Duke
UNIVERSITY

CHEMISTRY HANDBOOK

FOR MAJORS AND POTENTIAL MAJORS

2014 - 2015

http://www.chem.duke.edu/undergraduates/

To the student:

This Handbook is prepared expressly for you. For prospective majors, the Handbook provides a description of the curricular requirements and opportunities to help you to make an informed decision on whether a Chemistry major is right for you. For majors, the Handbook provides a guide to help you navigate your path to graduation. Included is an introduction to the Department of Chemistry; a description of courses open to undergraduates; recommendations on how these courses may be used to satisfy degree requirements; and information about special programs and opportunities available to the major in Chemistry.

A general statement of the discipline, mission, goals, and learning objectives for the Chemistry undergraduate program can be found on our web page at

http://www.chem.duke.edu/undergraduates/

The study of Chemistry provides a fascinating and intellectually stimulating foray into the molecular underpinnings of the world around us, and through independent study, an opportunity to participate first hand in cutting edge research that spans a wide range of disciplines in the molecular sciences. A Chemistry major provides a path to many educational and career opportunities, from graduate school in chemistry, biochemistry, or pharmacology, to professional degrees in medicine, engineering or patent law, to jobs in the chemical and pharmaceutical industries. For more information on our chemistry majors and the paths they pursue, see the section "Profile of a Chemistry Major."

Students who have not declared a major and have questions about the Chemistry major should feel free to contact the Director of Undergraduate Studies Group (R. MacPhail and C. Roy) at dus@chem.duke.edu. Students who have declared a Chemistry major will be assigned a faculty adviser in the Department who is available for consultation at any time during the academic year, or they may also contact the DUS group at the above e-mail address.

On behalf of our Chair, Professor Stephen Craig, and our faculty colleagues in the Department, we invite you to consider one of the degree programs described here.

Most sincerely yours,

Richard A. MacPhail
Director of Undergraduate Studies
in Chemistry

Christopher P. Roy
Associate Director of Undergraduate Studies
in Chemistry

HANDBOOK FOR MAJORS AND POTENTIAL MAJORS 2014-2015

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FACULTY

Professor Craig, *Chair;* Associate Professor Franz, *Associate Chair:* Associate Professor MacPhail *Director of Undergraduate Studies*; Lecturer Roy, *Associate Director of Undergraduate Studies and Supervisor of First-Year Instruction*; Associate Professor Hong, *Director of Graduate Studies*; Professors Baldwin, Beratan, Craig, Crumbliss, Fitzgerald, Liu, McCafferty, Therien, Toone, Vo-Dinh, Warren, Widenhoefer, and Yang; Associate Professors Franz, Hong, and MacPhail; Assistant Professors Charbonneau, Derbyshire, Hargrove, Malcolmson, Roizen, Wang, and Wiley; Professors Emeriti Arnett, Chesnut, McPhail, Palmer, Quin, Ramsay-Shaw, and Wells; Assistant Professor of the Practice Canelas; Lecturer Roy; Research Assistant Professor Zhang; Research Associate Professor Fischer; Secondary Appointments: Professors Chilkoti, Curtarolo, Donald, Lefkowitz, Oas, Reichert, West, and Zauscher; Associate Professors Ferguson and Zhou; Assistant Professors Lu and Yokoyama; Senior Lecturing Fellow Woerner; Lecturing Fellow Lyle; Instructors, Kasper and McCarthy

COURSES OF INSTRUCTION

Note: Courses are listed by the new course numbers that came into effect in fall 2012. Courses with numbers below 500 are undergraduate courses, while courses numbered 500 and 600 are graduate courses that are also open to undergraduates.

CHEM 020 - General Chemistry Credit. Pre-matriculation credit awarded for a score of 4 on the College Board AP chemistry examination (or the equivalent). Recommended placement is CHEM 110DL, but a student may choose to take CHEM 101DL without loss of credit. Instructor: Staff. One course.

CHEM 021 - General Chemistry Credit. Pre-matriculation credit awarded for a score of 5 on the College Board AP chemistry examination (or the equivalent). Recommended placement is CHEM 201DL, but a student may choose to take CHEM 110DL without loss of credit. Instructor: Staff. One course.

CHEM 081S - Introduction to Research in Chemistry. EI, NS, R Active participation in chemistry (or chemistry related) research group, accompanied by seminar classes covering research methodologies, case studies of ethical issues in chemistry, and communication of results of research. Prerequisite: CHEM 101L, or CHEM 110L, or CHEM 020, or CHEM 021. Instructor: Staff. One course.

CHEM 089S - First-Year Seminar. Topics vary each semester offered. Instructor: Staff. One course.

CHEM 091 - Chemistry, Technology, and Society. NS, STS Science, the scientific method, and background topics from chemistry, biochemistry, and environmental chemistry that enable citizens to utilize the inductive-deductive methodology of science to better evaluate the potential benefits and risks associated with selected existing and proposed technologies. Intended primarily for nonmajors. Instructor: Staff. One course. C-L: Energy and the Environment.

CHEM 099D - Introduction to Chemistry and Chemical Problem Solving. NS Introductory course for students with limited background in chemistry emphasizing chemical problem solving. Topics include atoms, molecules, ions, compounds, and the periodic table, stoichiometry and chemical reactions, reactions in solution, and an introduction to chemical bonding, thermochemistry, and gas laws. To be followed by CHEM 101DL. Not open to students who have credit for CHEM 020, 021 or 101DL. Instructor: Staff. One course.

CHEM 101DL - Core Concepts in Chemistry. NS Emphasizes core concepts required for organic chemistry, including atomic and molecular structure, chemical equilibrium with applications to acids and bases, thermodynamics, chemical kinetics, and reaction mechanisms. Relevance and integrated nature of these concepts illustrated through applications to a modern theme in chemistry, e.g. in biological, materials, or environmental chemistry. Laboratory illustrates experimental applications of these core concepts. Instructor: Staff. One course.

CHEM 110DL - Honors Chemistry : Core Concepts in Context. NS Emphasizes core concepts required for organic chemistry, including atomic and molecular structure, chemical equilibrium with applications to acids and bases, thermodynamics, chemical kinetics, and reaction mechanisms. Strong emphasis on applications of these concepts in context of large, interdisciplinary scientific challenge, e.g. in cancer biology or nanoscience. Laboratory illustrates experimental applications of these core concepts. Students may not receive credit for both CHEM 101DL and CHEM 110DL. Instructor: Staff. One course.

CHEM 180 - Chemistry Outreach: Sharing Chemistry with the Community. NS Principles of chemistry outreach with emphasis on chemical demonstrations. Activities include readings, discussion, and practice related to staging effective demonstrations, as well as structured service learning experiences in local schools and other venues. Societal issues relevant to chemistry outreach will be examined, along with assessment and pedagogical strategies. Participation in service learning is required. Prerequisites: CHEM 101DL, or CHEM 110DL , or CHEM 020, or CHEM 021. Instructor: Lyle. One course.

CHEM 190A - Duke-Administered Study Abroad: Special Topics in Chemistry. Topics differ by section. Instructor: Staff. One course.

CHEM 190S - Special Topics in Chemistry. Seminar on special topics in chemistry and chemistry related areas. Content varies by semester. Instructor: Staff. One course.

CHEM 190FS - Special Topics in Chemistry. Focus version of CHEM 190S. Instructor: Staff. One course.

CHEM 201DL - Organic Chemistry. NS, STS The structures and reactions of the compounds of carbon and the impact of selected organic compounds on society. Laboratory: techniques of separation, organic reactions and preparations, and systematic identification of compounds by their spectral and chemical properties. Prerequisite: CHEM 101DL, or CHEM 110DL, or CHEM 021. Instructor: Staff. One course.

CHEM 202L - Organic Chemistry. NS, STS Continuation of CHEM 201DL. Prerequisite: CHEM 201DL. Instructor: Staff. One course.

CHEM 210DL - Modern Applications of Chemical Principles. NS Modern applications of chemistry in context of larger scientific theme, e.g. in biology, materials science, or environmental chemistry. Revisits core concepts from CHEM 101DL or CHEM 110DL, incorporating additional topics including intermolecular interactions, phases of matter, solutions, quantitative treatment of aqueous equilibria, electron transfer reactions, and inorganic and coordination chemistry. Laboratory illustrates experimental approaches to modern problems in biological, materials, and environmental chemistry, as well as analytical and synthetic techniques. Prerequisite: CHEM 101DL or CHEM 110DL . Instructor: Staff. One course.

CHEM 290S - Special Topics In Chemistry. Seminar on special topics in chemistry and chemistry-related areas. Content varies by semester. Consent of department required. Instructor: Staff. One course.

CHEM 295 - Introduction to Research Independent Study. NS, W Includes research methodology, retrieval techniques for, and use of, the chemical literature, safety in the research laboratory, and the ethical conduct of research, and writing a research proposal. Co-requisite: registration for a first course in research independent study in chemistry (CHEM 393) or a related area. Lecture/discussion. Staff. Half course.

CHEM 301 - Elements of Physical Chemistry. NS Survey of physical chemistry including quantum chemistry, molecular structure, molecular spectroscopy, thermodynamics, and kinetics. Prerequisites: CHEM 210DL; or CHEM 020 plus CHEM 101DL; or CHEM 020 plus CHEM 110DL; or CHEM 021; MATH 112L, and PHYSICS 142L or PHYSICS 152L or PHYSICS 162L or consent of instructor. Instructor: Staff. One course.

CHEM 301L - Physical Chemistry Laboratory. NS, W Laboratory experiments designed to accompany CHEM 301. Includes instruction and practice in writing the laboratory notebook and formal laboratory reports. Prerequisite: (or corequisite) CHEM 301. Instructor: Staff. Half course.

CHEM 302 - Biophysical Chemistry. NS The physical chemical principles of and experimental methods employed in the study of biological macromolecules. Prerequisite: CHEM 301 or CHEM 310, or BIOCHEM 301 or consent of instructor. Instructor: Staff. One course.

CHEM 310 - Physical Chemistry. NS Fundamentals of physical chemistry. Emphasizes quantum chemistry, molecular structure, and molecular spectroscopy. CHEM 310L should be taken concurrently with CHEM 310. Prerequisites: CHEM 210DL; or CHEM 020 plus CHEM 101DL; or CHEM 020 plus CHEM 110DL; or CHEM 021; PHYSICS 142L or PHYSICS 152L or PHYSICS 162L; MATH 212 or consent of the instructor. Instructor: Staff. One course.

CHEM 310L - Physical Chemistry Laboratory. NS, W Laboratory experiments designed to accompany CHEM 310. Includes instruction and practice in writing the laboratory notebook and formal laboratory reports. Prerequisite: (or corequisite) CHEM 310. Instructor: Staff. Half course.

CHEM 311 - Physical Chemistry. NS Continuation of CHEM 310. Fundamentals of physical chemistry. Emphasizes thermodynamics and kinetics. CHEM 311L should be taken concurrently with CHEM 311. Prerequisite: CHEM 310 or consent of instructor. Instructor: Staff. One course.

CHEM 311L - Physical Chemistry Laboratory. NS, W Laboratory experiments designed to accompany CHEM 311. Prerequisite: (or corequisite). CHEM 311 or consent of instructor. Instructor: Staff. Half course.

CHEM 393 - Research Independent Study. R Individual research in a field of special interest under the supervision of a faculty member, the central goal of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Consent of instructor and

director of undergraduate studies required. Instructor: Staff. One course.
CHEM 394 - Research Independent Study. R Second semester of independent study. See CHEM 393. Consent of instructor and director of undergraduate studies required. Instructor: Staff. One course.

CHEM 401 - Analytical Chemistry. NS Fundamentals of qualitative and quantitative measurement with emphasis on chemometrics, quantitative spectrometry, electrochemical methods, and common separation techniques. This course corresponds with the lab CHEM 401L. Prerequisite: CHEM 301L or CHEM 310L. Instructor: Staff. One course.

CHEM 401L - Analytical Chemistry Laboratory. NS Laboratory experiments designed to accompany CHEM 401. Prerequisite: CHEM 401. Instructor: Staff. Half course.

CHEM 410 - Inorganic Chemistry. NS Bonding, structures, and reactions of inorganic compounds studied through physical chemical concepts. Prerequisite: CHEM 301 or CHEM 311. Instructor: Staff. One course.
CHEM 420L - Advanced Laboratory Techniques. NS Synthesis of less common substances by techniques such as high or low pressure, high or low temperature, and/or inert atmospheres. Characterization of products from measurements such as electrical conductance, optical rotation, ultraviolet-visible spectra, infrared spectra, and/or mass spectra. Prerequisite: (or corequisite) CHEM 410. Instructor: Staff. Half course.
CHEM 493 - Research Independent Study. R Third semester of independent study. See CHEM 393. Consent of instructor and director of undergraduate studies required. Instructor: Staff. One course.
CHEM 494 - Research Independent Study. R Fourth semester of independent study. See CHEM 393. Consent of instructor and director of undergraduate studies required. Instructor: Staff. One course.
CHEM 496 - Graduation with Distinction in Chemistry. Course for majors who are candidates for graduation with distinction in chemistry. Includes preparation of the research thesis, preparation and presentation of a poster describing student's research, and oral defense of the research thesis. Pre- or co-requisite: two semesters of research independent study. Lecture/ discussion. Satisfactory/Unsatisfactory grading only. Instructor: Staff. Half course.

Courses with numbers below 500 are undergraduate courses, while courses numbered 500 and 600 are graduate courses that are also open to undergraduates.

CHEM 501 - Analytical Chemistry. Fundamental considerations of chemical measurements, optical spectroscopy, mass spectrometry, and separation methods. One course.
CHEM 506 - Biomolecular Mass Spectrometry. Advanced topics in the mass spectral characterization of biopolymers with an emphasis on protein and DNA analysis. Fundamental and practical aspects of the ionization processes and the instrumentation associated with MALDI- and ESI-mass spectrometry will be discussed along with applications of these techniques to structural problems in chemistry and biochemistry. Prerequisite: CHEM 501 or permission of instructor. Half course.
CHEM 511 – Chemistry of Biomolecular Interactions. Chemistry of the noncovalent interactions governing biological systems. Topics include: review of biomacromolecules; chemical principles of non-covalent interactions and the use of model systems; experimental methods to determine binding interactions; interactions responsible for molecular recognition in biological systems; and applications in signal regulation. Recommended precursor to Chemistry 518. One course.
CHEM 518 - Chemical Biology. The application of chemical concepts and methods to solving problems in molecular and cell biology, with emphasis on the use of small molecules to elucidate and control information transfer in biological systems. Provides relevant background on both useful chemical tools and new biological targets. One course.
CHEM 521 - Inorganic Chemistry. A survey of the physical methods used to probe the electronic, magnetic and geometric structure of inorganic compounds, with particular emphasis on examples from bioinorganic chemistry. Topics include group theory, vibrational spectroscopy, electronic spectroscopy, magnetism, epr, Mossbauer and X-ray crystallography. One course.
CHEM 524 - Bioinorganic Chemistry. Topics to be covered includes metal activated enzymes in hydrolysis, oxygen carriers, nitrogen fixation, iron storage and transport, photosynthesis, protein electron transfer, and DNA mediated electron transfer. Half course.
CHEM 526 - Inorganic Reaction Mechanisms. A discussion of the mechanism of reactions of coordination compounds and transition metal organometallics in solution. Examples include ligand substitution, isomerisation and redox reactions, catalysis, and linear free energy relationships. Half course.
CHEM 529 - Special Topics in Inorganic Chemistry. Lectures, oral reports, and discussions on advanced topics and recent advances in the field of inorganic chemistry. Half course.

CHEM 531 - Organic Chemistry. Bonding and structure, stereochemistry, conformational analysis, substitution, addition, and elimination reactions, carbon reactive intermediates, concerted reactions, photochemistry, carbon alkylation, carbonyl addition, nucleophilic substitution, electrophilic additions, reduction, cycloadditions, rearrangements, main group organometallics, oxidation. One course.

CHEM 532 - Organic Reactions. Highlights strategic operations that enable selective synthesis of small molecules, including organic ligands, natural products, and molecular probes. Topics include chemical synthesis and retrosynthetic analysis; arrow-pushing mechanisms of polar, radical, transition metal-mediated and pericyclic reactions; protecting groups, oxidation, reduction, enolate reactivity; stereoselective reactions and conformational analysis; cross-coupling transformations. One course.

CHEM 533 - Nuclear Magnetic Resonance. Structural elucidation of organic and inorganic compounds by NMR. Fundamentals of data acquisition (pulse sequences, detection), multidimensional techniques, study of dynamic processes and their application to the determination of structure. Variable credit.

CHEM 534 - Physical Organic Chemistry. Reactive intermediates: carbocations, carbanions, carbenes, radicals, photochemistry. Prerequisite: CHEM 531. One course.

CHEM 535 - Organic Synthesis. NS Application of organic reactions to the synthesis of structurally and biologically interesting compounds. Topics include synthetic design, retrosynthetic analysis, synthetic methods, and total syntheses of natural products. Prerequisite: Chemistry 532 or consent of instructor.One course.

CHEM 536 - Bioorganic Chemistry. Basic enzymology, mechanisms of enzymatic reactions, cofactors, oxidoreductases, C1 chemistry, carbon-carbon bond formation, carboxylation/decarboxylation, heme, pyridoxal enzymes, thiamine enzymes. One course.

CHEM 538 - Organometallic Chemistry and Catalysis. Introduction to the structure and bonding of organometallic and coordination complexes, stressing the origin of metal-ligand interactions from a molecular orbital theory perspective. Elementary reactions of transition metal complexes and their application to organic synthesis, with special emphasis on catalytic reactions. General concepts of catalysis and the advantages and benefits of catalytic systems. Variable credit.

CHEM 539 - Special Topics in Organic Chemistry. Advanced topics and recent developments in organic chemistry. Variable credit.

CHEM 541 - Quantum Chemistry. Foundations and approximate methods in quantum chemistry, with an emphasis on their applications to molecular structure and modeling. One course.

CHEM 542 - Quantum Mechanics. Special emphasis on chemical applications. Topics include: linear algebra, the uncertainty relations, angular momentum, perturbation theory, time-dependent phenomena, molecules in electromagnetic fields, group theory, and electron correlation. One course.

CHEM 543 - Statistical Thermodynamics. Introduction to statistical thermodynamics, with an emphasis on ideal systems and selected model approaches to more complex systems, e.g. lattice models. Half course.

CHEM 544 - Statistical Mechanics. Fundamentals of quantum and classical statistical mechanics using the ensemble approach. Introduction of modern techniques and applications including the renormalization group treatment of phase transitions and linear response theory of time-dependent statistical mechanics. Prerequisite: CHEM 543 or consent of instructor. One course.

CHEM 548 - Solid State and Materials Chemistry. Introduction to the structure, physical and electronic properties of solid-state materials. Variable credit.

CHEM 549 - Special Topics in Physical Chemistry. Advanced topics and recent developments in physical chemistry. Variable credit.

CHEM 590 – Special Topics in Chemistry. Special topics in chemistry and chemistry-related areas. Content varies by instructor. One course.

CHEM 590-1 – Special Topics in Chemistry. Special topics in chemistry and chemistry-related areas. Content varies by instructor. Half course.

CHEM 601 - Biosensors. Theory and applications of biosensors. Basic principles of interactions between analytes and bioreceptors and various transduction techniques: optical, electrochemical, ion-selective electrode-based, voltametric, conductometric, and mass-sensitive techniques as well as novel nanotechnology-based biosensing systems including nanosensors, plasmonic nanoprobes, quantum dots, carbon nanotubes, molecular beacons, and molecular sentinel systems. Applications in chemical, environmental, biological and medical sensing. One course.

THE MINOR

Requirements. CHEM 101DL or CHEM 110DL or CHEM 021; plus four additional courses selected from the following: CHEM 180, 201DL, 202L, 210DL or 020; Chemistry courses numbered above 210; BIOCHEM 301, 302 ; BIOLOGY 372A; ENVIRON 540, 542; PHARM 350, 360, 533. Substitutions may be made in certain cases with the permission of the Director of Undergraduate Studies.

Students wishing to declare a chemistry minor may do so as follows: For students who have already declared a major in some field other than chemistry, a chemistry minor may be declared in the Registrar's Office, 114 S. Buchanan Blvd., Smith Warehouse, Bay 9, Room A289. For students who have not already declared a major, a chemistry minor may be declared in the Pre-Major Center at the same time that the major declaration is made.

REQUIREMENTS FOR A CHEMISTRY MAJOR

A.B. DEGREE IN CHEMISTRY

The A.B. degree program allows greater flexibility than the B. S. program in scheduling and course selection, while still maintaining the integrity of the Chemistry major. Students with interests in a second under-graduate major or in advanced work in a professional school (e.g. medical, dental, veterinary, business, or law) following graduation should consider this program. Students with an interest in employment in the chemical or a related industry, or in advanced study in chemistry or a related science (e.g. Biochemistry or Pharmacology) may also consider this program, although they are encouraged to augment their program with additional upper-level chemistry courses. Students in this category should consult their faculty advisers early in their junior year.

For the A.B. Degree

Prerequisites. CHEM 101DL or CHEM 110DL, or CHEM 021; [MATH 111L & MATH 112L, or MATH 122L]; [PHYSICS 141L & PHYSICS 142L or PHYSICS 151L & PHYSICS 152L or PHYSICS 161L & PHYSICS 162L].

Major Requirements. CHEM 201DL & CHEM 202L, [CHEM 210DL or CHEM 020 or CHEM 021], [CHEM 301 & CHEM 301L or CHEM 310 & CHEM 310L & CHEM 311]; CHEM 401 & CHEM 401L; plus one of the following three options:

Option 1. Three of the following: CHEM 302, CHEM 410; BIOCHEM 301, BIOCHEM 302; any CHEM courses at the 500 level.

Option 2. One of the following: CHEM 302, CHEM 410, BIOCHEM 301, any CHEM course at the 500 level; plus CHEM 393 & CHEM 394 or the equivalent in an approved chemistry-related discipline.

3. One of the following emphases:

a. Physics Emphasis

[CHEM 302 or CHEM 311] plus any 2 of the following:

PHYSICS 264L Optics and Modern Physics
PHYSICS 361 Intermediate Mechanics
PHYSICS 362 Electricity and Magnetism

b. Mathematics Emphasis

[CHEM 302 or CHEM 311] plus either of the following pairs of courses:
[MATH 221 and MATH 356] or [MATH 216 and MATH 353]. Titles for these courses are:

MATH 221 Linear Algebra and Application
MATH 356 Elementary Differential Equations
MATH 216 Linear Algebra and Differential Equations
MATH 353 Ordinary and Partial Differential Equations

c. Biology Emphasis

BIOCHEM 301 plus any 2 of the following:

BIOLOGY 201L Gateway to Biology
BIOLOGY 214L Experimental Cell and Molecular Biology
BIOLOGY 220 Cellular and Developmental Biology
BIOLOGY 227 Molecular Plant Physiology
BIOLOGY 329L Principles of Animal Physiology
BIOLOGY 414LS Development and Molecular Genetics
BIOLOGY 515 Principles of Immunology

Substitution may be made in certain cases with the permission of the Director of Undergraduate Studies.

SEQUENCE OF CORE COURSES FOR THE A.B. DEGREE IN CHEMISTRY

The following is a typical schedule for the core and prerequisite courses for a student who does not have advanced placement credits for CHEM or MATH and is seeking the A.B. degree. The additional courses listed in the various options above may be taken in the junior or senior year. Prerequisites for some of the options may need to be completed in the freshman or sophomore year. (Courses in brackets [ ] can be scheduled in other semesters or have equivalent courses that can be scheduled in other semesters.)

	Fall	**Spring**
Fr	CHEM 101DL [MATH 111L]	CHEM 201DL [MATH 112L]
So	CHEM 202L [PHYSICS 141L]*	CHEM 210DL [PHYSICS 142L]*
Jr	CHEM 301	CHEM 301L
Sr	CHEM 401 [CHEM 401L]	[CHEM 401L]

Note: CHEM 301/301L is a prerequisite for most upper level chemistry courses and usually taken in the junior year. Since PHYSICS 142L (or 152L or 162L) is a prerequisite for CHEM 301, Physics courses are normally taken in the sophomore year. Likewise, MATH 111L and 112L are taken in the first year since they are prerequisites for introductory Physics courses.

*PHY 141L (fall) - 142L (spring) may be replaced by PHY 151L (fall) - 152L (spring) or PHY 161L (spring) - 162L (fall).

Physics and Mathematics courses may be taken at other times, but only with considerable loss of flexibility in scheduling. See below for information about fulfilling physics requirements with transfer courses.

FULFILLING PHYSICS REQUIREMENTS WITH APPROVED TRANSFER COURSES

PHYSICS 100 may be substituted for required physics courses: PHYSICS 141L-142L, PHYSICS 151L-152L; or 161L-162L, in either the A.B. or B.S. chemistry major, provided the physics course(s) are (1) calculus-based, (2) taken at an institution that is accredited by the American Chemical Society, and (3) are the courses that are required for an ACS-certified degree at that institution.

AB Degree
(2011 Revision)

Name (Last, first, MI) _____

1. On the blank following either CHEM 020 or 021, indicate **entrance credit** by "AP".
2. On the blank following a **completed course**, indicate the grade earned, or "TR" for an approved course transferred from another institution.
3. On the blank following a **planned course**, indicate the semester and year in which you intend to take the course. Use F12 for fall of 2012, S12 for spring of 2012, and SS12 for summer session of 2012.
4. In the "Done" column, place a check for **completed requirements**.

Prerequisites								**Done**
MATH 111L ____ MATH 112L ____	OR	MATH 122L ____						
PHYSICS 141L ___ PHYSICS 142L ___	OR	PHYSICS 151L___ PHYSICS 152L___	OR	PHYSICS 161L__ PHYSICS 162L__				
CHEM 101DL___	OR	CHEM 110DL___	OR	CHEM 021 ___				
Advanced								
CHEM 201DL ___ CHEM 202L ___								
CHEM 210DL ___	OR	CHEM 020 ___	OR	CHEM 021 ___				
CHEM 301 ____ CHEM 301L ____	OR	CHEM 310 ____ CHEM 310L ____ CHEM 311 ____						
CHEM 401 ____ CHEM 401L ___								
Options								
Option 1 Any 3: CHEM 302 ____ CHEM 410 ____ BIOCHEM 301___ BIOCHEM 302___ CHEM 500+ ____	OR	**Option 2** Any 1: CHEM 302 ____ CHEM 410 ____ BIOCHEM 301___ CHEM 500+ ____ AND BOTH CHEM 393 ____ CHEM 394 ____	OR ↓					
Option 3.1 **PHYSICS** **Emphasis** CHEM 302 ____ OR CHEM 311 ____ AND any 2: PHYSICS 264L___ PHYSICS 361 ____ PHYSICS 362 ____	OR	**Option 3.2 MATH** **Emphasis** CHEM 302 ____ OR CHEM 311 ____ AND either pair: MATH 221/356 ___/___ OR MATH 216/353 ___/___	OR	**Option 3.3** **BIOLOGY** **Emphasis** BIOCHEM 301 ___ AND any 2: BIOLOGY 201L ___ BIOLOGY 214L __ BIOLOGY 220 ___ BIOLOGY 227 ___ BIOLOGY 329L ___ BIOLOGY 414LS BIOLOGY 515 ___			

B.S. DEGREE IN CHEMISTRY

The B.S. degree program is recommended for students planning to undertake graduate study in Chemistry or a related science (e.g. Biochemistry or Pharmacology) or for those contemplating employment in the chemical industry following graduation.

For the B.S. Degree

Prerequisites. CHEM 101DL or CHEM 110DL or CHEM 021; [MATH 111L & MATH 112L, or MATH 122L]; [PHYSICS 141L & PHYSICS 142L or PHYSICS 151L & PHYSICS 152L or PHYSICS 161L & PHYSICS 162L].

Major Requirements. CHEM 201DL , CHEM 202L , [CHEM 210DL or CHEM 020 or CHEM 021], CHEM 310, CHEM 310L, CHEM 311, CHEM 311L, CHEM 393 (or its equivalent in a chemistry-related area), CHEM 401, CHEM 401L, CHEM 410, CHEM 420L, plus two additional courses selected from the following: BIOCHEM 301*, CHEM 302, CHEM 394 (or its equivalent in a chemistry-related discipline)*, any CHEM courses at the 500 level.

***Certification of the BS degree by the American Chemical Society.** Certification of the BS degree by the American Chemical Society requires selection of BIOCHEM 301 and CHEM 394 (or its equivalent in a chemistry related discipline) plus CHEM 295.

SEQUENCE OF CORE COURSES FOR THE B.S. DEGREE IN CHEMISTRY

The following is a typical schedule for the core and prerequisite courses for a student who is seeking the B.S. degree and does not have advanced placement credits in CHEM or MATH. (Courses in brackets [ ] are prerequisites that can be scheduled in other semesters.)

	Fall	**Spring**
Fr	CHEM 101DL [MATH 111L]	CHEM 201DL [MATH 112L]
So	CHEM 202L [PHY 141L]* [MATH 212]	CHEM 210DL [PHY 142L]*
Jr	CHEM 310/310L	CHEM 311/311L
Sr	CHEM 401/401L	CHEM 410 CHEM 420L

* PHYSICS 141L (Fall) – PHYSICS 142L (Spring) may be replaced by PHYSICS 161L (Fall) – PHYSICS 162L (spring) or PHYSICS 151L (Spring) – PHYSICS 152L (Fall).

Note: CHEM 310/310L is a prerequisite for most upper level chemistry courses and is usually taken in the junior year. Since PHYSICS 141L/142L, or 151L/152L, or 161L/162L are prerequisites for CHEM 310, Physics is normally taken in the sophomore year. Since MATH 111L and MATH 112L are prerequisites for introductory physics courses, they are taken in the first year. Since MATH 212 is a prerequisite for CHEM 310, it needs to be taken in sophomore year. Physics and Math courses may be taken in other semesters, but only with considerable loss of flexibility in scheduling.

BS Degree
(2011 Revision)

Name (Last, first, MI) _____

1. On the blank following either CHEM 020 or 021, indicate **entrance credit** by "AP".
2. On the blank following a **completed course**, indicate the grade earned, or "TR" for an approved course transferred from another institution.
3. On the blank following a **planned course**, indicate the semester and year in which you intend to take the course. Use F12 for fall of 2012, S12 for spring of 2012, and SS12 for summer session of 2012.
4. In the "Done" column, place a check for **completed requirements**.

Prerequisites							**Done**
MATH 111L ____ MATH 112L ____	OR	MATH 122L _____					
MATH 212 ____							
PHYSICS 141L___ PHYSICS 142L___	OR	PHYSICS 151L___ PHYSICS 152L___	OR	PHYSICS 161L___ PHYSICS 162L___			
CHEM 101DL___	OR	CHEM 110DL___	OR	CHEM 021 ___			
Advanced							
CHEM 201DL____ CHEM 202L ____							
CHEM 210DL ___	OR	CHEM 020 ___	OR	CHEM 021 ___			
CHEM 310 ____ CHEM 310L ____							
CHEM 311 ____ CHEM 311L ____							
CHEM 401 ____ CHEM 401L ____							
CHEM 410 ____							
CHEM 420L ____							
CHEM 393 ____	OR	Equiv. to 393: _____ ____					
Options							
Any 2: CHEM 394 ____ CHEM 302 ____ BIOCHEM 301___ CHEM 500+ ____							
ACS-certified degree requires CHEM 394 (or equivalent) and BIOCHEM 301 and CHEM 295 ____							

DEGREE OPTIONS WITH CONCENTRATIONS

The Concentration in Biochemistry
In cooperation with the Department of Biochemistry in the School of Medicine, the Chemistry Department offers both an A.B. and a B.S. degree in chemistry with concentration in biochemistry. Certification of this concentration is designated on the official transcript.

For the A.B. Degree with Concentration in Biochemistry
Prerequisites. CHEM 101DL or CHEM 110DL or CHEM 021; [MATH 111L & MATH 112L, or MATH 122L]; [PHYSICS 141L & PHYSICS 142L or PHYSICS 151L & PHYSICS 152L or PHYSICS 161L & PHYSICS 162L]; BIOLOGY 201L.

Major Requirements. CHEM 201DL, CHEM 202L, [CHEM 210DL or CHEM 020 or CHEM 021], [CHEM 301 & CHEM 301L or CHEM 310 & CHEM 310L & CHEM 311], CHEM 401 & CHEM 401L; BIOCHEM 301, BIOCHEM 302; plus one of the following: CHEM 393, BIOLOGY 293, or BIOCHEM 593.

For the B.S. Degree with Concentration in Biochemistry
Prerequisites. CHEM 101DL or CHEM 110DL or CHEM 021; [MATH 111L & MATH 112L, or MATH 122L]; [PHYSICS 141L & PHYSICS 142L or PHYSICS 151L & PHYSICS 152L or PHYSICS 161L & PHYSICS 162L]; BIOLOGY 201L.

Major Requirements. CHEM 201DL, CHEM 202L, [CHEM 210DL or CHEM 020 or CHEM 021], [CHEM 301 & CHEM 301L & CHEM 302, or CHEM 310 & CHEM 301L & CHEM 311], CHEM 401 & CHEM 401L, CHEM 410; BIOCHEM 301, BIOCHEM 302; BIOLOGY 220; plus one of the following: CHEM 393, BIOLOGY 293, or BIOCHEM 593.

*To earn a B.S. degree in Chemistry that is certified by the American Chemical Society requires CHEM 295, CHEM 310 [which has a MATH 212 prerequisite], CHEM 310L, CHEM 311, CHEM 311L, CHEM 410, and CHEM 420L.

Sample Course Sequences

Sample –AB with Concentration in Biochemistry

	Fall Semester	Spring Semester
First Year	CHEM 101DL or 110DL MATH 111L	CHEM 201DL MATH 112L BIOLOGY 201L
Second Year	CHEM 202L PHYSICS 141L	CHEM 210DL PHYSICS 142L
Third Year	CHEM 295 CHEM 301 CHEM 393	CHEM 302 CHEM 394 CHEM 310L
Fourth Year	CHEM 401 BIOCHEM 301	CHEM 401L BIOCHEM 302

Sample – ACS Certified BS with Concentration in Biochemistry(w/GwD)

	Fall Semester	Spring Semester
First Year	CHEM 101DL or 110DL MATH 111L	CHEM 201DL MATH 112L BIOLOGY 201L
Second Year	CHEM 202L PHYSICS 141L MATH 212	CHEM 210DL PHYSICS 142L
Third Year	CHEM 310/310L BIOLOGY 220 CHEM 295 CHEM 393	CHEM 311/311L CHEM 394
Fourth Year	CHEM 401 BIOCHEM 301	BIOCHEM 302 CHEM 401L CHEM 410 CHEM 420L* CHEM 496**

*not needed if no ACS certified degree
**not needed if no GwD

AB Degree Concentration in Biochemistry
(2011 Revision)

Name (Last, first, MI) _____

1. On the blank following either CHEM 020 or 021, indicate **entrance credit** by "AP".
2. On the blank following a **completed course**, indicate the grade earned, or "TR" for an approved course transferred from another institution.
3. On the blank following a **planned course**, indicate the semester and year in which you intend to take the course. Use F12 for fall of 2012, S12 for spring of 2012, and SS12 for summer session of 2012.
4. In the "Done" column, place a check for **completed requirements**.

Prerequisites							**Done**
MATH 111L ___ MATH 112L ___	OR	MATH 122L ___					
PHYSICS 141L_ PHYSICS 142L_	OR	PHYSICS 151L_ PHYSICS 152L_	OR	PHYSICS 161L_ PHYSICS 162L_			
BIOLOGY 201L___							
CHEM 101DL__	OR	CHEM 110DL__	OR	CHEM 021 __			
Advanced							
CHEM 201DL____ CHEM 202L __							
CHEM 210DL __	OR	CHEM 020 __	OR	CHEM 021 ____			
CHEM 301 ___ CHEM 301L ___	OR	CHEM 310 ___ CHEM 310L____ CHEM 311____					
CHEM 401 ___ CHEM 401L ___							
BIOCHEM 301_ BIOCHEM 302_							
CHEM 393 ____	OR	BIOLOGY 293___	OR	BIOCHEM 593__			

BS Degree Concentration in Biochemistry
(2011 Revision)

Name (Last, first, MI) _____

1. On the blank following either CHEM 020 or 021, indicate **entrance credit** by "AP".
2. On the blank following a **completed course**, indicate the grade earned, or "TR" for an approved course transferred from another institution.
3. On the blank following a **planned course**, indicate the semester and year in which you intend to take the course. Use F12 for fall of 2012, S12 for spring of 2012, and SS12 for summer session of 2012.
4. In the "Done" column, place a check for **completed requirements**.

Prerequisites							**Done**
MATH 111L ___ MATH 112L ___	OR	MATH 122L _____					
PHYSICS 141L___ PHYSICS 142L___	OR	PHYSICS 151L___ PHYSICS 152L___	OR	PHYSICS 161L___ PHYSICS 162L___			
BIOLOGY 201L__							
CHEM 101DL___	OR	CHEM 110DL___	OR	CHEM 021 ___			
Advanced							
CHEM 201DL____ CHEM 202L __							
CHEM 210DL __	OR	CHEM 020 ___	OR	CHEM 021 ___			
CHEM 301 __ CHEM 301L __ CHEM 302 __	OR	CHEM 310 __ CHEM 310L __ CHEM 311 __					
CHEM 401 __ CHEM 401L __							
CHEM 410 __							
BIOLOGY 220___							
BIOCHEM 301___ BIOCHEM 302___							
CHEM 393 ____	OR	BIOLOGY 293___	OR	BIOCHEM 593__			

The Concentration in Pharmacology

In conjunction with the Department of Pharmacology in the Duke Medical Center, the Chemistry Department offers both an A.B. and a B.S. degree in chemistry with a Concentration in Pharmacology. Certification of the concentration is designated on the official transcript.

Pharmacology is more than the study of the mode of action of drugs. It is a science which uses the basic concepts of biology and chemistry to determine how drugs affect the organism; it gives a unique perspective in understanding how cells, organ systems, and organisms function. Unlike other basic science fields, pharmacology combines many disciplines so that one can investigate systematically the mechanisms underlying a biological event—from the molecular level to the whole animal. Pharmacology also allows us to study how biological systems fail, providing information on the etiology of disease and on the mechanisms underlying toxic reactions. Pharmacologic research is essential for the development, testing and use of drugs and other bioactive molecules such as pesticides or industrial chemicals.

The objective of Pharmacology as an Area of Concentration for Chemistry Majors is to provide students with knowledge of the basic principles underlying the design and actions of drugs and toxic substances. In addition, it provides the opportunity to apply these principles in a research setting. Ultimately, an introduction of pharmacology to undergraduates will encourage interested students to consider graduate study in the fields of pharmacology and/or medicinal chemistry, leading to a career in academic research, in governmental regulatory agencies, or in industry.

This area of concentration requires that students take specific courses in biological sciences and chemistry in addition to pharmacology, and two semesters of research in Pharmacology. The required courses are BIOLOGY 201L and BIOCHEM 301 [Introductory Biochemistry], which will provide the necessary biological background for Chemistry majors to proceed with studies in Pharmacology. The two semesters of pharmacology courses are: PHARM 350, which deals with drug actions and reactions, and PHARM 360, which deals with Drugs, Brain and Behavior. Students will also spend 2 semesters of independent study. Mentors for independent study are chosen from a list of approved pharmacology faculty. An additional recommended pharmacology course is PHARM 554, Mammalian Toxicology.

For the A.B. Degree with Concentration in Pharmacology

Prerequisites. CHEM 101DL or CHEM 110DL or CHEM 021; [MATH 111L & MATH 112L, or MATH 122L]; [PHYSICS 141L & PHYSICS 142L or PHYSICS 151L & PHYSICS 152L or PHYSICS 161L & PHYSICS 162L]; BIOLOGY 201L.

Major requirements: CHEM 201DL, CHEM 202L [CHEM 210DL or CHEM 020 or CHEM 021], [CHEM 301 & CHEM 301L or CHEM 310 & CHEM 310L & CHEM 311], CHEM 401 & CHEM 401L; BIOCHEM 301; PHARM 350** & PHARM 360**; plus 2 semesters of independent study involving some aspect of pharmacology (CHEM 393 & 394 or PHARM 393 & 394).

For the B.S. Degree with Concentration in Pharmacology

Prerequisites. CHEM 101DL or CHEM 110DL or CHEM 021; [MATH 111L & MATH 112L, or MATH 122L]; [PHYSICS 141L & PHYSICS 142L or PHYSICS 151L & PHYSICS 152L or PHYSICS 161L & PHYSICS 162L]; BIOLOGY 201L.

Major Requirements: CHEM 201DL, CHEM 202L, [CHEM 301 & CHEM 301L & CHEM 302, or CHEM 310 & CHEM 310L & CHEM 311], CHEM 401 & CHEM 401L, CHEM 410; BIOCHEM 301; PHARM 350** & PHARM 360**; plus 2 semesters of independent study involving some aspect of pharmacology (CHEM 393 & 394 or PHARM 393 & 394).

*To earn a B.S. degree in Chemistry that is certified by the American Chemical Society requires CHEM 295, CHEM 310 [which has a MATH 212 prerequisite], CHEM 310L, CHEM 311, CHEM 311L, CHEM 410, and CHEM 420L.

**Substitution may be made in certain cases with the permission of the Director of Undergraduate Studies.

AB Degree Concentration in Pharmacology
(2011 Revision)

Name (Last, first, MI) _____

1. On the blank following either CHEM 020 or 021, indicate **entrance credit** by "AP".
2. On the blank following a **completed course**, indicate the grade earned, or "TR" for an approved course transferred from another institution.
3. On the blank following a **planned course**, indicate the semester and year in which you intend to take the course. Use F12 for fall of 2012, S12 for spring of 2012, and SS12 for summer session of 2012.
4. In the "Done" column, place a check for **completed requirements**.

Prerequisites							**Done**
MATH 111L ___ MATH 112L ___	OR	MATH 122L ___					
PHYSICS 141L_ PHYSICS 142L_	OR	PHYSICS 151L_ PHYSICS 152L_	OR	PHYSICS 161L_ PHYSICS 162L_			
BIOLOGY 201L__							
CHEM 101DL__	OR	CHEM 110DL__	OR	CHEM 021 ___			
Advanced							
CHEM 201DL__ CHEM 202L __							
CHEM 210DL __	OR	CHEM 020___	OR	CHEM 021___			
CHEM 301 __ CHEM 301L __	OR	CHEM 310 __ CHEM 310L __ CHEM 311 __					
CHEM 401 __ CHEM 401L __							
BIOCHEM 301___							
PHARM 350 __ PHARM 360 __							
CHEM 393 __ CHEM 394 __	OR	PHARM 393 __ PHARM 394 __					

BS Degree Concentration in Pharmacology
(2011 Revision)

Name (Last, first, MI) _____

1. On the blank following either CHEM 020 or 021, indicate **entrance credit** by "AP".
2. On the blank following a **completed course**, indicate the grade earned, or "TR" for an approved course transferred from another institution.
3. On the blank following a **planned course**, indicate the semester and year in which you intend to take the course. Use F12 for fall of 2012, S12 for spring of 2012, and SS12 for summer session of 2012.
4. In the "Done" column, place a check for **completed requirements**.

Prerequisites							**Done**
MATH 111L ___ MATH 112L ___	OR	MATH 122L ___					
PHYSICS 141L_ PHYSICS 142L_	OR	PHYSICS 151L_ PHYSICS 152L_	OR	PHYSICS 161L_ PHYSICS 162L_			
BIOLOGY 201L_							
CHEM 101DL__	OR	CHEM 110DL__	OR	CHEM 021 __			
Advanced							
CHEM 201DL__ CHEM 202L __							
CHEM 210DL __	OR	CHEM 020__	OR	CHEM 021__			
CHEM 301 __ CHEM 301L __ CHEM 302 __	OR	CHEM 310 __ CHEM 310L __ CHEM 311 __					
CHEM 401 __ CHEM 401L __							
CHEM 410 __							
BIOCHEM 301__							
PHARM 350 __ PHARM 360 __							
CHEM 393 __ CHEM 394 __	OR	PHARM 393 __ PHARM 394 __					

The Concentration in Environmental Chemistry
In conjunction with the Nicholas School of the Environment, the Chemistry Department is pleased to offer both an A.B. and a B.S. degree in Chemistry with Concentration in Environmental Chemistry. Official recognition of the completion of the requirements given below will appear on the permanent transcript of a major.

For the A. B. Degree with Concentration in Environmental Chemistry
Prerequisites. CHEM 101DL or CHEM 110DL or CHEM 021; [MATH 111L & MATH 112L, or MATH 122L]; [PHYSICS 141L & PHYSICS 142L or PHYSICS 151L & PHYSICS 152L or PHYSICS 161L & PHYSICS 162L]; BIOLOGY 201L.

Major Requirements. CHEM 201DL, CHEM 202L, [CHEM 210DL or CHEM 020 or CHEM 021], CHEM 301 & CHEM 301L, or CHEM 310 & CHEM 310L & CHEM 311, CHEM 401 & CHEM 401L; ENV 360 or CE461L; plus any two of the following: ENVIRON 239, ENVIRON 540, ENVIRON 542; plus one of the following: CHEM 393 or ENVIRON 393 or CE 391.

For the B.S. Degree in Chemistry with Concentration in Environmental Chemistry
Prerequisites. CHEM 101DL or CHEM 110DL or CHEM 021; [MATH 111L & MATH 112L, or MATH 122L]; [PHYSICS 141L & PHYSICS 142L or PHYSICS 151L & PHYSICS 152L or PHYSICS 161L & PHYSICS 162L]; BIOLOGY 201L.

Major Requirements. CHEM 201DL, CHEM 202L, [CHEM 210DL or CHEM 020 or CHEM 021], [CHEM 301 & CHEM 301L & CHEM 302, or CHEM 310 & CHEM 310L & CHEM 311], CHEM 401 & CHEM 401L, CHEM 410; ENV 360 or CE 461L; plus any two of the following: ENVIRON 239, ENVIRON 540, ENVIRON 542; plus one of the following: CHEM 393 or ENVIRON 393 OR CE 391.

* To earn a B.S. degree in Chemistry that is certified by the American Chemical Society requires CHEM 295, CHEM 310 [which has a MATH 212 prerequisite], CHEM 310L, CHEM 311, CHEM 311L, CHEM 410, and CHEM 420L.

AB Degree Concentration in Environmental Chemistry
(2011 Revision)

Name (Last, first, MI) _____

1. On the blank following either CHEM 020 or 021, indicate **entrance credit** by "AP".
2. On the blank following a **completed course**, indicate the grade earned, or "TR" for an approved course transferred from another institution.
3. On the blank following a **planned course**, indicate the semester and year in which you intend to take the course. Use F12 for fall of 2012, S12 for spring of 2012, and SS12 for summer session of 2012.
4. In the "Done" column, place a check for **completed requirements**.

Prerequisites							**Done**
MATH 111L ___ MATH 112L ___	OR	MATH 122L ___					
PHYSICS 141L_ PHYSICS 142L_	OR	PHYSICS 151L_ PHYSICS 152L_	OR	PHYSICS 161L_ PHYSICS 162L_			
BIOLOGY 201L__							
CHEM 101DL__	OR	CHEM 110DL__	OR	CHEM 021 __			
Advanced							
CHEM 201DL__ CHEM 202L __							
CHEM 210DL __	OR	CHEM 020 __	OR	CHEM 021 __			
CHEM 301 __ CHEM 301L __	OR	CHEM 310 __ CHEM 310L __ CHEM 311 __					
CHEM 401 __ CHEM 401L __							
ENVIRON 360__	OR	CE 461L __					
ANY 2: ENVIRON 239__ ENVIRON 540__ ENVIRON 542__							
CHEM 393 __	OR	ENVIRON 393__	OR	CE 391 __			

BS Degree Concentration in Environmental Chemistry
(2011 Revision)

Name (Last, first, MI) _____

1. On the blank following either CHEM 020 or 021, indicate **entrance credit** by "AP".
2. On the blank following a **completed course**, indicate the grade earned, or "TR" for an approved course transferred from another institution.
3. On the blank following a **planned course**, indicate the semester and year in which you intend to take the course. Use F12 for fall of 2012, S12 for spring of 2012, and SS12 for summer session of 2012.
4. In the "Done" column, place a check for **completed requirements**.

Prerequisites							**Done**
MATH 111L ___ MATH 112L ___	OR	MATH 122L ___					
PHYSICS 141L_ PHYSICS 142L_	OR	PHYSICS 151L_ PHYSICS 152L_	OR	PHYSICS 161L_ PHYSICS 162L_			
BIOLOGY 201L__							
CHEM 101DL__	OR	CHEM 110DL__	OR	CHEM 021 __			
Advanced							
CHEM 201____ CHEM 202L __							
CHEM 210DL __	OR	CHEM 020 __	OR	CHEM 021__			
CHEM 301 __ CHEM 301L __ CHEM 302 __	OR	CHEM 310 __ CHEM 310L __ CHEM 311 __					
CHEM 401 __ CHEM 401L __							
CHEM 410 __							
ENVIRON 360__	OR	CE 461L __					
ANY 2: ENVIRON 239__ ENVIRON 540__ ENVIRON 542__							
CHEM 393 __	OR	ENVIRON 393__	OR	CE 391 __			

RESEARCH INDEPENDENT STUDY IN CHEMISTRY

Research independent study in chemistry generally involves carrying out a laboratory investigation in chemistry or a chemistry-related area. If the research is done in the chemistry department, a major registers for CHEM 393 & CHEM 394 in successive semesters. If the research is done outside the chemistry department in a chemistry-related area, a major registers for research independent study in that department using their numbering scheme such as BIOCHEM 593 for the first and all other semesters, PHARM 393-394, etc. Research courses taken outside the chemistry department require approval in order to count toward chemistry major requirements and requirements for Graduation with Distinction in Chemistry. The approval process and form for requesting approval are available at
http://www.chem.duke.edu/undergraduate/research-independent-study

Early in a major's first semester of research independent study in chemistry (or a related area), all majors who intend to use research independent study to fulfill a chemistry degree requirement must meet individually with Dr. Roy, Coordinator of Independent Study for Chemistry, to discuss requirements, deadlines, etc. Majors will be notified when they can begin scheduling the meeting.

The chemistry department considers research important both for the opportunity to work closely with a faculty member and his or her research group on a research project, and for the advancement of basic knowledge in science. The research results of Independent Study projects have appeared in many publications in major professional journals, with the chemistry major being listed as a co-author.

While it is not anticipated that the research project will be originated by the student, it is expected that the student will provide a high degree of independent thought and effort in the solution of the problem. For this reason it is essential that a student have a firm foundation in the principles and practices of chemistry, and a firm foundation in using the chemical research literature. The former is obtained by completing, at least, the laboratory courses through physical chemistry. The latter is obtained by taking CHEM 295, Introduction to Research Independent Study (half-course), preferably taken concurrently with their first semester of independent study. Students normally take CHEM 393, CHEM 394 and CHEM 295 during their junior and/or senior years. CHEM 295 is open to all majors, but is required only for majors who are candidates for an ACS-certified degree and/or are candidates for Graduation with Distinction in Chemistry.

Joining a Research Group. Participation in independent study usually involves joining an existing research group, which may be located in the chemistry department, or in a chemistry-related department elsewhere on campus, or in an approved nearby laboratory such as the Veterans Hospital or in Research Triangle Park. Majors who would like assistance in finding or joining a research group should see Dr. Roy in French Family Science Center room 1222 (in suite 1219).

To join a research group, you first have to decide what kind of research you find truly interesting. Your deep interest will be essential to your surviving some failures you will likely experience on your way to success.

You next need to determine what local groups are doing research in your area(s) of interest. Go online and look up research interests of faculty in the appropriate departments. Links to research interests of faculty in several departments are given at http://chem.duke.edu/undergraduate/finding-research-director-and-group Frequently these web sites will also include links to recent publications that you will find very helpful in determining a match for your interests.

Next you need to contact those faculty members whose research areas appeal to you to find out if they have openings in their research groups. If so, arrange to meet with them and discuss specific research problems that they have available. Notice that generally you will be asked to consider problems that are already available rather than creating a research problem on your own. The reason for this is that research requires significant funding for supplies, instruments, etc. The process of obtaining funding is rather lengthy and you will not have enough time to write a full grant proposal and get it funded before graduation. The faculty member has likely already obtained funding for the specific projects that you will be asked to consider.

Joining a research group involves a two-way selection process. Just as you probably interviewed with several research directors, those research directors have probably interviewed several students. As soon as you make your decision, notify your first choice research director that you would like to undertake a specific research problem with him/her. The research director will then decide which of the applicants is the best fit and will notify all applicants of the decision. If you are not selected, repeat the process with another research director.

Concluding Research. At the conclusion of a research project, a major communicates the results of the investigation in writing in the form of a formal research thesis (see http://www.chem.duke.edu/undergraduate/guideline-writing-senior-thesis) and orally in the form of a poster session (see http://www.chem.duke.edu/undergraduate/poster-sessions).

SUMMER RESEARCH PROGRAMS

Summer research opportunities are available at Duke as well as other institutions. Flyers advertising these opportunities will be posted on the bulletin boards adjacent to, and across from, room 1234 FFSC as they are received (usually in the period December-January). Interested majors should apply directly to all programs of interest well before the deadlines indicated on their flyers (usually February or March). Please see http://chem.duke.edu/undergraduate/summer-research-opportunities for links to some summer research programs.

STUDY ABROAD

Opportunities for study abroad are available to students whose course schedules permit it. Usually this involves direct enrollment for one semester on an individual basis. The university policies on study abroad are available from http://trinity.duke.edu/undergraduate/academic-policies/continuation-study-abroad. Pre-approved chemistry courses may be obtained from the Duke Global Education web site at https://courseapproval.studyabroad.duke.edu/cgi-bin/study.pl .

EMPLOYMENT WITHIN THE DEPARTMENT

The faculty views employment within the Department as an opportunity for the qualified student to gain valuable educational experience as a supplement to formal classroom instruction and at the same time to benefit financially. The following opportunities may be available. (Further information and application forms are available here: http://www.chem.duke.edu/undergraduate/financial-aid)

Undergraduate Teaching Assistants (UTA) and Undergraduate Prep Room Assistants (UPRA). Each year a number of seniors and advanced juniors may be selected on the basis of academic achievement, experience for certain courses, interest, and faculty recommendations to serve as UTA's or URPA's. Typical duties for UTA's are the supervision of one recitation or laboratory section of an undergraduate course, plus two hours per week spent in grading laboratory notebooks and preparing for the laboratory. Typical duties for UPRA's involve working in the laboratory preparations room for a specific course for three to six hours per week. The stipend is approximately $10.00 per hour. Interested majors or minors should complete and submit an employment application form according to the instructions found here: http://chem.duke.edu/sites/chem.duke.edu/files/uploads//JobApplication_0.pdf

Technicians. Occasionally individual faculty members have research funds available to hire undergraduate technicians to assist in a specific research project. Interested students should contact faculty directly to determine if there any openings in the area of their interest.

ADVISING

Director of Undergraduate Studies Group. (DUS-group). A major responsibility of the DUS group is to provide for the advising of departmental majors, especially those newly declared majors who have not been assigned a regular academic adviser. The DUS group is located in suite 1219 FFSC. Appointments with a member of the DUS-group may be made by emailing dus@chem.duke.edu. General information concerning chemistry majors is posted on a bulletin board accross from room 1234 FFSC. Information concerning registration will be posted on the chemistry website http://chem.duke.edu/undergraduate/advising

Academic. Most members of the Chemistry faculty who are not on leave serve as academic advisors, with the exception of the Chair, the Director of Graduate Studies and faculty serving in University administration. Each chemistry major is assigned to a faculty advisor by the DUS-group. Advisors may need to be reassigned depending on availability from semester to semester. Advisors are available by appointment to discuss all aspects of the student's academic concerns, including post graduation plans.

Academic Deans. Dean Daniel Scheirer is the academic dean for chemistry majors and also Director of Health Professions Advising. His office is in 011 Allen Building. Majors considering graduate school may also want to discuss options with Dean Keul (office: 011 Allen Building), who is the advisor for students considering graduate study.

Career Center. Majors considering employment should utilize the services of the Career Center, Smith Warehouse, Bay 5, 2nd floor. Their url is http://www.studentaffairs.duke.edu/career.

GRADUATION HONORS

Graduation with Distinction in Chemistry. Majors may be considered for Graduation with Distinction honors provided they have all of the following:

- At least a B average in chemistry courses (courses listed on the advisory report having the prefix CHEM) is required at the time of application and at graduation.
- Satisfactory completion of at least two semesters of independent study in chemistry or in an approved chemistry-related area.
- Enrollment and participation in CHEM 295, Introduction to Research Independent Study, preferably concurrently with their enrollment in their first independent study course.
- Enrollment and participation in CHEM 496, Graduation with Distinction in Chemistry, in the spring semester of the senior year. No formal declaration of candidacy is required. A major automatically becomes a candidate for GwD by enrolling in CHEM 496.
- Submission of a high quality research thesis based upon the results of independent study.
- Formal nomination for GwD by the research advisor based on the completed research thesis.
- Presentation of a poster based on the results of the independent study.
- Oral defense of the research thesis, completed as part of CHEM 496. Suggestions for preparing and delivering oral reports are given at http://www.chem.duke.edu/undergraduate/oral-reports
- Selection for the honor by the Chemistry Department Undergraduate Awards Committee.

The process for awarding Graduation with Distinction is as follows: The student's work is evaluated first by the supervising professor and then, upon his/her recommendation, by a committee of Chemistry faculty. Final decisions on Graduation with Distinction rest with the departmental awards committee. In recent years approximately 50% of majors have earned Graduation with Distinction.

GRADUATION AWARDS

The following Awards and Honors are conferred each year and are recorded in the Special Prizes and Awards section of the annual Commencement Program in May.

The American Chemical Society Undergraduate Award in Analytical Chemistry is given annually to a rising junior or senior chemistry major. Selection by a faculty committee is based on an aptitude for analytical chemistry, including academic excellence and laboratory proficiency. The award consists of a personalized certificate, as well as monthly highlights from the journal *Analytical Chemistry,* published by the American Chemical Society.

The American Chemical Society Undergraduate Award in Inorganic Chemistry is given annually to a graduating chemistry major. Selection by a faculty committee is based on demonstrated excellence in inorganic chemistry, including research experience, coursework and a desire to pursue a career in chemistry. The award consists of a personalized certificate and a letter of commendation from the American Chemical Society Division of Inorganic Chemistry.

The American Chemical Society Undergraduate Award in Organic Chemistry is given annually to a graduating chemistry major. Selection by a faculty committee is based on demonstrated excellence in organic chemistry, including research experience, coursework and a desire to pursue a career in chemistry. The award consists of a letter of recognition from the American Chemical Society Division of Organic Chemistry, an award certificate signed by the division chair, and a one-year membership to the Organic Division of the ACS.

The Chemistry Department Award is given annually to an outstanding senior B. S. chemistry major. Selection by a faculty committee is based on the student's independent research, scholastic achievement, and interest in pursuing graduate study in chemistry. The award consists of a one-year membership in the American Chemical Society and a one-year subscription to an appropriate journal.

The Merck Index Award is awarded annually to one or more graduating chemistry majors intending to pursue a career in medicine. Selection by a faculty committee is based on scholastic excellence. The prize consists of a copy of the *Merck Index*.

The Hypercube Scholar Award is awarded annually to an outstanding senior B.S. chemistry major. Selection by a faculty committee is based on the student's scholastic achievement, performance in independent study, and interest in pursuing advanced work in a field of chemistry that utilizes molecular modeling extensively. The prize consists of a molecular modeling computer software package presented by *Hypercube, Inc.*

University Latin Honors by Overall Academic Record. Overall academic excellence for the entire college career is recognized by the designations *summa cum laude* (highest 5%), *magna cum laude* (next highest 10%), and *cum laude* (next highest 10%).

TEACHER CERTIFICATION

Science majors interested in teaching in secondary or elementary schools are encouraged to consult with the Duke Program in Education about teacher preparation opportunities and fulfilling requirements for a teaching license. Students interested in a science teaching career are encouraged to begin planning early, prior to the preparation of a Long Range Plan and the declaration of the major, if possible. More information can be obtained at the Program in Education web-site:
http://educationprogram.duke.edu/teacherpreparation

UNDERGRADUATE WEBSITE

Updated and additional information is available from the undergraduate website at http://www.chem.duke.edu/undergraduates/

PORTRAIT OF A CHEMISTRY MAJOR

Here are some statistics that paint a picture of our chemistry majors.

On average, about 45 majors have graduated each of the past five years with degrees in chemistry. Of these, 65% earned BS degrees, about 40% completed a biochemistry concentration, 25% completed a pharmacology concentration, and 8% received ACS certified degrees. In terms of academic achievements, about 40% earned Graduation with Distinction honors, 10% were elected to Phi Beta Kappa, and 40% earned Latin Honors.

With regard to post-graduate plans, roughly 40% will enroll in medical school, 25% in graduate school in chemistry or a related area, and most of the rest are employed in a wide range of jobs or internships. A number of those with jobs will go on to graduate or professional training within 2 years of their graduation.