Jr. Laboratories, the W. Lowry and Susan S. Caudill Laboratories, Venable Hall, Murray Hall, Chapman Hall, and the Genome Sciences Building. The undergraduate laboratories are housed in the John Motley Morehead Laboratories. The department is home to several core laboratories managed by Ph.D.-level staff scientists: Electronics Core Laboratory, NMR Core Laboratory, Mass Spectrometry Core Laboratory, X-Ray Core Laboratory, and the Scientific Glass Shop. Hardware and software resources managed by ITS are tailored to meet the needs of a broad range of chemists working on applications in quantum mechanics, molecular dynamics, NMR spectroscopy, X-Ray crystallography, structural biology, and bioinformatics.

Financial Aid and Admission

The department awards a number of industrial fellowships and predoctoral research and teaching appointments. All outstanding prospective graduate students who apply for admission/support are automatically considered for fellowships.

There are more than 200 graduate students in the department. All are supported either as teaching assistants (27 percent), research assistants (65 percent), or as fellows (8 percent) supported by The Graduate School, industry, or the United States government. The duties of the teaching assistants include the preparation for and supervision of laboratory classes in undergraduate courses and the grading of laboratory reports.

Applications for assistantships and fellowships should be made before the end of December, although applicants for assistantships are considered after that date. All international students whose native language is not English must take the Test of English as a Foreign Language (TOEFL) examination in addition to the Graduate Record Examination. However, international students who hold a degree from a university in the United States may be exempt.

Application forms for admission can be completed online at the Graduate School's website (http://gradschool.unc.edu/admissions/). Financial support as well as information about the department can be obtained from the Chemistry Department's graduate website (http://www.chem.unc.edu/grads/). Questions about our program may be directed to the e-mail address chemgs@unc.edu.

Doctor of Philosophy

The Ph.D. degree in chemistry is a research degree, and students normally begin research during the first year in graduate school. The Ph.D. degree consists of completion of a suitable program of study, a preliminary doctoral oral examination, a written comprehensive examination (satisfied by a research summary and dissertation prospectus), an original research proposal, an original research project culminating in a dissertation, and a final oral examination.

Master of Arts (Non-Thesis)

The master of arts (non-thesis) degree requires a minimum of 30 semester hours. A typical path to degree completion is 18 hours of advanced chemistry courses and 12 hours in seminar courses and thesis registration. (Only six hours of CHEM 992 can count towards the 30-hour requirement.) Students must accrue a total of at least two semesters of "full time" status based on UNC–Chapel Hill course registration (9 hours in one semester is full-time, 6–8 hours is half-time, 3–5 hours is quarter-time). *Students must be registered for 3 hours of CHEM 992 in the semester in which the MA Written Report is completed and the degree will be conferred*. The M.A. written examination is a written report on the current state of research in an area that is relevant to a departmental research topic, submitted to and approved/signed by the research advisor. As a substitute for a thesis, the candidate must earn a minimum of three hours of CHEM 992 (master's non-thesis option) in the semester of planned graduation and submit a written research report to the research director.

Master of Science

The master of arts degree requires a minimum of 30 semester hours of credit. A typical course load involves 18 hours of advanced chemistry courses and 12 hours in seminar courses and thesis registration. (Only six hours of CHEM 993 can count towards the 30 hour requirement). Students must accrue a total of at least two semesters of "full time" status based on UNC–Chapel Hill course registration (9 hours in one semester is full-time, 6–8 hours is half-time, 3–5 hours is quarter-time). *Students must be registered for three hours of CHEM 993 in the semester in which the M.S. thesis is defended.* Third-, fourth-, and fifth-year students must register for CHEM 993 for three hours until they graduate. The written comprehensive examination is a research summary approved by the dissertation committee. The oral examination comprises the Doctoral Qualifying Examination as approved by the dissertation committee. A master's thesis and final oral examination are also required.

Following the faculty member's name is a section number that students should use when registering for independent studies, reading, research, and thesis and dissertation courses with that particular professor.

Professors

Erik J. Alexanian (077), Organic Chemistry
Jeffrey Aubé (082), Organic Chemistry
Todd L. Austell (070), Chemistry Education, Academic Advising, Lab Curriculum Development
James F. Cahoon (080), Polymer and Materials Chemistry
Jillian L. Dempsey (003), Inorganic Chemistry

Andrey Dobrynin (023), Polymer and Materials Chemistry
Dorothy A. Erie (011), Physical and Biological Chemistry
Michel R. Gagné (022), Inorganic, Organic and Polymer Chemistry
Gary L. Glish (040), Analytical Chemistry
Leslie M. Hicks (035), Analytical Chemistry
Brian P. Hogan (072), Chemistry Education, Academic Advising, Lab Curriculum Development
Jeffrey S. Johnson (058), Organic Chemistry
Yosuke Kanai (081), Physical Chemistry
David S. Lawrence (076), Organic Chemistry
Bo Li (085), Biological Chemistry
Gerald J. Meyer (054), Inorganic Chemistry
Alexander J. Miller (004), Inorganic Chemistry
Andrew M. Moran (006), Physical Chemistry
David A. Nicewicz (078), Organic Chemistry
Gary J. Pielak (046), Biological Chemistry
Matthew R. Redinbo (055), Biological Chemistry
Mark H. Schoenfisch (057), Analytical and Materials Chemistry
Sergei S. Sheiko (059), Polymer and Materials Chemistry
Jason D. Surratt (074), Analytical Chemistry
Joseph L. Templeton (031), Inorganic Chemistry
Domenic Tiani (071), Chemistry Education, Academic Advising, Lab Curriculum Development
Marcey Waters (056), Organic Chemistry
Kevin M. Weeks (053), Biological Chemistry
Wei You (042), Polymer and Materials Chemistry

Associate Professors

Erin Baker (012), Analytical Chemistry
Joshua E. Beaver (089), Chemistry Education, Academic Advising
Carribeth L. Bliem (083), Chemistry Education, Academic Advising
Nita Eskew (091), Chemistry Education, Academic Advising, Lab Curriculum Development
Frank A. Leibfarth (010), Organic, Polymer and Materials Chemistry
Matthew R. Lockett (037), Analytical Chemistry
Simon J. Meek (079), Organic Chemistry
Scott C. Warren (063), Polymer and Materials Chemistry
Danielle Zurcher (090), Chemistry Education, Academic Advising

Assistant Professors

Elizabeth C. Brunk (050), Biological Chemistry
Anna C. Curtis (073), Chemistry Education, Academic Advising, Lab Curriculum Development
Jade Fostvedt (039), Chemistry Education, Inorganic and Organometallic Chemistry
Megan Jackson (104), Inorganic, Physical and Materials Chemistry
Abigail Knight (014), Organic and Biological Chemistry
Huong Kratochvil (101), Biological Chemistry
Zhiyue Lu (009), Physical Chemistry
Elisa Pieri (025), Physical Chemistry
Sidney M. Wilkerson-Hill (013), Organic Chemistry
Alex Zhukhovitskiy (008), Organic, Polymer and Materials Chemistry

Professors Emeriti

Nancy L. Allbritton
Tomas Baer
Max L. Berkowitz
James L. Coke
Michael T. Crimmins
Joseph Desimone
Richard G. Hiskey
Eugene A. Irene
Richard C. Jarnagin
Donald C. Jicha
Charles S. Johnson Jr.
James W. Jorgenson
Thomas J. Meyer
Royce W. Murray
John Papanikolas
Robert G. Parr
Lee G. Pedersen
J. Michael Ramsey
Michael Rubinstein
Cynthia Schauer
Nancy Thompson
R. Mark Wightman

Chemistry (CHEM)

Advanced Undergraduate and Graduate-level Courses

CHEM 403. Environmental Chemistry Processes. 3 Credits.
Required preparation, a background in chemistry and mathematics, including ordinary differential equations. Chemical processes occurring in natural and engineered systems: chemical cycles; transport and transformation processes of chemicals in air, water, and multimedia environments; chemical dynamics; thermodynamics; structure/activity relationships.

Rules & Requirements
Requisites: Pre- or corequisite, CHEM 261.
Grading Status: Letter grade.
Same as: ENVR 403, ENEC 403.

CHEM 410. Instructional Methods in the Chemistry Classroom. 4 Credits.
Permission of the instructor. This course explores secondary school chemical education through current chemical education theory and classroom teaching. Students will develop a comprehensive approach to teaching chemistry content through student-centered activities.

Rules & Requirements
Making Connections Gen Ed: EE- Field Work.
Requisites: Prerequisites, CHEM 241, 251, 262, and 262L.
Grading Status: Letter grade.

CHEM 420. Introduction to Polymers. 3 Credits.
Chemical structure and nomenclature of macromolecules, synthesis of polymers, characteristic polymer properties. Previously offered as APPL 420.

Rules & Requirements
Requisites: Prerequisite, CHEM 261 or 261H; Pre- or corequisites, CHEM 262 or 262H, and 262L or 263L.
Grading Status: Letter grade.

CHEM 421. Synthesis of Polymers. 3 Credits.
Synthesis and reactions of polymers; various polymerization techniques. Previously offered as APPL 421.

Rules & Requirements
Requisites: Prerequisites, CHEM 251 and 262 or 262H.
Grading Status: Letter grade.

CHEM 422. Physical Chemistry of Polymers. 3 Credits.
Polymerization and characterization of macromolecules in solution. Previously offered as APPL 422.

Rules & Requirements
Requisites: Prerequisites, CHEM 420 and 481.
Grading Status: Letter grade.

CHEM 423. Intermediate Polymer Chemistry. 3 Credits.
Polymer dynamics, networks and gels. Previously offered as APPL 423.

Rules & Requirements
Requisites: Prerequisite, CHEM 422.
Grading Status: Letter grade.

CHEM 425. Polymer Materials. 3 Credits.
Solid-state properties of polymers; polymer melts, glasses and crystals.

Rules & Requirements
Requisites: Prerequisite, CHEM 421 or 422.
Grading Status: Letter grade.

CHEM 430. Introduction to Biological Chemistry. 3 Credits.
The study of cellular processes including catalysts, metabolism, bioenergetics, and biochemical genetics. The structure and function of biological macromolecules involved in these processes is emphasized. Honors version available.

Rules & Requirements
Requisites: Prerequisites, BIOL 101, and CHEM 262 or 262H.
Grading Status: Letter grade.
Same as: BIOL 430.

CHEM 431. Macromolecular Structure and Metabolism. 3 Credits.
Structure of DNA and methods in biotechnology; DNA replication and repair; RNA structure, synthesis, localization and transcriptional reputation; protein structure/function, biosynthesis, modification, localization, and degradation.

Rules & Requirements
Requisites: Prerequisites, CHEM 430 and BIOL 220 or BIOL 202.
Grading Status: Letter grade.

CHEM 432. Metabolic Chemistry and Cellular Regulatory Networks. 3 Credits.
Biological membranes, membrane protein structure, transport phenomena; metabolic pathways, reaction themes, regulatory networks; metabolic transformations with carbohydrates, lipids, amino acids, and nucleotides; regulatory networks, signal transduction.

Rules & Requirements
Requisites: Prerequisite, CHEM 430.
Grading Status: Letter grade.

CHEM 441. Intermediate Analytical Chemistry. 3 Credits.
Spectroscopy, electroanalytical chemistry, chromatography, thermal methods of analysis, signal processing.

Rules & Requirements
Requisites: Prerequisites, CHEM 241, 241L, 262, and 480 or 481.
Grading Status: Letter grade.

CHEM 441L. Intermediate Analytical Chemistry Laboratory. 2 Credits.
Experiments in spectroscopy, electroanalytical chemistry, chromatography, thermal methods of analysis, and signal processing. One four-hour laboratory a week and one one-hour lecture.

Rules & Requirements
Requisites: Corequisite, CHEM 441.
Grading Status: Letter grade.

CHEM 443. Surface Analysis. 3 Credits.
This class will focus on analytical techniques capable of probing the physical and chemical properties of surfaces and interfaces. These analyses are extremely challenging, as the sample sizes are small (e.g., 1E14 molecules/cm2 of a material). The course will focus on complementary techniques to assess surface structure and topography, atomic and molecular composition, organization or disorder, and reactivity.

Rules & Requirements
Requisites: Prerequisite, CHEM 441 or CHEM 481; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

CHEM 444. Separations. 3 Credits.
Theory and applications of equilibrium and nonequilibrium separation techniques. Extraction, countercurrent distribution, gas chromatography, column and plane chromatographic techniques, electrophoresis, ultra-centrifugation, and other separation methods.

Rules & Requirements
Requisites: Prerequisites, CHEM 441 and CHEM 480 or 481.
Grading Status: Letter grade.

CHEM 445. Electroanalytical Chemistry. 3 Credits.
Basic principles of electrochemical reactions, electroanalytical voltammetry as applied to analysis, the chemistry of heterogeneous electron transfers, and electrochemical instrumentation.

Rules & Requirements
Making Connections Gen Ed: EE- Mentored Research.
Requisites: Prerequisites, CHEM 480 or 481, and CHEM 441.
Grading Status: Letter grade.

CHEM 446. Analytical Spectroscopy. 3 Credits.
Optical spectroscopic techniques for chemical analysis including conventional and laser-based methods. Absorption, fluorescence, scattering and nonlinear spectroscopies, instrumentation and signal processing.

Rules & Requirements
Requisites: Prerequisites, CHEM 441 and 482.
Grading Status: Letter grade.

CHEM 447. Bioanalytical Chemistry. 3 Credits.
Principles and applications of biospecific binding as a tool for performing selective chemical analysis.

Rules & Requirements
Requisites: Prerequisite, CHEM 441.
Grading Status: Letter grade.

CHEM 448. Mass Spectrometry. 3 Credits.
Fundamental theory of gaseous ion chemistry, instrumentation, combination with separation techniques, spectral interpretation for organic compounds, applications to biological and environmental chemistry.

Rules & Requirements
Requisites: Prerequisites, CHEM 480 or 481, and CHEM 441.
Grading Status: Letter grade.

CHEM 449. Microfabricated Chemical Measurement Systems. 3 Credits.
Introduction to micro and nanofabrication techniques, fluid and molecular transport at the micrometer to nanometer length scales, applications of microtechnology to chemical and biochemical measurements.

Rules & Requirements
Requisites: Prerequisite, CHEM 441.
Grading Status: Letter grade.

CHEM 450. Intermediate Inorganic Chemistry. 3 Credits.
Introduction to symmetry and group theory; bonding, electronic spectra, and reaction mechanisms of coordination complexes; organometallic complexes, reactions, and catalysis; bioinorganic chemistry. Honors version available.

Rules & Requirements
Requisites: Prerequisite, CHEM 251.
Grading Status: Letter grade.

CHEM 451. Theoretical Inorganic Chemistry. 3 Credits.
Chemical applications of symmetry and group theory, crystal field theory, molecular orbital theory. The first third of the course, corresponding to one credit hour, covers point symmetry, group theoretical foundations and character tables.

Rules & Requirements
Requisites: Prerequisites, CHEM 262 or 262H and 450.
Grading Status: Letter grade.

CHEM 452. Electronic Structure of Transition Metal Complexes. 3 Credits.
A detailed discussion of ligand field theory and the techniques that rely on the theoretical development of ligand field theory, including electronic spectroscopy, electron paramagnetic resonance spectroscopy, and magnetism.

Rules & Requirements
Requisites: Prerequisite, CHEM 451.
Grading Status: Letter grade.

CHEM 453. Organotransition Metal Chemistry. 2 Credits.
Exploring the synthesis, bonding, and reactivity of of organotransition metal complexes. Topics typically include organometallic ligand classification, the elementary steps of organometallic reactions, and applications in catalysis.

Rules & Requirements
Requisites: Prerequisite, CHEM 465.
Grading Status: Letter grade.

CHEM 460. Intermediate Organic Chemistry. 3 Credits.
Modern topics in organic chemistry. Honors version available.

Rules & Requirements
Requisites: Prerequisite, CHEM 262 or 262H.
Grading Status: Letter grade.

CHEM 463. Bioorganic Chemistry. 3 Credits.
Bioorganic chemistry integrates topics from synthetic chemistry, biochemistry, and biophysics to study biomacromolecules and develop tools and materials that utilize them.

Rules & Requirements
Requisites: Prerequisites, CHEM 262 and CHEM 430.
Grading Status: Letter grade.

CHEM 465. Mechanisms of Organic and Inorganic Reactions. 4 Credits.
Kinetics and thermodynamics, free energy relationships, isotope effects, acidity and basicity, kinetics and mechanisms of substitution reactions, one- and two-electron transfer processes, principles and applications of photochemistry, organometallic reaction mechanisms.

Rules & Requirements
Requisites: Prerequisite, CHEM 450.
Grading Status: Letter grade.

CHEM 466. Advanced Organic Chemistry I. 3 Credits.
A survey of fundamental organic reactions including substitutions, additions, elimination, and rearrangements; static and dynamic stereochemistry; conformational analysis; molecular orbital concepts and orbital symmetry.

Rules & Requirements
Requisites: Prerequisite, CHEM 460.
Grading Status: Letter grade.

CHEM 467. Advanced Organic Chemistry II. 2 Credits.
Spectroscopic methods of analysis with emphasis on elucidation of the structure of organic molecules: 1H and 13C NMR, infrared, ultraviolet, ORD-CD, mass, and photoelectron spectroscopy.

Rules & Requirements
Requisites: Prerequisite, CHEM 466.
Grading Status: Letter grade.

CHEM 468. Synthetic Aspects of Organic Chemistry. 3 Credits.
Modern synthetic methods and their application to the synthesis of complicated molecules.

Rules & Requirements
Requisites: Prerequisite, CHEM 466.
Grading Status: Letter grade.

CHEM 469. Organometallics and Catalysis. 3 Credits.
Structure and reactivity of organometallic complexes and their role in modern catalytic reactions

Rules & Requirements
Requisites: Prerequisites, CHEM 450 and 466.
Grading Status: Letter grade.

CHEM 470. Fundamentals of Materials Science. 3 Credits.
Crystal geometry, diffusion in solids, mechanical properties of solids, electrical conduction in solids, thermal properties of materials, phase equilibria. Previously offered as APPL 470.

Rules & Requirements
Requisites: Prerequisite, CHEM 482 or PHYS 128; Pre- or corequisite, PHYS 441.
Grading Status: Letter grade.

CHEM 472. Chemistry and Physics of Electronic Materials Processing. 3 Credits.
A survey of materials processing and characterization used in fabricating microelectronic devices. Crystal growth, thin film deposition and etching, and microlithography. Previously offered as APPL 472. Permission of the instructor.

Rules & Requirements
Requisites: Prerequisite, CHEM 482 or PHYS 117 or 119.
Grading Status: Letter grade.
Same as: PHYS 472.

CHEM 473. Chemistry and Physics of Surfaces. 3 Credits.
The structural and energetic nature of surface states and sites, experimental surface measurements, reactions on surfaces including bonding to surfaces and adsorption, interfaces. Previously offered as APPL 473.

Rules & Requirements
Requisites: Prerequisite, CHEM 470.
Grading Status: Letter grade.

CHEM 480. Introduction to Biophysical Chemistry. 3 Credits.
Does not carry credit toward graduate work in chemistry or credit toward any track of the B.S. degree with a major in chemistry. Application of thermodynamics to biochemical processes, enzyme kinetics, properties of biopolymers in solution.

Rules & Requirements
Requisites: Prerequisites, CHEM 261 or 261H; and MATH 232; Pre- or corequisite, PHYS 105, or 115, or 117, or 119.
Grading Status: Letter grade.

CHEM 481. Physical Chemistry I. 3 Credits.
Thermodynamics, kinetic theory, chemical kinetics.

Rules & Requirements
Requisites: Prerequisites, CHEM 102 or 102H, PHYS 118 or 116; pre- or corequisites, MATH 383 and PHYS 119 or 117; C- or better required in chemistry course prerequisites.
Grading Status: Letter grade.

CHEM 481L. Physical Chemistry Laboratory I. 2 Credits.
Experiments in physical chemistry. One four-hour laboratory each week.

Rules & Requirements
Requisites: Pre- or corequisite, CHEM 482.
Grading Status: Letter grade.

CHEM 482. Physical Chemistry II. 3 Credits.
Introduction to quantum mechanics, atomic and molecular structure, spectroscopy, statistical mechanics.

Rules & Requirements
Requisites: Prerequisite, CHEM 481.
Grading Status: Letter grade.

CHEM 482L. Physical Chemistry Laboratory II. 2 Credits.
Experiments in physical chemistry. Solving thermodynamic and quantum mechanical problems using computer simulations. One three-hour laboratory and a single one-hour lecture each week.

Rules & Requirements
Requisites: Prerequisite, CHEM 482.
Grading Status: Letter grade.

CHEM 484. Thermodynamics and Introduction to Statistical Thermodynamics. 3 Credits.
Thermodynamics, followed by an introduction to the classical statistical mechanics and non-equilibrium thermodynamics.

Rules & Requirements
Requisites: Prerequisite, CHEM 482.
Grading Status: Letter grade.

CHEM 485. Chemical Dynamics. 3 Credits.
Experimental and theoretical aspects of atomic and molecular reaction dynamics.

Rules & Requirements
Requisites: Prerequisites, CHEM 481 and 482.
Grading Status: Letter grade.

CHEM 486. Introduction to Quantum Chemistry. 3 Credits.
Introduction to the principles of quantum mechanics. Approximation methods, angular momentum, simple atoms and molecules.

Rules & Requirements
Requisites: Prerequisites, CHEM 481 and 482.
Grading Status: Letter grade.

CHEM 487. Introduction to Molecular Spectroscopy. 3 Credits.
Interaction of radiation with matter; selection rules; rotational, vibrational, and electronic spectra of molecules; laser based spectroscopy and nonlinear optical effects.

Rules & Requirements
Requisites: Prerequisite, CHEM 486.
Grading Status: Letter grade.

CHEM 488. Quantum Chemistry. 3 Credits.
Applications of quantum mechanics to chemistry. Molecular structure, time-dependent perturbation theory, interaction of radiation with matter.

Rules & Requirements
Requisites: Prerequisite, CHEM 486.
Grading Status: Letter grade.

CHEM 489. Statistical Mechanics. 3 Credits.
Applications of statistical mechanics to chemistry. Ensemble formalism, condensed phases, nonequilibrium processes.

Rules & Requirements
Requisites: Prerequisite, CHEM 484.
Grading Status: Letter grade.

CHEM 492. Molecular Modeling in Chemistry. 2 Credits.
This course is offered to first-year graduate and upper-class undergraduate students in different chemistry disciplines who are interested in gaining skills in molecular modeling using modern methodologies from computational chemistry. No prior experience is required. An overview of quantum mechanics (QM) and molecular dynamics (MD) methodologies will be provided. It will also provide extensive experiences to perform different types of computations with abundant hands-on exercises using Gaussian package for QM and LAMMPS for MD simulations.

Rules & Requirements
Grading Status: Letter grade.

CHEM 520L. Polymer Chemistry Laboratory. 2 Credits.
Various polymerization techniques and characterization methods. One four-hour laboratory each week. Previously offered as APPL 520L.

Rules & Requirements

IDEAs in Action Gen Ed: RESEARCH.
Making Connections Gen Ed: EE- Mentored Research.
Requisites: Pre- or corequisite, CHEM 420 or 421 or 425.
Grading Status: Letter grade.

CHEM 530L. Laboratory Techniques for Biochemistry. 3 Credits.
An introduction to chemical techniques and research procedures of use in the fields of protein and nucleic acid chemistry. Two four-hour laboratories and one one-hour lecture a week.

Rules & Requirements

IDEAs in Action Gen Ed: RESEARCH.
Making Connections Gen Ed: EE- Mentored Research.
Requisites: Prerequisites, BIOL 202 or BIOL 220; pre- or co-requisite, CHEM 430.
Grading Status: Letter grade.

CHEM 541L. Advanced Instrumentation and Analytical Measurement Laboratory. 2 Credits.
A laboratory devoted to modern instrumental methods and analytical techniques. One four-hour laboratory and one one-hour lecture each week.

Rules & Requirements

IDEAs in Action Gen Ed: RESEARCH.
Requisites: Pre- or corequisite, CHEM 441.
Grading Status: Letter grade.

CHEM 550L. Synthetic Chemistry Laboratory I. 2 Credits.
A laboratory devoted to synthesis and characterization of inorganic complexes and materials. A four-hour synthesis laboratory, a characterization laboratory outside of the regular laboratory period, and a one-hour recitation each week.

Rules & Requirements

IDEAs in Action Gen Ed: RESEARCH.
Making Connections Gen Ed: CI.
Requisites: Prerequisites, CHEM 241L or 245L, 251, and 262L or 263L.
Grading Status: Letter grade.

CHEM 551L. Honors Synthetic Chemistry Lab. 2 Credits.
This is an honors laboratory course designed to lead you from challenging introductory experiments to five weeks of laboratory work on an independent research project. In addition to exposing you to advanced synthetic techniques, this course will allow you to use multiple modern techniques to characterize the inorganic and organometallic complexes you prepare. Students may not receive credit in both CHEM 551L and CHEM 550L.

Rules & Requirements
Requisites: Prerequisites, CHEM 262L and 251.
Grading Status: Letter grade.

CHEM 692H. Senior Honors Thesis. 3 Credits.
CHEM 395 or equivalent must have been in the same laboratory as 692H. Senior majors only. Required of all candidates for honors or highest honors.

Rules & Requirements
Requisites: Prerequisite, six credit hours of CHEM 395 or equivalent research experience in same laboratory as 692H.
Grading Status: Letter grade.

Graduate-level Courses

CHEM 701. Introduction to Laboratory Safety. 1 Credits.
Permission of the instructor for undergraduates. This introductory course in laboratory chemical safety is required for all entering chemistry graduate students. Topics include laboratory emergencies, chemical hazards, laboratory inspections and compliance, working with chemicals, waste handling, case studies of university accidents, laboratory equipment, biosafety, radiation, animals, and microfabrication and nanomaterials.

Rules & Requirements
Grading Status: Letter grade.

CHEM 721. Seminar in Materials Chemistry. 2 Credits.
Graduate standing required.

Rules & Requirements
Repeat Rules: May be repeated for credit.
Grading Status: Letter grade.

CHEM 730. Chemical Biology. 2-4 Credits.
Application of chemical principles and tools to study and manipulate biological systems; in-depth exploration of examples from the contemporary literature. Topics include new designs for the genetic code, drug design, chemical arrays, single molecule experiments, laboratory-based evolution, chemical sensors, and synthetic biology.

Rules & Requirements
Requisites: Prerequisite, CHEM 430.
Grading Status: Letter grade.

CHEM 731. Seminar in Biological Chemistry. 2 Credits.
Graduate standing required. Literature survey dealing with topics in protein chemistry and nucleic acid chemistry.

Rules & Requirements
Grading Status: Letter grade.

CHEM 732. Advances in Macromolecular Structure and Function. 3 Credits.
In-depth analysis of the structure-function relationships governing protein-protein and protein-nucleic acid interactions. Topics include replication, DNA repair, transcription, translation, RNA processing, protein complex assembly, and enzyme regulation. Course includes both the current and classic literature that highlight the techniques used to study these processes.

Rules & Requirements
Grading Status: Letter grade.

CHEM 733. Special Topics in Biological Chemistry. 0.5-21 Credits.
Modern topics in biological chemistry.

Rules & Requirements
Grading Status: Letter grade.

CHEM 741. Literature Seminar in Analytical Chemistry. 2 Credits.
Graduate standing required. Colloquium of modern analytical chemistry topics presented by graduate students and select invited speakers.

Rules & Requirements
Grading Status: Letter grade.

CHEM 742. Analytical Research Techniques. 2 Credits.
Introduction to chemical instrumentation including digital and analog electronics, computers, interfacing, and chemometric techniques. Two one-hour lectures a week.

Rules & Requirements
Grading Status: Letter grade.

CHEM 742L. Laboratory in Analytical Research Techniques. 2 Credits.
Experiments in digital and analog instrumentation, computers, interfacing and chemometrics, with applications to chemical instrumentation.

Rules & Requirements
Requisites: Co-requisite, CHEM 742.
Grading Status: Letter grade.

CHEM 744. Special Topics in Analytical Chemistry. 0.5-21 Credits.
Modern topics in analytical chemistry, including advanced electroanalytical chemistry, advanced mass spectrometry, chemical instrumentation, and other subjects of recent significance. Two lecture hours a week.

Rules & Requirements
Grading Status: Letter grade.

CHEM 745. Analytical Technical Writing Workshop. 1 Credits.
Students will participate in 12 workshop sessions co-presented by the instructor and TA covering the basics of technical writing. Each workshop is designed to help students prepare successful proposals for external graduate fellowships, but skills practiced are readily extended to the 2nd-year prospectus, manuscript preparation, the thesis, and beyond.

Rules & Requirements
Repeat Rules: May be repeated for credit. 3 total credits. 1 total completions.
Grading Status: Letter grade.

CHEM 752. Special Topics in Inorganic Chemistry. 0.5-21 Credits.
Permission of the instructor. Research-level survey of topics in inorganic chemistry and related areas.

Rules & Requirements
Grading Status: Letter grade.

CHEM 754. Literature Seminar in Inorganic Chemistry. 2 Credits.
Graduate standing required.

Rules & Requirements
Grading Status: Letter grade.

CHEM 755. Inorganic Technical Writing Workshop. 1 Credits.
Students will participate in 11 workshop sessions co-presented by the instructor and TA covering the basics of technical writing. They are designed to help students prepare successful proposals for external graduate fellowships, but skills practiced are readily extended to the 2nd-year prospectus, 3rd-year proposal, manuscript preparation, the thesis, and beyond.

Rules & Requirements
Grading Status: Letter grade.

CHEM 758. Introduction to Chemical Crystallography. 3 Credits.
The course "Introduction to Chemical Crystallography" is intended for graduate students who wish to acquire a basic understanding of crystallography, the mathematical foundations of diffraction principles, the hands-on experience in the operation of X-ray diffractometers, computer software for crystal structure determination and visualization, as well as crystallographic databases. The goal of the course is to prepare students to independently operate diffractometers and carry out X-ray structure determinations for their Ph.D. or M.S. theses.

Rules & Requirements
Requisites: Prerequisites, Knowledge of elementary and differential calculus is assumed; this course is designed to introduce students to the techniques used in solving and refining crystal structures by the use of X-ray diffraction; no prior knowledge of crystallography is required, but students are required to pass the radiation safety exam in the first week of the course.
Grading Status: Letter grade.

CHEM 761. Seminar in Organic Chemistry. 2 Credits.
Graduate standing required. One afternoon meeting a week and individual consultation with the instructor.

Rules & Requirements
Grading Status: Letter grade.

CHEM 764. Special Topics in Organic Chemistry. 1-3 Credits.
Two lecture hours a week.

Rules & Requirements
Repeat Rules: May be repeated for credit. 9 total credits. 9 total completions.
Grading Status: Letter grade.

CHEM 765. Modern Free Radical Chemistry. 3 Credits.
This course is intended for 2nd year and higher graduate students who have the appropriate prerequisites or permission from the instructor(s). The topics covered in this course pertain to modern radical chemistry in organic synthesis and the goal is to prepare students for the implementation of radical chemistry in advanced applications.

Rules & Requirements
Requisites: Prerequisite, CHEM 466 or permission of the instructor.
Grading Status: Letter grade.

CHEM 780. Advanced Materials Science. 3 Credits.
This course covers the physical fundamentals of material science with an in-depth discussion of structure formation in soft and hard materials and how structure determines material mechanical, electrical, thermal, and optical properties. Topics include amorphous and crystal structures, defects, dislocation theory, thermodynamics and phase diagrams, diffusion, interfaces and microstructures, solidification, and theory of phase transformation. Special emphasis will be on the structure-property relationships of (bio)polymers, (nano)composites, and their structure property relationships.

Rules & Requirements
Grading Status: Letter grade.
Same as: MTSC 780, BMME 780, PHYS 780.

CHEM 781. Seminar in Physical Chemistry. 2 Credits.
Graduate standing required. Two hours a week.

Rules & Requirements
Grading Status: Letter grade.

CHEM 783. Special Topics in Physical Chemistry. 0.5-21 Credits.
Permission of the instructor. Modern topics in physical chemistry, chemical physics, or biophysical chemistry. One to three lecture hours a week.

Rules & Requirements
Grading Status: Letter grade.

CHEM 786. Special Topics in Physical Chemistry. 0.5-21 Credits.
Permission of the instructor. Modern topics in physical chemistry, chemical physics, or biophysical chemistry. One to three lecture hours a week.

Rules & Requirements
Grading Status: Letter grade.

CHEM 791. Special Topics in Chemistry. 1-4 Credits.
Selected research-level, cross-disciplinary topics in modern chemistry.

Rules & Requirements
Grading Status: Letter grade.

CHEM 921. Research Methodology and Seminar in Polymer/Materials Chemistry. 1-21 Credits.
Seminar and directed study on research methods of polymer/materials chemistry. This course provides a foundation for master's thesis or doctoral dissertation research.

Rules & Requirements
Repeat Rules: May be repeated for credit.
Grading Status: Letter grade.

CHEM 931. Research Methodology and Seminar in Biological Chemistry. 1-21 Credits.
Seminar and directed study on research methods of biological chemistry. This course provides a foundation for master's thesis or doctoral dissertation research.

Rules & Requirements
Grading Status: Letter grade.

CHEM 941. Research Methodology and Seminar in Analytical Chemistry. 1-21 Credits.
Seminar and directed study on research methods of analytical chemistry. The course provides a foundation for master's thesis or doctoral dissertation research.

Rules & Requirements
Grading Status: Letter grade.

CHEM 951. Research Methodology and Seminar in Inorganic Chemistry. 1-21 Credits.
Seminar and directed study on research methods of inorganic chemistry. The course provides a foundation for master's thesis or doctoral dissertation research.

Rules & Requirements
Grading Status: Letter grade.

CHEM 961. Research Methodology and Seminar in Organic Chemistry. 1-21 Credits.
Seminar and directed study on research methods of organic chemistry. The course provides a foundation for master's thesis or doctoral dissertation research.

Rules & Requirements
Grading Status: Letter grade.

CHEM 981. Research Methodology and Seminar in Physical Chemistry. 1-21 Credits.
Seminar and directed study on research methods of physical chemistry. The course provides a foundation for master's thesis or doctoral dissertation research.

Rules & Requirements
Grading Status: Letter grade.

CHEM 992. Master's (Non-Thesis). 3 Credits.
Rules & Requirements
Repeat Rules: May be repeated for credit.

CHEM 993. Master's Research and Thesis. 3 Credits.
Rules & Requirements
Requisites: Prerequisite, CHEM 921, 931, 941, 951, 961, or 981.
Repeat Rules: May be repeated for credit.

CHEM 994. Doctoral Research and Dissertation. 3 Credits.
Rules & Requirements
Requisites: Prerequisite, CHEM 921, 931, 941, 951, 961, or 981.
Repeat Rules: May be repeated for credit.

Contact Information

Department of Chemistry
Visit Program Website (http://www.chem.unc.edu)

Chair
Wei You
chemchair@unc.edu

Director of Graduate Studies
Alex Miller
ajmm@email.unc.edu

Chemistry Student Services Coordinator
Jill Fallin
chemgs@unc.edu