Department of Chemistry

Professor: *Kolodny (Chair), Coleman, Hearn, Wolfson, Arumainayagam*[A2]

Associate Professor: *Haines, Miwa, Flynn*

Assistant Professor: *Elmore, Vardar-Ulu, Carrico-Moniz,*[A] *Radhakrishnan,*[A] *Virgo*

Adjunct Assistant Professor: *Reisberg, Verschoor*

Senior Instructor in Chemistry Laboratory: *Turnbull, Doe, Hall, McCarthy*

Instructor in Chemistry Laboratory: *Boyer, Oakes, Trainor*

Chemistry has often been referred to as "The Central Science." Knowledge of the properties and behavior of atoms and molecules is crucial to our understanding of medicine, biological systems, neuroscience, nanotechnology, environmental science and a myriad of other areas. All of the traditional divisions of chemistry—analytical chemistry, biochemistry, inorganic chemistry, organic chemistry and physical chemistry—are represented on the faculty, in the course offerings and in opportunities for student-faculty collaborative research.

Unless otherwise noted, all courses meet for three periods of lecture/discussion and one 3.5 hour laboratory appointment weekly. CHEM 306 and the selected topics courses will generally be taught without laboratory, but may include laboratory for some topics.

The Chemistry Department reviews elections of introductory chemistry students and places them in 105, or 120 according to their previous preparation, Advanced Placement (AP) scores, Advanced level grades, International Baccalaureate (IB) scores, and department placement exams. Students with a 5 on the Chemistry AP exam (or C or better on the A-level or 5 or higher on the higher level IB exam) typically elect CHEM 120. They may elect CHEM 211 if they demonstrate sufficient mastery of material from CHEM 120 on the department's exemption exam. Details of the AP/IB/A-level policy and the exemption and placement exams are on the department's Web site, www.wellesley.edu/Chemistry/chem.html. Students who have taken one year of high school chemistry should elect CHEM 105 followed by either CHEM 205 or 211.

Goals for the Major

Be able to think both concretely and abstractly about the world on a molecular level;

Learn fundamental lab techniques and understand how concepts learned in lecture and laboratory can be implemented in the real world;

Perform scientific research in the form of independent study or thesis program;

Approach and model problems using concepts and skills grounded in chemistry and learn about how solving such problems benefits the broader society;

Have a solid foundation in chemical principles and the ability to integrate concepts from chemistry and related fields in an interdisciplinary way;

Be able to present chemically-relevant material clearly and accurately to an expert or a non-expert audience;

Be prepared for postgraduate study and/or public/private sector employment in fields such as chemistry, medicine, teaching, marketing and sales, human resources, law, consulting, and business management.

CHEM 102 Contemporary Problems in Chemistry with Laboratory

Reisberg

Topic for 2010-11: Understanding Drugs. A study of a wide variety of drugs, both legal and illegal. The focus will be on how these molecules affect our minds and bodies based on an understanding of their biochemistry. Topics will include antibiotics, steroids, stimulants, intoxicants, narcotics, and hallucinogens. The history, discovery, development, testing, regulation and prohibition of these substances will also be considered. The laboratory will include synthesis and analysis of an analgesic and an intoxicant, plus the detection of drugs in our bodies and on currency.

Prerequisite: Open to all students except those who have taken any other chemistry course.
Distribution: Natural and Physical Science
Semester: Spring Unit: 1.25

CHEM 105 Fundamentals of Chemistry with Laboratory

Staff

This course is designed for students majoring in the physical and biological sciences as well as those wishing an introduction to modern molecular science. Core principles and applications of chemistry are combined to provide students with a conceptual understanding of chemistry that will help them in both their professional and everyday lives. Topics include principles of nuclear chemistry, atomic and molecular structure, molecular energetics, chemical equilibrium, and chemical kinetics. The laboratory work introduces students to synthesis and structural determination by infrared and other spectroscopic techniques, periodic properties, computational chemistry, statistical analysis and various quantitative methods of analysis.

Prerequisite: One year of high school chemistry is strongly recommended. Chemistry 105 is designed for students who have completed high school chemistry and mathematics equivalent to two years of algebra. Students must have fulfilled the basic skills component of the Quantitative Reasoning requirement. Students who have questions about their chemistry preparation should consult the department chair. Students who have AP or IB credit in Chemistry, and who elect CHEM 105, forfeit the AP or IB credit.
Distribution: Natural and Physical Science or Mathematical Modeling
Semester: Fall, Spring, Summer Unit: 1.25

CHEM 120 Intensive Introductory Chemistry with Laboratory

Arumainayagam

A one-semester course for students who have completed more than one year of high school chemistry, replacing CHEM 105 and 205 as a prerequisite for more advanced chemistry courses. It presents the topics of nuclear chemistry, atomic structure and bonding, periodicity, kinetics, thermodynamics, electrochemistry, equilibrium, acid/base chemistry, solubility and transition metal chemistry. All of these topics are presented in the context of both historical and contemporary applications. The laboratory includes experiments directly related to topics covered in lecture, an introduction of statistical analysis of data, molecular modeling and computational chemistry, instrumental and classical methods of analysis, thermochemistry and solution equilibria. The course meets for four periods of lecture/discussion and one 3.5 hour laboratory.

Prerequisite: Open to students who have a score of 5 on the Chemistry AP exam or an IB score of 5 or above; open also to students with two years of chemistry but without the requisite AP or IB score who perform sufficiently well on the Chemistry 120 Placement Exam. Students must have fulfilled the basic skills component of the Quantitative Reasoning requirement. Not open to students who have completed 105 and/or 205. Students who have AP or IB credit in Chemistry, and who elect CHEM 120, forfeit the AP or IB credit.
Distribution: Natural and Physical Science or Mathematical Modeling. Fulfills the Quantitative Reasoning overlay course requirement.

Semester: Fall Unit: 1.25

CHEM 205 Chemical Analysis and Equilibrium with Laboratory

Staff

This course builds on the principles introduced in CHEM 105, with an emphasis on chemical equilibrium and analysis, and their role in the chemistry of the environment. Topics include chemical reactions in aqueous solution with particular emphasis on acids and bases, solubility and complexation, electrochemistry, atmospheric chemistry, photochemistry and smog, global warming and acid deposition, sampling and separations, modeling of complex equilibrium and kinetic systems, statistical analysis of data, and solid state chemistry of ceramics, zeolites and new novel materials. The laboratory work includes additional experience with instrumental and noninstrumental methods of analysis, sampling, computational chemistry and solution equilibria.

Prerequisites: 105 and fulfillment of the basic skills component of the Quantitative Reasoning requirement. Not open to students who have taken 120.
Distribution: Mathematical Modeling or Natural and Physical Science. Fulfills the Quantitative Reasoning overlay course requirement.
Semester: Fall, Spring Unit: 1.25

CHEM 211 Organic Chemistry I with Laboratory

Staff

Topics covered include: stereochemistry, synthesis and reactions of alkanes, alkenes, alkynes, alkyl halides, alcohols and ethers, nomenclature of organic functional groups, IR, and GC/MS.

Prerequisite: 105, or 120 or permission of the department.
Distribution: Natural and Physical Science
Semester: Fall, Spring Unit: 1.25

CHEM 212 Organic Chemistry II with Laboratory

Staff

A continuation of CHEM 211. Includes NMR spectroscopy, synthesis, reactions of aromatic and carbonyl compounds, amines, and carbohydrates. In addition, students are expected to study the chemical literature and write a short chemistry review paper.

Prerequisite: 211
Distribution: Natural and Physical Science
Semester: Fall, Spring Unit: 1.25

CHEM 221 Biochemistry I with Laboratory

Elmore

A study of the chemistry of biomolecules and macromolecular assemblies with emphasis on the structure of proteins, nucleic acids, carbohydrates, and lipids, as well as methodologies for studying them. This course is the first half of a year-long course sequence in biochemistry that continues with CHEM 328. Students who only intend to take a single semester of biochemistry should enroll in CHEM 222.

Prerequisite: 205, 211 and BISC 220; or 120, 211 and BISC 220
Distribution: Natural and Physical Science
Semester: Fall Unit: 1.25

CHEM 222 Introduction to Biochemistry with Laboratory

Vardar-Ulu

A study of the chemistry of biomolecules and macromolecular assemblies, with emphasis on structure-function relationships; an introduction to bioenergetics, enzyme kinetics, and metabolism. This course is intended for students who plan to complete only one semester of biochemistry coursework at Wellesley. Students who plan to continue in Biochemistry II (CHEM 328) should enroll in CHEM 221.

Prerequisite: 205, 211 and 212; or 120, 211 and 212
Distribution: Natural and Physical Science
Semester: Fall, Spring Unit: 1.25

CHEM 232 Physical Chemistry for the Life Sciences with Laboratory

Kolodny

An examination of several topics in physical chemistry, with an emphasis on their applications to the life sciences. Topics include quantum chemistry and spectroscopy, molecular mechanics, chemical thermodynamics, and kinetics. Does not count toward the chemistry major, but counts toward the biological chemistry major and chemistry minor.

Prerequisite: 205 or 120 and 211, or permission of the department; and MATH 116, 116Z, or 120 and PHYS 104 or 107. Not open to students who have taken 233, 334 or 335.
Distribution: Natural and Physical Science or Mathematical Modeling. Fulfills the Quantitative Reasoning overlay course requirement.
Semester: Spring Unit: 1.25

CHEM 233 Physical Chemistry I with Laboratory

Arumainayagam

Molecular basis of chemistry; intensive overview of theories, models, and techniques of physical chemistry; extensive coverage of quantum mechanics; applications of quantum mechanics to atomic and molecular structure, and spectroscopy; classical thermodynamics of gases and solutions; intermediate topics in chemical kinetics and introduction to reaction dynamics; basic statistical mechanics to calculate thermodynamic variables and equilibrium constants.

Prerequisite: 205 or 120, or by permission of the department; and MATH 116, 116Z, or 120 and PHYS 104 or 107. Not open to students who have taken 232, 334, or 335.
Distribution: Natural and Physical Science or Mathematical Modeling. Fulfills the Quantitative Reasoning overlay course requirement.
Semester: Fall Unit: 1.25

CHEM 250 Research or Individual Study

Research is supervised by a member of the Wellesley College Chemistry Department. Off-campus research requires active participation of a Wellesley faculty member throughout the research period. Course fulfills the research requirement for the major only upon completion of a paper of 8–10 pages on the research and a presentation to the Chemistry Department during one of the two research seminar presentation periods. A copy of the paper must be submitted to the chair of the department. (Note: paid internships are not eligible for CHEM 250.)

Prerequisite: Open by permission to students who have taken at least one chemistry course.
Distribution: None
Semester: Fall, Spring Unit: 1.0

CHEM 306 Seminar

Vardar-Ulu

Topic A for 2010-11: From the Kitchen to the Spa: The Chemistry Behind Food Preparations and Beauty Formulations. Food recipes and beauty formulations are much more than just ingredients strung together. They are among the oldest practical results of chemical research and represent both the culture they come from and the lives of the people who prepare them. This seminar will offer the students a hands-on opportunity to apply their scientific backgrounds to develop an understanding and appreciation of the chemistry associated with the creation of the food they eat and the cosmetics they use. Throughout the semester, we will focus on the interplay between chemical, biological, and physical principles that facilitate individual ingredients lose their own identity while producing a new physical form, and also investigate the specific interactions between these products and the human body. Class meetings will combine a mixture of components involving the analysis and discussions of: original literature, short videos and demonstrations, tasty and fragrant experiments conducted in class, a professional production site visit, and extensive group work culminating in student presentations. The participatory nature of the course is intended to encourage students to develop new scientific background and vocabulary to better appreciate the world they live in and become scientifically informed, conscious citizens while practicing their systematic problem solving and scientific thinking skills on everyday phenomena.

Prerequisites: 205, 211, and one other 200-level science course.
Distribution: Natural and Physical Science
Semester: Fall Unit: 1.0

CHEM 306/ES 306 Seminar

Coleman

Topic B for 2010-11: Green Chemistry. A study of the impact of chemicals and the chemical industry, broadly defined, on the global environment, and on emerging approaches to reducing that impact. The major focus will be on the fundamentals of designing chemical processes that produce smaller amounts of harmful by-products, reduce the use of toxic solvents, exploit catalysis, and maximize the conversion of reactants to the desired product. We will also examine the economic and political issues that surround green chemistry. *Students may register for either CHEM 306 or ES 306 and credit will be granted accordingly.*

Prerequisites: 205 and 211, or 120 and 211, or permission of instructor
Distribution: Natural and Physical Science
Semester: Spring Unit: 1.0

CHEM 328 Biochemistry II with Laboratory

Elmore

A further study of the function and regulation of biomolecules and macromolecular assemblies introduced in CHEM 221, with special emphasis on enzymes and metabolic pathways. Both the lecture and laboratory components of the course emphasize the development of independent research proposals to further students' conceptual and experimental understanding of biochemistry.

Prerequisite: 221 (students with 222 should get permission of the instructor to enroll in 328)
Distribution: Natural and Physical Science
Semester: Spring Unit: 1.25

CHEM 335 Physical Chemistry II with Laboratory

Virgo

Quantum mechanics, group theory and statistical thermodynamics provide the foundation for molecular spectroscopy that is used to understand the chemical nature of molecules. By addressing modern chemical problems, students will gain insight into how chemical reactions occur while learning about exciting, vibrant fields of modern chemical research. This advanced course will emphasize the mathematical basis of physical chemistry with an emphasis on matrix representations. The essential fundamentals will be reinforced while modern applications and new developments in experimental and theoretical chemical kinetics and reaction dynamics are introduced.

Prerequisite: 233 (232 by permission of the instructor), PHYS 106 or 108; and MATH 215. Not open to students who have taken [334].
Distribution: Natural and Physical Science or Mathematical Modeling
Semester: Spring Unit: 1.25

CHEM 341 Inorganic Chemistry with Laboratory

Coleman

Atomic structure, multi-electron atoms, the periodic table and periodicity, chemical applications of group theory, molecular orbital theory, the chemistry of ionic compounds, generalized acid/base theories, transition metal complexes, organometallic chemistry, catalysis, and bioinorganic chemistry. The laboratory introduces a number of experimental and computational techniques used in inorganic chemistry.

Prerequisites: 205 or 120; prerequisite/corequisite: 212.
Distribution: Natural and Physical Science
Semester: Spring Unit: 1.25

CHEM 350 Research or Individual Study

Research is supervised by a member of the Wellesley College Chemistry Department. Students will be expected devote (per week)10–12 hours for Chemistry 350 and 5–6 hours for Chemistry 350 H. Student projects will be planned accordingly. Off-campus research requires active participation of a Wellesley faculty member throughout the research period. Course fulfills the research requirement for the major only upon the completion of a paper of 8–10 pages on the research and a presentation to the chemistry department during one of the two research seminar presentation periods. A copy of the paper must be submitted to the chair of the department. (Note: paid internships are not eligible for CHEM 350.)

Prerequisite: Open by permission to students who have taken at least three chemistry courses.
Distribution: None
Semester: Fall, Spring Unit: 1.0

CHEM 350H Research or Individual Study

Research is supervised by a member of the Wellesley College Chemistry Department. Students will be expected devote (per week)10–12 hours for Chemistry 350 and 5–6 hours for Chemistry 350 H.

Prerequisite: Open by permission to students who have taken at least three chemistry courses.
Distribution: None
Semester: Fall, Spring Unit: 0.5

CHEM 355 Chemistry Thesis Research

The first course in a two-semester investigation of a significant research problem, culminating in the preparation of a thesis and defense of that thesis before a committee of faculty from the Chemistry Department. Students will participate in a regular weekly seminar program, in which they will discuss their research progress informally with faculty and student colleagues and gain familiarity with contemporary research through presentations by outside seminar speakers. This route does not lead to departmental honors. If the first semester of thesis is used to fulfill the research requirement, the student must complete a paper of 8–10 pages on the research and give a presentation to the Chemistry Department during one of the two research seminar presentation periods. A copy of the paper must be submitted to the chair of the department. (Note: paid internships are not eligible for CHEM 355.)

Prerequisite: Open only to seniors by permission of the instructor.
Distribution: None
Semester: Fall, Spring Unit: 1.0

CHEM 360 Senior Thesis Research

CHEM 360 is the first course in a two-semester investigation of a significant research problem, culminating in departmental honors upon the completion in the second semester of a thesis and defense of that thesis before a committee of faculty from the Chemistry Department. Students in 360 and 370 will be expected to attend the weekly departmental honors seminar, listed in the schedule of classes. The seminar provides a forum for students conducting independent research to present their work to fellow students and faculty. See Academic Distinctions. If the first semester of thesis is used to fulfill the research requirement, the student must complete a paper of 8–10 pages on the research and give a presentation to the Chemistry Department during one of the two research seminar presentation periods. A copy of the paper must be submitted to the chair of the department. (Note: paid internships are not eligible for CHEM 360.)

Prerequisite: By permission of department.
Distribution: None
Semester: Fall, Spring Unit: 1.0

CHEM 361 Analytical Chemistry with Laboratory

Flynn

Classical and instrumental methods of chemical analysis. Topics include statistical analysis, electronics and circuitry, electrochemistry, spectroscopy, and separations science with special attention to instrument design and function. The course work emphasizes the practical applications of chemical instrumentation and methods to address questions in areas ranging from art history to biochemistry to materials science. The laboratory work focuses on the design, construction, and use of chemical instrumentation along with the interfacing of instruments with computers.

Prerequisites: 205 and 211 or 120 and 211.
Distribution: Natural and Physical Science. Fulfills the Quantitative Reasoning overlay course requirement.
Semester: Fall Unit: 1.25

CHEM 365 Chemistry Thesis

The second course in a two-semester investigation of a significant research problem, culminating in the preparation of a thesis and defense of that thesis before a committee of faculty from the Chemistry Department. Students will participate in a regular weekly seminar program, in which they will discuss their research progress informally with faculty and student colleagues and gain familiarity with contemporary research through presentations by outside seminar speakers. This route does not lead to departmental honors. Course counts toward the research requirement if the student completes the thesis and the thesis presentation. (Note: paid internships are not eligible for CHEM 365.)

Prerequisite: 355
Distribution: None
Semester: Fall, Spring Unit: 1.0

CHEM 370 Senior Thesis

CHEM 370 is the second course in a two-semester investigation of a significant research problem, culminating in departmental honors upon the completion of a thesis and defense of that thesis before a committee of faculty from the Chemistry Department. Students will participate in a regular weekly seminar program, in which they will discuss their research progress informally with faculty and student colleagues and gain familiarity with contemporary research through presentations by outside seminar speakers. Course counts toward the research requirement if the student completes the thesis and

the thesis presentation. See Academic Distinctions. (Note: paid internships are not eligible for CHEM 370.)

Prerequisite: 360 and permission of department.
Distribution: None
Semester: Fall, Spring Unit: 1.0

Requirements for the Major

Any student who plans to take chemistry beyond 205 or 120 should consult one or more members of the Chemistry Department faculty. The department Web site (http://www.wellesley.edu/Chemistry/chem.html) contains specific suggestions about programs and deals with a variety of topics including preparation in mathematics and physics, graduate programs, and careers of former majors.

The major will consist of:

- 105 and 205, or 120;
- 211 and 212;
- 233;
- three from among: 222 or 221, 335, 341, 361;
- one unit of research/independent study (CHEM 250, 350, 355, or 360) or completion of approved summer or off-campus research and required paper/presentation;
- one additional non-research/thesis chemistry course at the 300 level
- MATH 116 or MATH 120; and PHYS 106 or PHYS 108

Students planning to go to graduate school in chemistry should choose PHYS 108, MATH 215, AND CHEM 335. Students planning to study physical chemistry in graduate school should consider taking CHEM 335 in their junior year and PHYS 349 in their senior year.

The required mathematics and physics courses (PHYS 108 but not PHYS 106) may also be counted toward a major or a minor in those departments. Early completion of the mathematics and physics requirements is strongly encouraged.

Normally no more than three courses of chemistry taken at another institution may be counted towards the major.

Students interested in the interdepartmental major in biological chemistry are referred to the section of the catalog where that major is described. They should also consult with the director of the biological chemistry program.

Students interested in an independent major in chemical physics should consult the department chair.

Independent Research

The chemistry major requires one semester or summer of research. The research requirement for the chemistry major can be fulfilled in the following ways:

A. Independent Study in Chemistry (CHEM 250 or 350): Research is supervised by a member of the Wellesley College Chemistry Department. Off-campus research requires active participation of a Wellesley faculty member throughout the research period. In order to fulfill the research requirement for the major, the student must complete an 8−10 page paper on the research and give a presentation to the Chemistry Department during one of the two research seminar presentation periods. The paper must contain substantial literature references, demonstrating a familiarity with searching the chemical literature. A copy of the paper must be submitted to the chair of the Chemistry Department. (Note: paid internships are not eligible for CHEM 250 or 350.)

B. Thesis in Chemistry (355/365 or 360/370): If the first semester of thesis (355 or 360) is used to fulfill the research requirement, the student must complete a paper of 8–10 pages on the research and give a presentation to the Chemistry Department during one of the two research seminar presentation periods. The paper must contain substantial literature references, demonstrating a familiarity with searching the chemical literature. A copy of the paper must be submitted to the chair of the department. If the student completes the second semester (365 or 370), the thesis and the thesis defense fulfill the paper and presentation requirement.

C. Other Research Experiences: A student may participate in an approved off-campus research program during the academic year (10 hours per week minimum for one semester) or an approved summer research program (eight weeks minimum length), write an 8−10 page paper on the research, and give a presentation to the Chemistry Department during one of the two research seminar presentation periods. The paper must contain substantial literature references, demonstrating a familiarity with searching the chemical literature. A copy of the paper must be submitted to the chair of the department. Students electing to use an off-campus research experience to fulfill the research requirement must have the research project approved by a faculty member in the Chemistry Department before starting the program.

Requirements for the Minor

A minor in chemistry includes: 105 and 205, or 120; 211; 233 or 232; a choice of 221 or 222 or 341 or 361; one additional 200 or 300 level unit, excluding 350. The mathematics and physics prerequisites for 233/232 must also be satisfied. Normally no more than one unit in chemistry from another institution may be counted toward the minor.

Honors

The only route to honors in the major is writing a thesis and passing an oral examination (CHEM 360 and 370). To be admitted to the thesis program, a student must have a grade point average of at least 3.5 in all work in the major field above the 100 level; the department may petition on her behalf if her GPA in the major is between 3.2 and 3.5. See Academic Distinctions.

Chemist Accreditation

The American Chemical Society has established a set of requirements in various areas which it considers essential for the training of chemists. Students wishing to meet the standard of an accredited chemist as defined by this society should consult the chair of the department.

Teacher Certification

Students interested in obtaining certification to teach chemistry in the Commonwealth of Massachusetts should consult the chair of the Education Department.

Transfer Credit

In order to obtain Wellesley credit for any chemistry course taken at another institution, during the summer or the academic year, approval must be obtained via the Wellesley College Registrar's Office from the chair of the department prior to enrolling in the course. Students, especially those taking chemistry courses abroad, may be required to contact the course professor to obtain specific details about the course because the online course description may be insufficient to make an informed decision. In general, courses from two-year colleges will not be accepted at any level. These restrictions normally apply only to courses taken after enrollment at Wellesley. Transfer students wishing to obtain credit for chemistry courses taken prior to enrollment at Wellesley should consult the chair of the department.

Advanced Placement and Exemption Examinations

If a student scores a 5 on the AP or 5 or higher on the IB higher level examination or C or higher on the A-levels, she automatically qualifies for CHEM 120. The department offers exemption and placement examinations at the beginning of the fall semester. If a student scores a 5 on the AP or 5 or higher on the IB higher level examination or C or higher on the A-levels and does well on the CHEM 120 **exemption** exam, she can go directly into CHEM 211. If a student scores below a 5 on the Chemistry AP or below 5 on the IB higher level examination or below C on the A-levels, but performs well on the CHEM 120 **placement** exam, she will be placed into CHEM 120. A student may take CHEM 105 without taking AP chemistry or a placement exam.

Withdrawal from Courses with Laboratory

Students who withdraw from a course which includes laboratory, and then elect that course in another semester, must complete both the lecture and laboratory portions of the course the second time.