Chemistry and Biochemistry

Undergraduate chemistry at UMass Dartmouth provides the student with the theoretical and practical expertise necessary for success in a wide variety of careers, consistent with the nature of chemistry as the central science. Chemists pursue a broad spectrum of rewarding professional careers ranging from production supervisors in the chemical or petroleum industries to physicians and patent attorneys. The Department is professionally accredited by the American Chemical Society and provides individualized attention and instruction usually encountered only in a small-college setting. Class sizes, especially at the junior and senior levels, are usually small, affording the student ample opportunities for interaction with the faculty.

Teaching and research facilities of the Department of Chemistry and Biochemistry are equipped with modern instrumentation, from an atomic absorption spectrophotometer to a voltametric analyzer, with an impressive range of biosensors, calorimeters, chromatographs, electrophoresis systems, a DNA sequencer, scintillation counter, specialized spectrometers, spectrofluorometers, and ultracentrifuges, in between.

The Department, consistent with university policies, emphasizes computer use and maintains a variety of computers and accessories, including IBM and Macintosh microcomputers, terminals, plotters, and printers. Students have access to the full range of campus computing services.

The Department of Chemistry and Biochemistry at UMass Dartmouth also offers a graduate program leading to the degree of Master of Science in Chemistry and, in conjunction with UMass Lowell or UMass Amherst, a Ph.D. in Chemistry. The Department actively participates in the Ph.D. program in Biomedical Engineering and Biotechnology with departmental faculty serving as research advisors for students in that program.

The need for K-12 teachers in the areas of science is great in the region. Chemistry is a strong major for future teachers. The Chemistry Department participates in UMass Dartmouth's programs to prepare teachers who are highly qualified, helping provide opportunities for students to receive professional licensure. Specifically, the department supports students who seek professional licensure as a Teacher of Chemistry (8-12) through the MAT program. Students should indicate their interest both to their major advisor and to an advisor in UMass Dartmouth's Education Department, to plan to take appropriate prerequisite and enrichment courses.

Faculty and Fields of Interest

Alan H Bates inorganic and organometallic chemistry

Donald W Boerth physical organic chemistry, theoretical chemistry

William L Dills, Jr (chairperson) biochemistry of carbohydrates, metabolism and metabolic effects of carbohydrate analogues

James A Golen physical inorganic chemistry, synthesis and molecular spectroscopy of inorganic compounds

David Z Goodson physical chemistry, theoretical chemical physics, environmental chemistry

Msolin Guo biochemical processes, drug design

Michele I Mandrioli transition metal chemistry and magnetic resonance, computers in chemical education

Catherine C Neto organic, agricultural, and food chemistry, isolation and elucidation of bioactive natural products

Vesa Nevalainen organic chemistry, catalytic and enantioselective reactions, synthetic and computational chemistry

Emmanuel C A Ojadi chemical physics, laser spectroscopy and photochemistry

Bal-Ram Singh physical biochemistry, structure-function relationships of biological macromolecules

Timothy C K Su physical chemistry, ion-molecule reactions, mass spectrometry

Dragic Vukomanovic analytical chemistry, electroanalytical chemistry, mass spectrometry, redox biochemistry

Yuegang Zuo analytical, marine, and environmental chemistry

Faculty Member with Chemistry and Biochemistry Joint Appointment
Primary Department

Mark A Altabet
School of Marine Sciences and Technology

Chemistry Major
BS degree

The programs for chemistry majors are designed to provide a solid foundation in the theoretical knowledge and practical laboratory skills necessary for a variety of professional careers. The programs prepare students for graduate study, medical or other professional school, science teaching, technical sales, technical writing, and industrial or government employment.

In order to fit the needs of the individual student, the department offers various options within the major. The principal options are "Chemistry" or "Biochemistry," either of which can be customized to meet medical school admissions requirements. The Chemistry option can be customized to suit the needs of students who wish to focus on environmental chemistry.

Educational Outcomes

The objectives of the BS programs are the following:

1
Provide a solid background in the fundamental concepts and methods of inorganic chemistry, organic chemistry, analytical chemistry, physical chemistry, and biochemistry and an appreciation of issues in each of these fields that areas of current research.
2
Provide a specialized knowledge of at least one of these areas, sufficient to qualify for entry-level employment in industry and admission to graduate school.
3
Provided practical experience in laboratory technique, including competence to keep legible and complete experimental records, synthesize and characterize chemical compounds, design experiments, use and understand modern analytical instruments, perform accurate and precise qualitative measurements, analyze data statistically and draw reasonable conclusions from them, use computers to analyze chemical and biochemical questions, work effectively in small groups or teams, communicate effectively through oral and written reports, and anticipate, recognize, and respond properly to hazards of chemical manipulations.
4
Provide competence in searching the scientific literature and in understanding scientific journal articles.

Chemistry Major
Chemistry and Biochemistry Options

Requirements

The following two options prepare students for professional or graduate schools or for employment in a variety of industry, education, or government settings. They can be supplemented with graduate work in education, law, library science, or business administration to prepare for such careers as high school science teacher, patent attorney, science librarian, chemical or pharmaceutical industry executive, or small business owner.

Core courses (Common to all options)		Credits
First Year		
CHM 155, 156	Principles of Modern Chemistry I, II	6
CHM 163, 164	Introduction Chemistry Lab I, II	2
MTH 111, 112	Analytical Geometry and Calculus I, II	8
Second Year		
CHM 204	Introduction to Analytical Chemistry	3
CHM 251, 252	Organic Chemistry I, II	6
CHM 265, 266	Organic Chemistry Lab I, II	4
MTH 211	Analytical Geometry and Calculus III	4
PHY 113, 114	Classical Physics I, II	8
Third Year		
CHM 305	Modern Methods of Chemical Analysis	3
CHM 307	Procedures of Chemical Analysis	2
CHM 315, 316	Physical Chemistry I, II	8
Fourth Year		
CHM 401, 402	Chemistry Seminar	1
CHM 491 or 492	Research	3-6

Additional Requirements, Chemistry Option

This option prepares students for employment in teaching or in the chemical industry, and for graduate study in most pure and applied chemistry areas, such as organic, inorganic, physical, analytical, polymer, or forensic chemistry. It satisfies the American Chemical Society requirements for professional certification. With permission, appropriate advanced courses in other departments can be substituted for the advanced chemistry electives.

CHM 170	Introduction to Inorganic Chemistry	1
CHM 318, 319	Physical Chemistry Measurements I, II **or**	
CHM 552	Instrumental Methods of Analysis	4
CHM 411	Biochemistry I	3
CHM 416	Computer Methods in Biochem. and Bioinformatics	1
CHM 424	Mathematical Methods in Physical Science	2
CHM 431	Principles of Inorganic Chemistry	3
CHM 433	Inorganic Chemistry Laboratory	1
CHM 4xx	Advanced Chemistry Electives	at least 6 credits

Additional Requirements, Biochemistry option

This option prepares students for employment in the pharmaceutical industry and for graduate study in biochemistry, molecular biology, pharmacology, nutrition, and other areas of life science. The advanced biology electives must be approved by the biochemistry advisor. Note that students with weak backgrounds in biology may need to take BIO 121, 122, 131, and 132 before attempting other biology courses.

BIO 234, 244	Biology of Cells, Biology of Cells Laboratory	4
CHM 411, 412	Biochemistry I, II	6
CHM 414	Biochemistry Lab	3
CHM 416	Computer Methods in Biochem. and Bioinformatics	1
CHM 529	Physical Biochemistry	3
CHM 4xx	Advanced Chemistry Electives	at least 3 credits
BIO 3xx or 4xx	Advanced Biology Electives	at least 6 credits

Premedical

Both options satisfy the mathematics, physics, and chemistry requirements for admission to medical, osteopathic, optometric, podiatric, dental, or veterinary school. To satisfy biology requirements students will typically need 11 credits of biology courses including BIO 234 (Biology of Cells), Biology 244 (Biology of Cells Lab), Bio 333 (General genetics), and one appropriate advanced BIO elective, which should be chosen in consultation with the departmental faculty advisor. *All premedical students need to have their degree programs approved by the Premedical Faculty Advisor to make suer that they will satisfy the perquisites of the professional schools to which they plan to apply.*

For students in the Chemistry degree option, these Biology courses can replace CHM 319, CHM 431/433, CHM 491, and one of the advanced science electives. Also, Bio 430 (Introduction to Biological Statistics) can be substituted for CHM 424. Although CM 319, CHM 431/433, and CHM 491 are not required, they can be taken as electives in order to qualify for American Chemical Society certification. In the Biochemistry option the premedical biology courses can be used to satisfy existing degree requirements.

Environmental Chemistry

For students interested in marine chemistry, geochemistry, toxicology, environmental monitoring and analysis, environmental law, or other areas of environmental science, the department allow for a more interdisciplinary course of study, with electives chosen from other departments, such as biology, physics, environmental engineering, economics, or political science.

The Chemistry option is modified as follows: CHM 552 (Instrumental Methods of Analysis) is substituted for CHM 318 and 319. CHM 431, CHM 433, and either CHM 416 or 424 can be waived. In place of the two advanced science electives, at least five courses chosen from an approved list of environmental electives are required. (One of these can count toward the university social science requirement.) Contact the department's environmental chemistry advisor for full details.

The BS/MS option permits the student to achieve both a Bachelor's and a Master's degree in five years, rather than the usual six years required. This option provides exposure to graduate courses and research, making easier the transition from BS-MS to PhD-level. For those going directly into teaching or industry, the master's degree typically yields a significant increase in starting salary.

By counting some beginning graduate courses also as senior chemistry courses, this combined program permits the student to achieve both degrees in 143 credits, fewer than the total if the two degree programs were taken separately. Two summers of research are necessary. Entrance into this program requires approval of the department.

Under this option the student works toward completion of the course curriculum for one of the BS options. The student may apply for acceptance to this program as early as the fourth semester. A research project is typically begun in the summer of the third year and continued through one or two summers, the fall of the fourth year (as CHM 491), the spring of the fourth year and in both semesters of the fifth year (as 9 credits of CHM 600). A total of 12 additional credits of advanced CHM electives beyond those required for the BS (or, with approval of the departmental advisor, advanced electives in another department) is required at the 500 level. The student is also required to enroll in Graduate seminar (CHM 650) in both semesters of the fifth year. Since this program has a relatively demanding course load, students without significant advanced placement credit are advised to take general education electives during the summer after the first or second year.

The student should request permission to pursue this degree option no later than the beginning of the fall semester of the fourth year. A requirement for admission into the program is an overall GPA of at least 2.75 and a GPA of at least 3.00 in all core and advanced elective chemistry courses. These minimum requirements must be maintained throughout the remainder of the program.

Students in this program are eligible for teaching assistantships after completing the BS requirements (typically by the spring of the fourth year) and may be eligible for summer research stipends. At this time, they will apply for formal entrance to the graduate level by submitting an application through the Office of Graduate Studies. Applicants will state their specific intention of applying for the BS/MS program and do not need to submit GRE scores or reference letters.

Chemistry and Biochemistry Minors

Candidates for degrees in other departments who have a grade point average of at least 2.5 in the 100- and 200-level chemistry courses may request admission to the Chemistry or Biochemistry minors. This request must be approved by the Department. A minimum GPA of 2.0 grade point average in all the listed courses will be required for completion of the minor.

Minor in Chemistry

		credits
CHM 155, 156	Principles of Modern Chemistry I, II **or**	6
CHM 151, 152	Principles of Modern Chemistry I, II	
CHM 163, 164	Introduction to Applied Chemistry I, II **or**	2
CHM 161, 162,	Introduction to Applied Chemistry I, II	
CHM 204	Introduction to Analytical Chemistry	3
CHM 251	Organic Chemistry I	3
CHM 265	Organic Chemistry Laboratory I **or**	1 or 2
CHM 263	Bio-Organic Chemistry Laboratory I	
CHM 252	Organic Chemistry II **or**	3 or 1
CHM 170	Inorganic Chemistry	
CHM 3xx	Chemistry Electives at the 300 (or higher) level*	at least 9
	Total credits:	27-29

Minor in Biochemistry

CHM 155, 156	Principles of Modern Chemistry I, II **or**	6
CHM 151, 152	Principles of Modern Chemistry I, II	
CHM 163, 164	Introduction to Applied Chemistry I, II **or**	2
CHM 161, 162,	Introduction to Applied Chemistry I, II	
CHM 204	Introduction to Analytical Chemistry	3
CHM 251	Organic Chemistry I	3
CHM 265, 266	Organic Chemistry Laboratory I, II **or**	2 or 4
CHM 263, 264	Bio-Organic Chemistry Laboratory I, II	
CHM 252	Organic Chemistry II	3
CHM 411, 412	Biochemistry I, II	6
CHM 3xx	Chemistry Electives, 300 or higher level**	at least 3
	Total credits:	27-29

***** The advanced electives should be chosen in consultation with the departmental advisor for chemistry minors. Note that may of these electives have prerequisite requirements that must be satisfied before enrolling in the course.

******Typically this will be satisfied with CHM 305 but other choices are possible with approval of the departmental advisor for biochemistry minors.

Departmental General Education Requirements

Students majoring in Chemistry will meet their departmentally-determined General Education requirements as follows:

Area E: Students should select a course from the published list of available courses that satisfy this requirement.

Area I, Tier 2: Satisfied by CHM 416 or CHM 424

Area W, Tier 2: Satisfied by CHM 307 and either CHM 318, CHM 412, or CHM 552

Area O: Satisfied by CHM 401/402 and CHM 491, or 492

Literature: 6 credits of courses from the published list of available courses that satisfy this requirement.

Humanities/Social Science: An additional 18 credits with at least 6 in social science and at least 6 in humanities (excluding logic, applied music, or literature)

NOTE on minimum grades

For all majors in the Department of Chemistry & Biochemistry, any course that is prerequisite for another required course must be passed with a grade of at least C-.

Gen Ed note: Chemistry courses satisfy the Natural Science and Technology requirement. Those marked **S** below are appropriate for non-science/engineering majors.

Chemistry and Biochemistry Courses

CHM 100 four administrative credits*
Preparation for College Chemistry
2 hours lecture, 1 hour recitation, 2 hours laboratory
Helps students overcome science, mathematics, and reasoning difficulties so that they may be successful in their required general chemistry course. The lecture and the laboratory are integrated to ensure that students have direct hands-on experience with most of the abstract ideas covered in the lecture.

CHM 101 three credits **S**
General Chemistry I
4 hours lecture and recitation
For non-science majors, nursing
Pre- or Corequisite: MTH 101
An introduction to the fundamental chemical laws and theories covering inorganic and organic chemistry and biochemistry with some descriptive chemistry.

CHM 102 three credits **S**
General Chemistry II
4 hours lecture and recitation
Prerequisite: At least a C- in CHM 101
Continuation of CHM 101.

CHM 130 three credits **S**
Chemistry and the Environment
3 hours lecture
Available to anyone in the university, this course provides substantial treatment, with demonstrations, of the chemistry involved in consumer concerns (food additives, medicines, detergents, etc.), air and water pollution, elementary biochemistry, and the general question of power generation and utilization (fuel cells, solar energy conversion, nuclear energy, etc.). No knowledge of chemistry is assumed, but it is hoped the student will have had high school chemistry or its equivalent.

CHM 132 three credits **S**
Chemistry in Nutrition and Health
3 hours lecture
Nutrition and health issues facing people today and the chemistry needed to understand them. Topics to be discussed include health efforts of toxic substances, the science of proper diet, and some of the biochemistry needed to understand diseases such as cancer and AIDS.

CHM 151 three credits **S**
Principles of Modern Chemistry I
4 hours lecture and recitation
For science and engineering majors
Prerequisites: High school chemistry and algebra; and satisfactory score on departmental placement examination
Corequisites: MTH 131 or 111, CHM 161
Physical and chemical principles pertaining to the structure of chemical species and the nature, extent, and rates of chemical reactions. The details of stoichiometry, energy changes associated with chemical reactions, atomic and molecular structure, chemical bonding, and the phenomenon of chemical periodicity are emphasized and discussed in light of modern scientific theories.

CHM 152 three credits **S**
Principles of Modern Chemistry II
4 hours lecture and recitation
For science and engineering majors
Prerequisite: At least a C- in CHM 151
Corequisite: CHM 162
A continuation of CHM 151. The details of the behavior of solids, liquids, and gases, the types of intermolecular forces, colligative properties, gaseous equilibrium, aqueous equilibrium, thermodynamics, electrochemistry, kinetics, and nuclear chemistry are emphasized and discussed in light of modern scientific theories.

CHM 153 three credits **S**
Principles of Modern Chemistry for Engineers
Combined lecture/laboratory
Prerequisites: High school chemistry and algebra
Corequisites: MTH 113 or 111
Physical and chemical principles pertaining to the structure of chemical species and the nature, extent and rates of chemical reactions. The details of stoichiometry, energy changes associated with chemical reactions, atomic and molecular structure, chemical bonding, chemical periodicity, and the application to materials are emphasized and explored in an interactive format.

CHM 155 three credits **S**
Principles of Modern Chemistry I
4 hours lecture and recitation
For chemistry majors and honors students
Prerequisites: High school chemistry and algebra; and satisfactory score on departmental placement examination
Corequisites: MTH 131 or 111, CHM 163
Physical and chemical principles pertaining to the structure of chemical species and the nature, extent, and rates of chemical reactions. The details of stoichiometry, energy changes associated with chemical reactions, atomic and molecular structure, chemical bonding, and the phenomenon of chemical periodicity are emphasized and discussed in light of modern scientific theories.

CHM 156 three credits **S**
Principles of Modern Chemistry II
4 hours lecture and recitation
For chemistry majors and honors students
Prerequisite: At least a C- in CHM 155
Corequisite: CHM 164
A continuation of CHM 155. The details of the behavior of solids, liquids, & gases, the types of intermolecular forces, colligative properties, gaseous equilibrium, aqueous equilibrium, thermodynamics, electrochemistry, kinetics, and nuclear chemistry are emphasized and discussed in light of modern scientific theories.

CHM 161 one credit
Introduction to Applied Chemistry I
1 hour lecture, 2 hours laboratory
For science and engineering majors
Prerequisites: High school chemistry (with laboratory) is strongly recommended.
Corequisite: CHM 151
An introduction to chemical laboratory techniques and methods with emphasis on preparation, purification, and identification of compounds, elemental analysis, reaction stoichiometry, chemical ionization, thermochemistry, spectrophotometric techniques, and selective descriptive inorganic chemistry. Most experiments involve the identification of unknowns and statistical analysis of data. The experiments in CHM 161 parallel the topics covered in CHM 151. A written laboratory report summarizing the procedure and results for each experiment is required.

CHM 162 one credit
Introduction to Applied Chemistry II
1 hour lecture, 2 hours laboratory
For science and engineering majors
Prerequisites: At least a C- in CHM 151, 161
Corequisite: CHM 152
A continuation of CHM 161 with emphasis on molecular weight determination techniques, colligative properties, qualitative analysis, acid-base chemistry, properties of buffer solutions, chromatographic techniques, kinetics, solubility constant determination, and electrochemistry. Most experiments involve the identification of unknowns and statistical analysis of data. The experiments in CHM 162 parallel the topics covered in CHM 152. A written

***** Administrative credits do not count towards the total required for graduation.

laboratory report summarizing the procedure and results for each experiment is required.

CHM 163 one credit
Introduction to Chemistry Laboratory I
1 hour lecture, 2 hours laboratory
For chemistry majors and honors students
Prerequisites: High school chemistry (with laboratory) is strongly recommended.
Corequisite: CHM 155
An introduction to chemical laboratory techniques and methods with emphasis on preparation, purification, and identification of compounds, elemental analysis, reaction stoichiometry, chemical ionization, thermochemistry, spectrophotometric techniques, and selective descriptive inorganic chemistry. Most experiments involve the identification of unknowns and statistical analysis of data. The experiments in CHM 163 parallel the topics covered in CHM 155. A written laboratory report summarizing the procedure and results for each experiment is required. Previously offered as CHM 165.

CHM 164 one credit
Introduction to Chemistry Laboratory II
For chemistry majors and honors students
1 hour lecture, 2 hours laboratory
Prerequisites: At least a C- in CHM 151, 161
Corequisite: CHM 156
A continuation of CHM 163 with emphasis on molecular weight determination techniques, colligative properties, qualitative analysis, acid-base chemistry, properties of buffer solutions, chromatographic techniques, kinetics, solubility constant determination, and electrochemistry. Most experiments involve the identification of unknowns and statistical analysis of data. The experiments in CHM 164 parallel the topics covered in CHM 156. A written laboratory report summarizing the procedure and results for each experiment is required. Previously offered as CHM 166.

CHM 167 one credit
Introduction to Statistics for the Chemistry Lab
2 hours lecture and recitation
Statistics at an introductory level as applied to experiments in a college freshman level chemistry laboratory. Topics covered include the nature of distributions of data, histograms, basic statistical calculations, the normal distribution, t-distributions, statistical tests appropriate for small samples of data criteria for rejection of data, analysis of data and reporting of result and an introduction to propagation of errors.

CHM 170 onecredit
Introduction to Inorganic Chemistry
2 hours lecture
Prerequisites: At least a C- in CHM 152, 166
A survey of the preparations and reactions of selected representative elements and transition metals. The physical and chemical properties of each element are covered, including its extraction and uses and industrial processes.

CHM 204 three credits
Introduction to Analytical Chemistry
1 hour lecture, 2 hours laboratory
Prerequisites: At least a C- in CHM 152, 166
A survey of the preparations and reactions of selected representative elements and transition metals. The physical and chemical properties of each element are covered, including the occurrence of the element in nature and important compounds and their uses, including industrial processes. The course introduces transition metal complexes and includes an advanced treatment of ionic equilibria including precipitation and complex-formation reactions.

CHM 251 three credits
Organic Chemistry I
4 hours lecture and recitation
Prerequisite: At least a C- in CHM 152
A survey of the chemistry of carbon compounds and introduction to the basic principles of organic chemistry.

CHM 252 three credits
Organic Chemistry II
4 hours lecture and recitation
Prerequisite: At least a C- in CHM 251
Continuation of CHM 251.

CHM 263 one credit
Bio-organic Chemistry Laboratory I
1 hour lecture, 3 hours laboratory
Prerequisites: At least a C- in CHM 152, 162
Corequisite: CHM 251
The synthesis of organic compounds and an introduction to the organic methods of separation, purification and identification. This course is coordinated with CHM 251 and is designed for biology and medical laboratory science majors.

CHM 264 one credit
Bio-organic Chemistry Laboratory II
1 hour lecture, 3 hours laboratory
Prerequisites At least a C- in CHM 251, 263
Corequisite: CHM 252
Continuation of CHM 263.

CHM 265 two credits
Organic Chemistry Laboratory I
1 hour lecture, 3 hours laboratory
Prerequisites: At least a C- in CHM 152, 166; or CHM 162
The synthesis of organic compounds and an introduction to the organic methods of separation, purification and identification. This course is coordinated with CHM 251 and is designed for chemistry and textile chemistry majors.

CHM 266 two credits
Organic Chemistry Laboratory II
1 hour lecture, 3 hours laboratory
Prerequisites: At least a C- in CHM 251, 265
Corequisite: CHM 252
Continuation of CHM 265.

CHM 298 one to six credits
Experiential Learning
Prerequisites: At least sophomore standing; permission of the instructor, department chairperson, and college dean
Work experience at an elective level supervised for academic credit by a faculty member in an appropriate academic field. Conditions and hours to be arranged. Graded CR/NC. For specific procedures and regulations, see section of catalogue on Other Learning Experiences.

CHM 305 three credits
Modern Methods of Chemical Analysis
3 hours lecture, 1 hour recitation
Prerequisites: At least a C- in CHM 252, 266, 166; recommended: CHM 272
Introduction to chemical and instrumental analytical techniques. The theory of neutralization reactions in aqueous and nonaqueous systems. Oxidation-reduction and complex formation equilibria. Basic theory of electronic circuitry. Introduction to electrochemical methods. Introduction to chromatographic and spectrophotometric techniques.

CHM 307 two credits
Procedures of Chemical Analysis
1 hour lecture, 4 hours laboratory
Corequisite: CHM 305
Laboratory experimentation designed to develop the techniques and illustrate applications of analytical procedures to the solution of chemical problems.

CHM 315 four credits
Physical Chemistry I
4 hours lecture, 1 hour recitation
Prerequisites: At least a C- in CHM 152, MTH 211, two semesters of college physics
An introduction to the theoretical principles underlying chemical phenomena; applications of thermodynamics to chemical

Gen Ed note: Chemistry courses satisfy the Natural Science and Technology requirement. Those marked **S** below are appropriate for non-science/engineering majors.

phenomena.

CHM 316 four credits
Physical Chemistry II
4 hours lecture, 1 hour recitation
Prerequisite: At least a C- in CHM 315
An introduction to quantum mechanics, symmetry, spectroscopy, chemical kinetics and transport processes.

CHM 318 two credits **W**
Physical Chemical Measurements I
1 hour lecture, 4 hours laboratory
Prerequisites: At least a C- in CHM 305, 307, 315
Corequisite: CHM 316
Experiments in physical chemistry designed to test established theoretical principles which have been introduced in CHM 315 and 316. The experiments provide the student with basic experience in obtaining precise physical measurements of chemical interest.

CHM 319 two credits **W**
Physical Chemical Measurements II
1 hour lecture, 4 hours laboratory
Prerequisites: At least a C- in CHM 305, 307, 316
Continuation of CHM 318.

CHM 355 three credits **O**
Aquatic Environmental Chemistry
Prerequisites: At least a C- in CHM 151, 152 or permission of instructor
Fundamentals of aquatic environmental chemistry. Topics include dissolved gases chelation, complexation, role of humic substances in the aquatic environment, oxidation-reduction phenomena, chemical speciation, phase equilibria and chemistry related to water pollution issues.

CHM 356 three credits **W**
Atmospheric/Terrestrial Environmental Chemistry
Prerequisite: At least a C- in CHM 355
Fundamentals of atmospheric and terrestrial environmental chemistry. Topics include physical and chemical characteristics of the atmosphere, reactions involving oxygen, nitrogen, carbon dioxide, water and particulates in the atmosphere, gaseous organic and inorganic pollutants. Additional topics include fundamentals of soil chemistry, organic and inorganic soil contaminants and environmental biochemistry and toxicology.

CHM 401 one-half credit **O**
Chemistry Seminar I
1 hour lecture
Lectures on current topics in chemistry from guest lecturers and students. Majors must enroll for two semesters out of four in the junior and senior years.

CHM 402 one-half credit **O**
Chemistry Seminar II
1 hour lecture
Continuation of CHM 401.

CHM 411 three credits
Biochemistry I
3 hours lecture
Prerequisite: At least a C- in CHM 252, recommended BIO 234
Students may not receive credit for both CHM 362 and CHM 411, 412
See description under CHM 511.

CHM 412 three credits **W**
Biochemistry II
Prerequisite: At least a C- in CHM 411
See description under CHM 512.

CHM 414 three credits
Biochemistry Laboratory
1 hour lecture, 6 hours laboratory
Prerequisite: At least a C- in CHM 264 or 266; CHM 411
Pre- or Corequisite: CHM 412
Recommended: CHM 305, 307; BIO 234, 244
Basic biochemical techniques and methods including spectrophotometry, electrophoresis, chromatography, ultracentrifugation and radioisotopic techniques and their application to amino acids and proteins, lipids and membranes, enzymes and nucleic acids.

CHM 416 one credit
Computer Methods in Biochemistry and Bioinformatics
Prerequisites: At least a C- in CHM 155, 156, 251, 252; or permission of instructor
Topics in computer science with applications to organic chemistry and bioinformatics. Includes molecular modeling, quantum chemistry, computational molecular biology, and biological data analysis. Includes an introduction to computer programing for computational molecular biology and biological data analysis and an overview of methods for molecular modeling and quantum chemistry.

CHM 421 three credits
Organic Mechanisms
Pre- or Corequisite: At least a C- in CHM 315
See description under CHM 521.

CHM 424 two credits
Mathematical Methods in Physical Science
Prerequisites: At least a C- in CHM, two semesters of college physics, and three semesters of calculus; or permission of instructor.
Prerequisite or corequisite: CHM 316
Topics in applied mathematics with applications to physical chemistry. Includes introduction to differential equations, linear algebra, computer programming, curve and surface fitting, numerical integration, and trajectory calculations. Computer mathematics software will be used extensively throughout the course.

CHM 426 three credits
Polymer Synthesis and Characterization
2 hours lecture, 4 hours laboratory
Prerequisites: At least a C- in CHM 252, 315; recommended, TEC 410
See description under CHM 526.

CHM 431 three credits **O**
Principles of Inorganic Chemistry
Prerequisite: One year of physical chemistry with grades of C- or better
The application of physico-chemical principles to inorganic systems. Discussion of chemistry of the representative elements utilizing thermodynamic principles and the modern theories of bonding and structure. Introduction to coordination chemistry.

CHM 432 four credits
Organic Analysis
Prerequisites: Organic and analytical chemistry with grades of C- or better
Quantitative elemental and group determination on a microscale followed by a study of the systematic identification of organic compounds. Extensive laboratory work on unknowns is required.

CHM 433 one credit
Inorganic Chemistry Laboratory
Prerequisite: At least a C- in CHM 316; corequisite: CHM 431
Synthetic and instrumental techniques currently used by inorganic chemists, including electrolytic, inert atmosphere, tube furnace and organometallic syntheses; ultraviolet-visible, nuclear magnetic resonance, infrared and mass spectrometry, magnetic susceptibility determination, as applied to a range of inorganic materials.

CHM 442 three credits
Applied Spectroscopy
3 hours lecture
Prerequisites: At least a C- in CHM 252, 266, 315

Note: Some graduate courses may be open to undergraduates. Please consult your department chairperson. See the Graduate Catalogue for graduate general and program requirements.

See description under CHM 544.

CHM 449 three credits
Theory and Applications of One- and Two-Dimensional Fourier Transform Nuclear Magnetic Resonance
Prerequisites: At least a C- in CHM 251/252 and CHM 315
See description under CHM 549.

CHM 491 three to six credits
Introduction to Research I
9 to 18 hours laboratory
Prerequisite: Departmental permission
Chemistry majors who are doing well in formal course work and who have indicated research potential are encouraged to undertake an original investigation under the direction of a member of the chemistry faculty.

CHM 492 three to six credits
Introduction to Research II
9 to 18 hours laboratory
Continuation of CHM 491.

CHM 495 variable credit
Independent Study
Prerequisites: Upper-division standing; permission of instructor, department chairperson, and college dean
Study under the supervision of a faculty member in an area not otherwise part of the discipline's course offerings. Terms and hours to be arranged.

CHM 196, 296, 396, 496 variable credit
Directed Study
Prerequisites: Permission of the instructor, department chairperson, and college dean
Study under the supervision of a faculty member in an area covered in a regular course not currently being offered. Terms and hours to be arranged.

Graduate Courses in Chemistry and Biochemistry

CHM 510 three credits
Advanced Organic Chemistry
Prerequisites: One year of physical chemistry and CHM 521 with grades of C- or better
A study of mechanisms and stereo-chemical aspects of chemical reactions including considerations of chemical kinetics and reactivity in terms of modern bonding theory and structural concepts.

CHM 511 three credits
Biochemistry I
Prerequisite: One year of organic chemistry with grades of C- or better; recommended, cell biology or equivalent
A comprehensive study of biochemistry including amino acid and protein chemistry, enzymology, enzyme kinetics, bioenergetics, metabolism of carbohydrates, lipids, amino acids, nucleotides; biosynthesis of nucleic acids and proteins.

CHM 512 three credits
Biochemistry II
Prerequisite: At least a C- in CHM 511
A continuation of CHM 511.

CHM 514 three credits
Biochemistry Laboratory
1 hour lecture, 6 hours laboratory
Basic biochemical techniques and methods including spectrophotometry, electrophoresis, chromatography, ultracentrifugation and radioisotopic techniques and their application to amino acids and proteins, lipids and membranes, enzymes and nucleic acids.

CHM 521 three credits
Organic Mechanisms
Prerequisite: CHM 252. Prerequisite or Corequisite: One semester of physical chemistry
The first part of the course provides a background in the various areas of physical organic chemistry such as thermodynamics, kinetics, acid-base theory, structure-reactivity relationships and dipole moments. This is followed by a systematic study of reaction mechanisms.

CHM 522 three credits
Computer and Mathematical Methods in Physical Science
Prerequisites: One semester physical chemistry; two semesters of college physics, three semesters of calculus, or permission of instructor. Pre- or Corequisite: CHM 316, or equivalent
Selected topics in applied mathematics and computer science with applications to physical chemistry, organic chemistry, and bioinformatics. Includes introduction to differential equations, linear algebra, computer programming, curve and surface fitting, numerical integration, trajectory calculations, molecular modeling, quantum chemistry, computational molecular biology, and biological data analysis.

CHM 523 three credits
Chemistry of the Mind
Prerequisite: CHM 315, or equivalent
Exploration of the states of matter as understood by mind by considering reductionist and holistic approaches. Fundamental assumptions in developing scientific principles are examined with examples of kinetic theory of gases, ideal gas equation, and laws of thermodynamics. Application of thermodynamic laws to biological systems to model mind and brain activities. Structure, evolution, and functioning of the nervous system and neurological and metaphysical understanding of mind and consciousness are examined.

CHM 525 three credits
Theoretical Organic Chemistry
Prerequisites or Corequisites: One year each of organic and physical chemistry
Molecular orbital theory of organic molecules; applications of molecular orbital theory; reactivity, ESR, Carbon-13 NMR, photoelectron spectroscopy, etc.; orbital symmetry in electrocyclic reactions, cycloadditions, and sigmatropic reactions.

CHM 526 four credits
Polymer Synthesis and Characterization
Prerequisites: At least a C- in CHM 252, CHM 315; recommended, TEC 410
Laboratory synthesis of polymers and copolymers by different methods with an emphasis on the practical aspects of polymer synthesis. A discussion of various techniques of polymer characterization in terms of basic principles, experimental procedure, and interpretation of results. A selected number of experiments will be conducted on a class-project basis.

CHM 527 three credits
Electronic Structure of Atoms and Molecules
Prerequisite: One year of physical chemistry with grades of C- or better
Fundamental quantum mechanical principles of electronic structure. Angular momentum, the hydrogen atom problem, helium ground and excited states, electron spin and

antisymmetrization, many electron atoms, bonding theory, valence bond and molecular orbital theory of diatomic and polyatomic molecules, applications of group theory to molecular orbital calculations, the self-consistent field method.

CHM 529 three credits
Physical Biochemistry
Prerequisite: One year each of physical chemistry and biochemistry with grades of C- or better
Physico-chemical principles governing structures of biological macromolecules. Topics include energetics and kinetics of biochemical processes, including binding, catalysis, diffusion/transport, and folding/unfolding; behavior of macromolecules in aqueous medium; and application of spectroscopic methods in biochemistry.

CHM 531 three credits
Chemical Kinetics
Prerequisite: One year of physical chemistry with grades of C- or better
Principles and selected topics, including analysis of reaction rates, kinetic and transition state theories, reactions in gas and liquid phases, unimolecular reactions, fast reactions, trajectory calculations, ion-molecule reactions, enzyme kinetics, and polymer kinetics.

CHM 533 three credits
Statistical Methods
Prerequisite: One year of physical chemistry with grades of C- or better
Introduction to the principles and methods of statistical mechanics. Classical and quantum partition functions applied to the calculation of thermodynamic properties.

CHM 544 three credits
Applied Spectroscopy
Prerequisites: One year each of organic and physical chemistry with grades of C- or better
A study of spectroscopic methods of determination of structure of organic compounds, especially infrared, ultraviolet, visible, nuclear magnetic resonance, and mass spectrometry, with extensive applications to individual cases.

CHM 549 three credits
Theory and Applications of One- and Two-Dimensional FT-NMR
Prerequisites: At least a C- in CHM 251/252 and 315, or equivalent
Fundamentals of Fourier Transform Nuclear Magnetic Resonance (FT-NMR) spectroscopy, including one- and two-dimensional techniques discussed from the perspective of structural determination. Generation of NMR signals and parameter optimization using a 300 MHz FT-NMR spectrometer will complement the analysis of NMR signals generated in situ.

CHM 550 three credits
Special Topics in Chemistry
Prerequisite: Permission of instructor
An advanced treatment of special topics in chemistry with an emphasis on recent developments. The subject matter varies from year to year.

CHM 552 four credits
Instrumental Methods of Analysis
Prerequisites: Quantitative analysis and one year of physical chemistry with grades of C- or better
The theory and practice of modern analysis utilizing optical and electrochemical instrumentation in the solution of chemical problems. Topics discussed include ultraviolet, visible, and infrared spectrophotometry, fluorimetry, flame emission and atomic absorption spectroscopy, plasma emission spectroscopy, potentiometry utilizing ion specific electrodes, radiochemistry, thermoanalytical methods, voltammetry including polarography, amperometry, and coulometry; liquid chromatography, electron spectroscopy, x-ray fluorescence analysis, and neutron activation analysis.

CHM 553 three credits
Nuclear and Radiochemistry
Prerequisite: One year of physical chemistry with grades of C- or better
Application of nuclear and radiochemical methods. Topics include fundamentals of radioactive decay, radiation safety, interaction of radiation with matter, instrument design and function, radiotracers, radioanalytical methods, and related non-destructive methods for quantitative analysis.

CHM 555 three credits
Methods of Chemical Separation
Prerequisites: Analytical and physical chemistry with grades of C- or better
A survey and practice of modern separation methods. Topics include liquid, gas, thin layer and ion exchange chromatography; electrophoresis; sample preparation and extraction.

CHM 562 three credits
Natural Products
Prerequisite: One year of organic chemistry with grades of C- or better
Isolation, structure elucidation, total synthesis, biosynthetic pathways, metabolism, and physiological importance and pharmacological uses of natural products.

CHM 595 three credits
Graduate Independent Study
Prerequisites: Graduate standing; permission of instructor, graduate director, and college dean
Study under the supervision of a faculty member in an area not otherwise part of the discipline's course offerings. Terms and hours to be arranged.

CHM 596 three credits
Graduate Directed Study
Prerequisites: Graduate standing; permission of instructor, graduate director, and college dean
Study under the supervision of a faculty member in an area covered in a regular course not currently being offered. Terms and hours to be arranged. Terms and hours to be arranged.

CHM 600 three to nine credits per term
Thesis Research
Prerequisite: Departmental permission
Original chemical research and preparation of thesis. Required for Plan A master's degree. Graded P/F.

CHM 610 two to five credits per term
Project Research
Prerequisite: Departmental permission
Original chemical research, required for Plan B master's degree. Written project report required. Graded P/F.

CHM 620 two to five credits per term
Library Research
Prerequisite: Departmental permission
Survey of a particular topic in the chemical literature. Written final summary report required. Graded P/F.

CHM 650 one credit
Graduate Seminar
Lectures on current topics in chemistry from guest lecturers and students. The graduate student will present a total of two seminars, one of which will be the thesis seminar. Each graduate student is required to enroll in this course for each semester in residence. This course will not count toward the 30 credits of course work and research required for the degree.