Chemistry and Biochemistry

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The department offers programs of concentration for students interested in continuing their studies in medical school or graduate school, for those interested in a career as a chemist or biochemist in government or private industry, and for those interested in teaching chemistry at the secondary level. A concentration in chemical engineering is offered with the Engineering Department. Students who are majoring in Environmental Science with a Chemistry focus should consult the entry under Environmental Science for a description of this program.

Prerequisite to a program of concentration in chemistry or biochemistry is a minimum average of "C" (2.0) in Chemistry 104 and in one course from Chemistry 201, 253, or 261. The physical science core requirement may be met by Chemistry 101, 103, 104, or 115. For general college students the preferred core course is Chemistry 101.

All students who are majoring in the department, with the exception of those in a secondary education program, and who enrolled at Calvin in 2001 or later must complete a capstone course during the senior year. Normally this course will be IDIS 310- History of Science. Other options for the capstone course are possible but must be approved by the student's academic advisor.

CHEMISTRY MAJOR

Chemistry 103 and 104
Chemistry 201
Chemistry 261 and 262
Chemistry 304 or 317
Two from Chemistry 318, 323/383, 329, and 330
IDIS 310 or an approved course in integrative studies
Chemistry 295 (four times)
Completion of Major Field Test in Chemistry

Cognates

Mathematics 161 and 162
Physics 221 and 222 or 133 and 235

CHEMISTRY MINOR

Chemistry 103 and 104
Chemistry 201
Chemistry 253 or 261
Chemistry 304 or 317
One from Chemistry 262, 318, 323/383, 329, or an approved interim course

CHEMISTRY MAJOR (ACS Certified)

For students preparing for graduate study in chemistry, the certification requirements of the American Chemical Society for professional training in chemistry may be met by completing the following courses:

Chemistry 103 and 104
Chemistry 201
Chemistry 261 and 262
Chemistry 295 (four times)
Chemistry 317 and 318
Chemistry 323
Chemistry 329
Chemistry 330
Chemistry 395 (3 or 4 semester hours)
Chemistry 325
IDIS 310 or an approved course in integrative studies
Completion of Major Field Test in Chemistry

Cognates

Mathematics 161 and 162
Mathematics 261
Mathematics 231 or 256
Physics 133 and 235

SECONDARY EDUCATION CHEMISTRY MAJOR

Chemistry 103 and 104
Chemistry 201
Chemistry 253 and a four semester-hour Chemistry elective (recommended); or Chemistry 261 and 262
Chemistry 295 (three times)
Chemistry 304 (recommended) or 317
Chemistry 323 and 383

Chemistry 396 (offered odd years)
Completion of Major Field Test in Chemistry

Cognates
Mathematics 132 or 161
Physics 133 and 235 or Physics 221 and 222
IDIS 214

SECONDARY EDUCATION CHEMISTRY MINOR

Chemistry 103 and 104
Chemistry 201
Chemistry 253 (recommended) or 261
Chemistry 295 (two times)
Chemistry 304 (recommended) or 317
Chemistry 323 and 383
Chemistry 396 (offered odd years)

Cognates
SCES 214
and one of the following 2-course packages
Math 161/162; Math 132/143; Physics 133/134; Math 161 or 132 and Physics 221 or 133

ELEMENTARY AND SECONDARY INTEGRATED SCIENCE STUDIES

Students in the Elementary or Secondary Education Program wishing to major or minor in science should consult the Science Education section of the catalog

BIOCHEMISTRY MAJOR

Chemistry 103 and 104
Chemistry 201
Chemistry 261 and 262
Chemistry 304 or 317
Chemistry 323 and 324
Chemistry 383
IDIS 310 or an approved course in integrative studies
Chemistry 295 (four times)
Completion of Major Field Test in Chemistry

Cognates
Mathematics 132/143 or 161/162
Physics 221 and 222 or 133/235
Biology 141
Two from Biology 242, 243, 321, 333, 335, or 336 (one of which must be a 300-level course)

BIOCHEMISTRY MINOR

Chemistry 103 and 104
Chemistry 253 or 261
Chemistry 323 and 324
Chemistry 383
One course from Chemistry 201, 262, 304, 317, or an approved interim

BIOCHEMISTRY MAJOR (ACS Certified)

For students preparing for graduate study in biochemistry, the certification requirements of the American Chemical Society for professional training in chemistry may be met by completing the following courses:

Chemistry 103 and 104
Chemistry 201
Chemistry 261 and 262
Chemistry 295 (four times)
Chemistry 317 and 318
Chemistry 323 and 324
Chemistry 329
Chemistry 330
Chemistry 383
Chemistry 395 (3 semester hours)
IDIS 310 or an approved course in integrative studies
Completion of Major Field Test in Chemistry

Cognates
Mathematics 161 and 162
Physics 133 and 235
Biology 141
Biology 321
One course from Biology 242, 243, 333, 335, and 336

GROUP SCIENCE MAJORS

A group major in science and Mathematics meets the needs of some students, particularly those in professional programs. These majors are not normally appropriate for students who anticipate attending graduate school and cannot be taken by students in teacher education programs. Such group majors require twelve courses in the sciences and mathematics, ten of which must be from two departments with no fewer than four from either, with the remaining two courses chosen from a third department. At least two 300-level courses in one discipline must be included in the ten-course component of this group. The chairs of the three depart-

ments involved must approve each program of this type.

HONORS PROGRAM

The Department of Chemistry sponsors an honors program to supplement the formal course offerings in the department's degree programs, increase both the breadth and depth of the student's knowledge of modern chemistry, and lead to an honors degree in chemistry upon graduation. The program offers guided study in chemistry through tutorials, independent research, and seminars.

The requirements for graduation with honors in chemistry or biochemistry are: (1) at least a 3.3 cumulative grade point average (3.5 beginning with class of 2007) ; (2) at least a 3.0 (3.5 beginning with class of 2007) cumulative grade point average in the departmental major courses; (3) six honors courses (18 hours minimum) overall with three being departmental courses in the major and three courses outside of the major, not more than one of which may be a cognate course to the major; (4) completion of a major in Chemistry or Biochemistry; (5) completion of at least 4 semester hours of 395 H (research seminar for honors) as one of the departmental major courses, one of the two other required departmental major courses must be at the 200-level or higher.

COURSES

101 **The Molecular World** (4). S. This is a general course designed for the non-science major and the elementary education student. The course explores the role of chemistry and its resulting technologies in the environment and contemporary society. It emphasizes the nature of scientific investigation, some historical developments in chemical theory, chemical periodicity and reactivity, and our daily interaction with synthetic materials and chemicals. The course is taught from a biblical worldview and addresses issues such as the validity and limitations of scientific knowledge, human responsibility in applying such knowledge in society, and the care and stewardship of natural resources. Laboratory.

103 **General Chemistry I** (4). F. This course is a study of the basic principles of chemistry, with emphasis on the laws of chemical combination, descriptive inorganic chemistry, thermochemistry, the gas, liquid, and solid states of matter, the periodic law, atomic structure and chemical bonding, and the nature of intermolecular forces. The course is taught from a biblical and reformed worldview and addresses issues such as the validity and limitations of scientific knowledge, the methodology of the physical sciences, human responsibility in applying such knowledge in society, and the care and stewardship of natural resources. Laboratory. Prerequisite: One year of high-school chemistry or permission of the instructor. Note: Successful completion of the Chemistry 103-104 sequence meets the two-course requirement of the Natural World category.

103R **General Chemistry Recitation** (1). F. A special course in the introductory concepts of chemistry that is open only to students who have not studied chemistry previously or who have a weak high school background in mathematics and chemistry. The course emphasizes problem solving and the understanding of basic chemistry concepts. Prerequisite: Concurrent registration in Chemistry 103.

104 **General Chemistry II** (4). S. A continuation of Chemistry 103 with emphasis on kinetics, chemical equilibria involving gases, weak acids and bases, and slightly soluble solids, free energy changes, electrochemistry, transition metal chemistry, descriptive chemistry, and nuclear chemistry. Laboratory. Prerequisite: Chemistry 103 or the equivalent.

115 **Chemistry for the Health Sciences** (4). F and S. This course is specifically designed for those planning for a health care career such as Nursing or other allied health careers that require a chemistry course. The fundamental concepts of general chemistry, organic chemistry, and biochemistry are presented with an emphasis on the chemical nature of biological systems. Topics such as molecular bonding and structure, equilibrium chemistry, and chemical reactivity as illustrated by acid/base reactions and redox reactions are presented in a biological context such

as membranes, enzymes, buffers, and cellular energy metabolism. Issues regarding the ethics and stewardship of health also will be discussed. Laboratory. Prerequisite: High school chemistry.

201 **Analytical Chemistry** (4). F. A problem-solving approach that incorporates sampling, sample preparation, separation of the analyte from interfering substances, measurement, data analysis, and interpretation. Quantitative analysis is presented in the context of analytical methods that primarily include separation science (gas, liquid, ion chromatography, and eletrophoresis), optical spectroscopy (uv-visible, fluorescence, and atomic absorption spectroscopy), and electrochemistry (electrode potentials, ion-selective electrodes, and sensors). The laboratory includes chemical analysis of water in the athletic field and nature preserve ponds, and the measurement of air quality across Calvin's campus using modern analytical techniques and wet chemical methods. These methods illustrate the principles of complex equilibria, theory of acids and bases, and titrations. Laboratory. Prerequisite: Chemistry 104. Not open to seniors except by permission.

253 **Fundamentals of Organic Chemistry** (5). F. A study of organic compounds, reactions, and reaction mechanisms, emphasizing their biochemical significance. Laboratory. Prerequisite: Chemistry 104.

261 **Organic Chemistry I** (5). F, SS. A detailed study of organic compounds, their synthesis and reactions, presented within the framework of modern physico-chemical theory, together with an introduction to modern methods of analysis and identification. Laboratory. Prerequisite: Chemistry 104.

262 **Organic Chemistry II** (5). S, SS. A continuation of Chemistry 261. Laboratory. Prerequisite: Chemistry 261.

271 **Environmental Chemistry** (3). I, odd years. A study of the chemistry of the atmosphere, natural water, and soils, with a special focus on environmental problems arising from the activities of humans, including a study of acid precipitation, greenhouse gases, ozone depletion, urban and indoor air pollution, water and soil pollution, solid and hazardous waste disposal, and risk assessment all presented within the context of a Christian view of humans and nature. Prerequisite: Chemistry 253 or 261. Not offered 2005-2006.

281 **Laboratory in Environmental Chemistry** (1). S, odd years. Experiments and investigations devoted to chemical analysis of samples obtained from the atmosphere, hydrosphere, and lithosphere using EPA approved protocols involving both instrumental and wet chemical methods. Prerequisite: Chemistry 271. Not offered 2005-2006.

295 **Chemistry Seminar**. F and S, no credit. A seminar devoted to an exploration of topics in current chemical research in both academic and industrial laboratories. Junior and senior chemistry majors must attend each semester; freshmen and sophomores intending to major in chemistry are encouraged to attend.

304 **Physical Chemistry for the Biological Sciences** (4). S. A survey of physical chemistry with emphasis on the laws of thermodynamics, physical equilibria, transport phenomena, and enzyme kinetics. Topics are treated with life science applications. Prerequisite: Chemistry 104, a one-semester college level calculus course.

317 **Physical Chemistry I** (4). F. A study of macroscopic properties of matter as described by chemical thermodynamics and kinetics. Major topics include: The laws of thermodynamics and their application to pure substances, chemical reactions, solutions, and physical and chemical equilibria, and reaction kinetics. Laboratory. Prerequisites: Chemistry 104, Mathematics 162, and a college physics course.

318 **Physical Chemistry II** (4). S, even years. A study of the microscopic even of matter in terms of quantum mechanics and statistical mechanics. Major topics include: The structure, energy, and spectroscopy of atoms and molecules given by quantum theory, and the relationship between microscopic and macroscopic properties of matter (statistical mechanics). Laboratory includes a six-week project on a topic proposed by the instructor. Prerequisite: Chemistry 317.

323 **Biochemistry I** (4). * F. A study of proteins, enzymes, carbohydrates, lipids, and membranes with an emphasis on the relationship of structure and function. Also included is the study of catabolism with primary focus on glycolysis, gluconeogenesis, glycogen metabolism, Krebs cycle, and oxidative phosphorylation. Prerequisite: Chemistry 253 or 262.

324 **Biochemistry II** (4). * S. A continuation of Chemistry 323. Topics covered are lipid metabolism, photosynthesis, biosynthesis of macromolecular precursors, the chemistry of the storage, transmission and expression of genetic information, biochemical dimensions of selected physiological processes, and philosophical and ethical issues related to biochemistry. Also listed as Biology 324. Prerequisite: Chemistry 323.

325 **Advanced Organic Chemistry** (4). * S, odd years. A study of selected topics in organic synthesis or physical organic chemistry. In the laboratory individual projects involving multi-step syntheses are carried out based upon procedures found in the literature. All compounds prepared are characterized using spectroscopic methods and other instrumental techniques. Prerequisites: Chemistry 262 and 304 or 317. Not offered 2005-2006.

329 **Instrumental Methods for Chemical and Biological Sciences** (4). * S. The aim of this course is to expose students to several instrumental techniques in chemistry, biochemistry, and biotechnology. The course will cover the principles underlying common instrumental methods, surface analytical methods used for studies in chemical and biological materials, spectroscopic techniques, separation techniques and thermal methods. A combination of lecture and/or laboratory will cover a number of instrumental techniques. Special emphasis will be paid to techniques such as nuclear magnetic resonance and mass spectrometry, which are essential to the chemical and pharmaceutical industries. An important aspect of this course is to provide students with "hands-on" experience on a number of instruments used in industrial and academic laboratories. The focus is to examine how these instruments work, how they are best used, and what type of performance one can expect. In the laboratory, students have the option of choosing the types of instruments and/or experiments to investigate based on their intended major. The final six laboratory sessions will be devoted to an independent project, which will use a minimum of two instruments. Laboratory. Prerequisite: Chemistry 201 or 261 and Mathematics 143.

330 **Advanced Inorganic Chemistry** (4). * F, odd years. A study in the chemistry of metals and non-metals with emphasis on symmetry, structure-property correlations, and periodicity. Types of compounds discussed are ionic solids, cluster and cage compounds, and organometallics. For coordination compounds the stereochemistry, reaction mechanisms, spectra, and magnetism are treated in detail. Laboratory. Prerequisite: Chemistry 304 or 317.

359 **Seminar in Secondary Teaching of Chemistry** (3). S. A course in perspectives on, principles of, and practices in the teaching of Chemistry on the secondary level. This course should be taken concurrently with Education 346. The seminar provides a forum for the discussion of concerns that develop during directed teaching. This course is part of the professional education program and may not be included in the major or minor in Chemistry.

383 **Laboratory in Biochemistry** (1). * F and S. A laboratory course designed to teach students modern biochemical separation and analytical techniques. Included in this course are the following topics: Exclusion, ion-exchange, affinity, and high performance liquid chromatography, agarose gel and polyacrylamide gel electrophoresis, ultracentrifugation, ultraviolet/visible spectroscopy, enzyme kinetics, and recombinant DNA techniques. Students will be required to carry out individual projects involving the purification and analysis of a biological macromolecule from cells or tissue. Also listed as Biology 383. Pre or corequisite: Chemistry 323.

385 **Internship in Chemistry** (3). F and S. Internships in industrial or commercial chemistry laboratories or in non-profit chemistry laboratories will be arranged for

qualified students. Students work in off-campus laboratories or offices for 10-12 (3 semester hours) or 13-15 (4 semester hours) hours per week throughout the semester. They will work under the supervision of an off-campus employer-supervisor and a faculty internship coordinator. Interns will meet with their faculty coordinator bi-weekly, will be required to keep a reflective journal, and must submit a final written paper summarizing their internship experience. The off-campus supervisor will send in an evaluation report on the work of the intern. To be enrolled in an internship, the student must have junior or senior standing, must have a cumulative GPA of 2.0 or better, an average GPA of 2.0 or better in all credited science and Mathematics courses, must have completed the second semester of Organic Chemistry (Chemistry 262) or equivalent, must complete an Internship Application Form, and must be approved by both the department and the off-campus employer.

390 **Independent Study**. F, I, and S. Directed readings or projects. Admission by permission of the chair and instructor under whom the work will be done.

395 **Research Seminar**. * F, I, and S. Library and laboratory research on a project selected in consultation with a faculty member. Each student will be required to present a seminar in the departmental seminar series and to write a formal report on the project. Normally open to juniors and seniors by permission of the chair and instructor under whom the work will be done.

396 **Perspectives in Chemistry** (1). * F, odd years. Reflections on the discipline of chemistry: Its history, methodology, philosophy, curricular structure, key ideas, and concepts; its role as a central science in technology and society; and the responsibilities of its practitioners in industry and in academic and research institutions. Prerequisite: Junior or senior status in a chemistry program of concentration.

IDIS 310 **History of Physical Science** (3). S. Integrative Studies/ Capstone. An examination of natural philosophy in the 17th century and of major developments since then in the physical sciences (predominantly physics and chemistry). Particular attention is given to the philosophical and religious background of scientific ideas and the institutional context in which science develops. A central theme of this capstone course will be the investigation of the interaction of science and religion with a view toward articulating a critical reformed Christian perspective on this historical development. Some primary texts will be considered. Prerequisites: DCM, HIST 151 or 152, PHIL 153, REL 121 or 131, junior/senior standing, and a declared major in the natural sciences (or approval of the instructor).

Off-Campus Offering

332 **Environmental Chemistry.** Principles and analysis of chemical movement and distribution in natural environments. Sampling and analytical methods are included for water, soil, and air. Work conducted both in natural habitats and the laboratory. Prerequisites: One year of general chemistry and one semester of either biochemistry or organic chemistry. Offered in conjunction with the AuSable Institute.

Graduate Courses

590 **Independent Study**. * F, I, and S.