CHEMISTRY (CHEM)

CHEM 135 — Drugs and Biotechnology Course count: 1
Advances in technology have changed how we can control our health and bodies and the world around us. People use drugs to cure infection, to alter perception, to influence cellular pathways, and to enhance their performance. Scientists can manipulate genomes, stem cells, and reproductive fitness to challenge natural selective pressures. We will explore the fundamental biochemistry and pharmacology of drug design as well as the scientific background and ethical implications of topics in biotechnology including genetic testing, gene therapy, stem cell research, surrogacy and assisted reproduction, and the allocation of health-care spending and resources. The course will follow a seminar format, with active student participation a key component of the class. One Unit.

Prerequisite: Students who are BIOL or CHEM majors are unable to enroll in this course.
GPA units: 1
Common Area: Natural Science
Typically Offered: Every Third Year

CHEM 141 — Environmental Chemistry Course count: 1
Investigates the chemistry of the Earth's environment through systematic studies of our atmosphere, hydrosphere and lithosphere and the exchange and interplay between them. The primary focus of the course will be environmental change taking place today including those that threaten plant and animal habitats and pose hazards to human health. Understanding of our environment and current threats to it will be gained through a combination of readings, lectures, discussions, demonstrations, and problem sets.

Antirequisite: Students who have taken CHEM 181 may not enroll in this course.
GPA units: 1
Common Area: Natural Science
Typically Offered: Every Third Year

CHEM 142 — Chemistry of Food Course count: 1
This course addresses the chemical components of food and the chemical processes involved in cooking. Have you ever wondered why Julia Child whips egg whites in copper bowls? Why certain foods expand during cooking? Or why different cookie recipes require different baking temperatures? We will look into the science that explains these food wisdoms by a combination of lecture, discussions, and food-chemistry experiments. We will also discuss the nutrients in food, how they are enhanced or altered by cooking, and the role this plays in human nutrition. This class is suited for non-science majors. Students may not enroll in this course if they have previously taken Chemistry 181.

Antirequisite: Students who have taken CHEM 181 may not enroll in this course.
GPA units: 1
Common Area: Natural Science
Typically Offered: Every Third Year

CHEM 143 — Science Literacy and Responsible Citizenship Course count: 1
Students will acquire a knowledge and understanding of the scientific issues being discussed daily in the press that are required for them as citizens to make informed opinions and decisions e.g. climate change, genetic engineering, artificial intelligence, nutrition, drug development, space exploration, waste management and antiviral and antibacterial agents. Students will be required to purchase one month digital subscriptions to the NYT, WSJ, Washington Post, the Guardian and Apple News all of which are inexpensive for that period of time.

Prerequisite: Students who have taken CHEM 231 may not enroll in this course.
GPA units: 1
Common Area: Natural Science
Typically Offered: Annually

CHEM 144 — Chemistry & Society Course count: 1
Acquaints non-science majors with chemistry as a human endeavor and helps them acquire some appreciation of the benefits and limitations of science. Readings from the current popular and scientific literature are examined to illustrate the relationships of science to society. Some of the basic concepts and principles of chemistry necessary for an understanding of environmental problems will be considered in detail. One unit.

Students who have taken CHEM 181 may not enroll in this course.
GPA units: 1
Common Area: Natural Science
Typically Offered: Annually

CHEM 181 — Atoms & Molecules Course count: 1
This introductory general chemistry course leads students to explore in-depth the scientific method through the formulation and testing of hypotheses in the laboratory. Laboratory experiments lead students to discover basic principles, i.e., stoichiometric relationships, electronic configuration and molecular structure. Lectures will explain and expand upon laboratory results. This is first course in the Discovery Chemistry Core sequence for science majors and students interested in health professions. This course includes both lecture and a weekly "Discovery Lab" session.

GPA units: 1.5
Common Area: Natural Science
Typically Offered: Annually Fall

CHEM 215 — Science in the Community Course count: 1
Scientific progress around the world finds itself in a moment of crisis: due to hundreds of years of exclusion, a significant portion of the world's population finds itself at the fringe of scientific fields. This course offers undergraduate students at the College of the Holy Cross with the opportunity to address this crisis, consistent with the mission of Jesuit higher education. As such, this course engages local community partners and includes a CBL component. During the course, undergraduate students will mentor elementary-school students in the Worcester community in a semester-long science fair project. This mentor-mentee relationship will be mutually beneficial. The younger students' self-efficacy will benefit from one-on-one discussions, while the undergraduate students will become active possessors of their own scientific knowledge.

Prerequisite: CHEM 181 or BIOL 161 or 162 or 163 or PHYS 115 or NEUR 110.
GPA units: 1

CHEM 221 — Organic Chemistry 1 Course count: 1
A study of organic compounds organized around functional groups, modern structural theory and reaction mechanisms. The chemistry of aliphatic hydrocarbons, alkenes, alkynes, dienes, alkyl halides, alcohols and ethers is introduced. Substitution, addition and elimination mechanisms are studied in detail. Emphasis is placed on stereochemistry. The lecture portion meets four hours per week. One two-hour discovery laboratory session per week is included. Students learn various techniques of separation, purification, and spectroscopic analysis of organic compounds in the laboratory. There is an emphasis on one-step synthetic conversions that introduce the reactions to be studied in the lecture course.

Prerequisite: CHEM 181
GPA units: 1.5
Common Area: Natural Science
Typically Offered: Spring

CHEM 222 — Organic Chemistry 2 Course count: 1
A continuation of Chemistry 221. Aromatic compounds, alcohols, ethers, aldehydes, ketones, amines, carboxylic acids and their derivatives are studied. Aromatic substitution, acyl transfer and carbonyl condensation reactions are developed. The mechanistic implications and synthetic applications of these organic reactions are evaluated. One four-hour "discovery" laboratory session per week is included. Microscale synthetic techniques and identification (chemical and spectroscopic) of organic compounds are included. (It is recommended that students with a grade of C- or below in Chemistry 221 do not continue in Chemistry 222.)

Prerequisite: CHEM 221
GPA units: 1.5
Typically Offered: Annually Fall

CHEM 231 — Equilibrium & Reactivity Course count: 1
Focuses on studying and understanding the role equilibrium, thermodynamics and kinetics play in chemical systems. Specific topics include phase and chemical equilibria, colligative properties of solutions, acid/base equilibria, chemical kinetics, electrochemistry, thermodynamics including enthalpy, entropy and free energy, and gas laws. Laboratory focused, this general chemistry course also introduces students to modern analytical instrumentation while developing critical wet chemical analytical techniques. One four-hour discovery laboratory session per week is included.

Prerequisite: CHEM 181.
GPA units: 1.5
Typically Offered: Spring

CHEM 289 — Advanced Organic Chemistry Course count: 1
Focuses on the application of the electron pushing formalism for manipulating Lewis structure representations of organic molecules. The course is organized around the four fundamental reaction types (polar, pericyclic, free radical, and transition metal-mediated) with an emphasis on mechanistic rationalization of complex organic transformations.

Prerequisite: CHEM 222
GPA units: 1
Typically Offered: Spring

CHEM 300 — Instrumental Chemistry/Analytical Methods Course count: 1
The application of instrumentation to chemical research and analysis has had a dramatic impact on the field of chemistry. This course provides an in depth look inside modern chemical instrumentation, such as molecular UV-Vis, IR, and fluorescence spectroscopy, atomic absorption and emission spectroscopy, electrochemistry, gas and liquid chromatography, and mass spectrometry. One four-hour laboratory session per week is included. Laboratory work provides hands-on experience with instrumental design, quantitative analytical methods, and experimental method development.

Prerequisite: CHEM 231 and Prerequisite or Corequisite: CHEM 222 and PHYS 111 or PHYS 115.
GPA units: 1.5
Typically Offered: Annually

CHEM 301 — Biochemistry Course count: 1
A detailed study of the chemistry of biological molecules, with a focus on the structure of biological macromolecules and the chemical mechanism of biochemical transformations. Topics may include the structure and synthesis of proteins, nucleic acids, carbohydrates and lipids, enzymatic catalysis, biological thermodynamics, glycolysis and gluconeogenesis, the citric acid cycle, fatty acid oxidation, oxidative phosphorylation, and metabolic regulation. A strong background in thermodynamics and organic chemistry is highly recommended. This course may serve as a prerequisite for Biology 302. Students may not count both Biology 301 and Chemistry 301 for credit.

Prerequisite: CHEM 222 and CHEM 231
GPA units: 1
Typically Offered: Fall

CHEM 304 — Synthetic Organic Chemistry Course count: 1
Covers a selection of modern synthetic methods and reagents used in organic chemistry. Topics presented include oxidation/reduction, organometallic reactions, functional group interconversions, protecting group strategies, enolate additions and pericyclic reactions with a focus on asymmetric synthesis. The course will build upon the individual methods discussed to ultimately demonstrate their combined use in the synthesis of complex organic molecules.

Prerequisite: CHEM 289
GPA units: 1
Typically Offered: Every Third Year

CHEM 305 — Mechanistic Organic Chemistry Course count: 1
There are critical and, at times, subtle factors that influence organic reactions. These factors will be illustrated through specific case studies. The case studies will demonstrate how experimental data is used to develop mechanistic knowledge about a reaction. The course will aim to develop skills for thinking critically and logically about the mechanism of organic reactions.

Prerequisite: CHEM 289
GPA units: 1
Typically Offered: Every Third Year

CHEM 306 — Chemistry of Materials Course count: 1
This class focuses on the connections between the chemical structures of materials, their physical properties, and their applications. By studying materials at the atomic level we will be able to understand electronic, optical, and mechanical properties. Topics will include inorganic, organic, and nanoscale materials, as well as instrumental characterization methods. Applications will include solar cells, transistors, and batteries.

Prerequisite: CHEM 300.
GPA units: 1
Typically Offered: Every Third Year

CHEM 309 — Spectroscopy Course count: 1
This course focuses on chemical structure identification through the interpretation of spectroscopic data with a concentration on organic molecules, Mass, Vibrational (IR and Raman), and Magnetic Resonance (NMR and EPR) spectra are analyzed. There is an emphasis on NMR spectroscopy (including an introduction to modern multipulse techniques) to elucidate molecular structure. The course is conducted with a problem solving approach and student participation is expected.

Prerequisite: CHEM 222
GPA units: 1
Typically Offered: Every Third Year

CHEM 317 — Nanotechnology Course count: 1
Introduces students to nanometer scale material and devices. Materials in this size regime often possess unusual properties that have application in molecular electronics, medical diagnostics and devices, molecular motors, and self-assembly and surface chemistry. Students will read a variety of books and scientific articles from peer reviewed journals. Nanotechnology is a multidisciplinary field of study where projects often require collaborations between chemists, physicists, biologists and engineers. Students other than chemistry majors who have completed the prerequisites are encouraged to enroll to broaden both their own perspective and that of the class.

Prerequisite: CHEM 222 and CHEM 231.
GPA units: 1
Typically Offered: Every Third Year

CHEM 322 — Applications of Analytical Chemistry Course count: 1
This course will focus on various applications found in the field of analytical chemistry including topics in environmental, forensic and food chemistry. This course will build on instrumentation learned in Chem 300 and go beyond the instruments used in typical labs. Primary literature will guide our discussion of various techniques and applications. Understanding of the details of these advanced instrumental techniques and applications will be gained through a combination of reading, lectures, discussions, and an independent lab experience. This course will meet two days per week. Some weeks (about six during the semester), a 3 hour lab will be held during the one afternoon time slot.

Prerequisite: CHEM 300
GPA units: 1
Common Area: Natural Science
Typically Offered: Every Third Year

CHEM 325 — Environmental Forensics Course count: 1
This course will focus on the measurement of chemical contaminants and their origins. You will investigate methods and instrumentation employed in the fields of environmental, forensic and environmental forensic chemistry. Primary literature will guide our discussion of various techniques and applications. Understanding of the details of these advanced instrumental techniques and applications will be gained through a combination of reading, lectures, discussions, and integrated lab experiences. This course will meet two days per week. About six weeks during the semester, a 2.5 hour lab will be integrated into the course.

Prerequisite: CHEM 300
GPA units: 1
Typically Offered: Every Third Year

CHEM 335 — Quantum Mechanics & Spectroscopy Course count: 1
The course is a study of the basic concepts, principles and methods of modern physical chemistry. Physical chemistry asks "how?" and/or "why?" things happen as they do. Here, the emphasis will be on developing a deeper understanding of the quantum mechanical properties that govern chemical phenomena. The topics covered may include quantum mechanics, statistical mechanics, spectroscopy, group theory,kinetics and computational chemistry. One four hour laboratory session per week is included. In the lab you will learn techniques and analyses related to physical chemistry and will develop your scientific writing skills.

Prerequisite: CHEM 231 and MATH 134 or MATH 136 or equivalent.
Prerequisite or Corequisite: PHYS 111 or PHYS 115 and CHEM 222.
GPA units: 1.5
Typically Offered: Annually

CHEM 336 — Chemical Thermodynamics Course count: 1
This course is a study of the basic concepts, principles and methods of classical physical chemistry. Physical chemistry asks how? and/or why? things happen as they do. Here, the emphasis will be on developing a deeper understanding of the macroscopic properties that govern chemical phenomena. The topics covered may include thermodynamics, chemical and phase equilibria, kinetics, reaction dynamics, complex solution behavior and surface thermodynamics.

Prerequisite: CHEM 231 and MATH 134 or MATH 136 or MATH 241 and
Prerequisite or Corequisite: CHEM 222 and PHYS 111 or PHYS 115
GPA units: 1
Typically Offered: Annually

CHEM 351 — Inorganic Chemistry Course count: 1
Group theory and modern theories of bonding are used to discuss structural and dynamic features of in-organic compounds. The structure and bonding of transition metal coordination compounds are related to various reaction mechanisms. The principal structural and mechanistic features of transition metal organo-metallic chemistry are studied with emphasis on catalysis of organic reactions. The role of inorganic chemistry in biological systems is also explored.

Prerequisite: CHEM 222 and CHEM 231
GPA units: 1
Typically Offered: Spring

CHEM 352 — Inorganic Chem Lab Course count: 0
This advanced laboratory course is designed to introduce students to the synthetic and characterization methods of modern inorganic chemistry. Students synthesize and purify compounds by a variety of techniques. Compounds are characterized using modern instrumentation. The course emphasizes synthetic techniques and analysis of compounds using various spectroscopic techniques; learning is reinforced by report writing.

Prerequisite or Corequisite: CHEM 351
GPA units: 0.25
Typically Offered: Spring

CHEM 361 — Biophysical Chemistry Course count: 1
This course aims to develop an understanding of the chemical interactions that govern the structure and function of biological molecules. A thorough discussion of the spectroscopic techniques used in modern research for analyzing such molecules will be incorporated. In addition, the course covers topics in protein folding and mis-folding (as associated with disease), focusing in particular on the thermodynamic and kinetic processes involved. Time will be spent reading and discussing primary literature with an emphasis on interpreting the results obtained by others.

Prerequisite or Corequisite: CHEM 300
GPA units: 1
Typically Offered: Every Third Year

CHEM 364 — Advanced Biochemistry Course count: 1
This course will examine current topics of interest in the field of biochemistry. It will be run in a seminar format, with extensive student participation expected. Students will facilitate and participate in discussions of the current literature, provide a seminar on a topic of their choice, and practice other tools of scientific communication. Topics may include protein folding, misfolding and disease; enzyme mechanism and drug design; post-transcriptional and post-translational control mechanisms; and the utility of omic data (proteomics, genomics, metabolomics).

Prerequisite: CHEM 301 or BIOL 301
GPA units: 1
Typically Offered: Every Third Year

CHEM 373 — Polymer Chemistry Course count: 1
Organic polymers fill a inescapable role in modern life. All polymers share a common beginning, from smaller monomeric substrates ultimately assembling into large macromolecules. Polymerization relies on a collection of fundamental organic reactions, that allow the structure grow as reactions continue to propagate. The characteristics of the polymer depend on the functional groups included in the polymer, as well as how they can be assembled. Of interest will be the local structure and reactivity of these macromolecules, as well as the methods to study their properties.

Prerequisite: CHEM 255 and CHEM 256
GPA units: 1
Typically Offered: Every Third Year

CHEM 381 — Bioinorganic Chemistry Course count: 1
This course is organized around the important biological proteins, enzymes and other biological systems that utilize metal ions. An important goal is to explain their functional/positional importance based on the chemistry at the metal center(s). Topics include bioinorganic systems such as photosynthesis, hemoglobin/myoglobin and other iron proteins, copper proteins, and the biochemistry of zinc. Current research efforts in the field are discussed to demonstrate the dynamic nature of the subject.

Prerequisite or Corequisite CHEM 351
GPA units: 1
Typically Offered: Every Third Year

CHEM 389 — Introduction to Research Course count: 0
Involves a commitment to join a research group. Specific activities will be established with the individual research advisor but may include: attendance of group meetings, working on a lab or computer project with other group members, and/or reading/discussing literature related to group research. The course is by permission only. It is taken as an overload and receives no grade. It may be taken more than once. Interested students are invited to apply early in the fall or spring of the second, third or fourth year. The candidate's academic record will be reviewed to determine if the student could reasonably benefit from such a program.

Prerequisite: CHEM 221 or CHEM 231
GPA units: 0
Typically Offered: Fall, Spring

CHEM 390 — Independent Research Course count: 1
Involves an original and individual experimental investigation with associated literature study in one of the fields of chemistry under the supervision of a member of the faculty. The culmination of all research projects will be a report. The course is by permission only. Interested students are invited to apply before the registration period in the spring of the second or third year or the fall of the third or fourth year. The candidate's academic record will be reviewed to determine if the student could reasonably benefit form such a program. This course does not count toward the minimum number of chemistry courses required of the major.

Prerequisite: CHEM 222 and CHEM 231
GPA units: 1
Typically Offered: Fall, Spring

CHEM 392 — Tutorial Course count: 1
GPA units: 1
Typically Offered: Fall, Spring

CHEM 405 — General Research 1 Course count: 0
Involves an original and individual experimental and/or computational investigation with associated literature study in one of the fields of chemistry under the supervision of a member of the faculty. The culmination of all research projects will be a report, as well as an oral presentation to be given during the spring semester. Students will be required to attend the weekly department seminar program (fall and spring). Chemistry 405 is the first course of the consecutive two-semester research experience and carries no course credit; it is taken as an overload, on an "in-progress" basis. A grade will be given upon completion of Chemistry 406, which carries one and one-half units. Satisfactory completion of Chemistry 405 (including a poster presentation) is a prerequisite for Chemistry 406. Each course is by permission only. Interested students are invited to apply before the registration period in the spring of the second or third year. Application in the first year requires nomination by a faculty member. Taking Chemistry 405 in the spring semester requires approval of the Department Chair. The candidate's academic record will be reviewed to determine if the student could reasonably benefit from such a program.

Prerequisite: CHEM 222 and CHEM 231
GPA units: 0
Typically Offered: Fall, Spring

CHEM 406 — General Research 2 Course count: 1
Involves an original and individual experimental and/or computational investigation with associated literature study in one of the fields of chemistry under the supervision of a member of the faculty. The culmination of all research projects will be a report, as well as an oral presentation to be given during the spring semester. Students will be required to attend the weekly department seminar program (fall and spring). Chemistry 405 is the first course of the consecutive two-semester research experience and carries no course credit; it is taken as an overload, on an "in-progress" basis. A grade will be given upon completion of Chemistry 406, which carries one and one-half units. Satisfactory completion of Chemistry 405 (including a poster presentation) is a prerequisite for Chemistry 406. Each course is by permission only. Interested students are invited to apply before the registration period in the spring of the second or third year. Application in the first year requires nomination by a faculty member. Taking Chemistry 405 in the spring semester requires approval of the Department Chair. The candidate's academic record will be reviewed to determine if the student could reasonably benefit from such a program.

Prerequisite: CHEM 405
GPA units: 1.5
Typically Offered: Fall, Spring

CHEM 407 — General Research 3 Course count: 0
This program builds on the experiences gained in Chemistry 405 and 406. The second year of research provides the opportunity for further in-depth investigations. The culmination of all research projects will be a report and oral presentation to the chemistry faculty during the spring semester. Students will be required to attend the weekly departmental seminars program (fall and spring). Chemistry 407 is the first course of this consecutive two-semester research experience and carries no course credit; it is taken as an overload, on an in-progress basis. A grade will be given upon completion of Chemistry 408, which carries one and one- half units. Chemistry 408 can not be counted toward the required minimum number of chemistry courses. Satisfactory completion of Chemistry 407 (including a poster presentation) is a prerequisite for Chemistry 408. Both Chemistry 407 and 408 are by permission only. Interested students normally apply before the registration period in the spring of the third year. The candidate's academic record to date, with particular attention given to performance in Chemistry 405 and 406, will be reviewed to determine if the student could reasonably benefit from such a program.

Prerequisite: CHEM 405 406
GPA units: 0
Typically Offered: Fall, Spring

CHEM 408 — General Research 4 Course count: 1
This program builds on the experiences gained in Chemistry 405 and 406. The second year of research provides the opportunity for further in-depth investigations. The culmination of all research projects will be a report and oral presentation to the chemistry faculty during the spring semester. Students will be required to attend the weekly departmental seminars program (fall and spring). Chemistry 407 is the first course of this consecutive two-semester research experience and carries no course credit; it is taken as an overload, on an "in-progress" basis. A grade will be given upon completion of Chemistry 408, which carries one and one- half units. Chemistry 408 can not be counted toward the required minimum number of chemistry courses. Satisfactory completion of Chemistry 407 (including a poster presentation) is a prerequisite for Chemistry 408. Both Chemistry 407 and 408 are by permission only. Interested students normally apply before the registration period in the spring of the third year. The candidate's academic record to date, with particular attention given to performance in Chemistry 405 and 406, will be reviewed to determine if the student could reasonably benefit from such a program.

Prerequisite: CHEM 407
GPA units: 1.5
Typically Offered: Fall, Spring

CHEM 410 — Advanced Research Course count: 1
This program builds on the experiences gained in prior research courses, providing the opportunity for further in-depth investigations. The culmination of all research projects will be a written report and a presentation to the chemistry faculty. Students will be required to attend the weekly departmental seminars program. This course is by permission only. Interested students normally apply to the department before the relevant registration period. The candidates academic record to date, with particular attention give to performance in prior research courses, will be reviewed to determine if the student could reasonably benefit form such a program.

Prerequisite: CHEM 390 or CHEM 406
GPA units: 1.25
Typically Offered: Fall, Spring