Department of Chemistry

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Mission Statement

Chemistry at Carnegie Mellon University is committed to making advances in the molecular sciences with lasting impact on foundational knowledge while tackling critical global challenges including sustainability, health, and quality of life.

Chemistry is the science of studying the properties and reactions of substances—from living cells to subatomic particles. It lies at the heart of numerous scientific and technological fields, offering essential knowledge and tools to solve pressing societal challenges and drive new discoveries. Fields as diverse as genetic engineering, materials science, and nanotechnology rely on chemistry to shape the future, because the deepest understanding begins at the molecular level.

Flexible Career Options

The chemistry profession is extraordinarily diverse, offering career opportunities across a wide range of sectors—including the chemical, petroleum, renewable energy, nuclear power, polymer materials, metals, personal care, and pharmaceutical industries. Chemistry also plays a critical role in the expanding biomedical and biotechnology fields. In addition to industry and academia, chemistry graduates find impactful careers in public-sector organizations such as the National Institutes of Health, the Food and Drug Administration, the Environmental Protection Agency, the National Institute of Standards and Technology, and the Department of Energy. Many also pursue consulting or enter technical fields where their problem-solving and communication skills are highly valued.

Chemistry is particularly well suited for students preparing for medical and other health professions. Medical schools value the strong analytical and reasoning skills that chemistry students develop, and our graduates have an excellent track record of admission to medical, dental, pharmacy, and pharmacology programs. The Health Professions Program supports all Carnegie Mellon students considering careers in health-related fields. (See the Health Professions Program section in this catalog for more details.)

Chemistry is also excellent preparation for careers in law—especially for students interested in patent, intellectual property, or environmental law. The curriculum provides flexibility for students to explore opportunities such as the CMU Washington Semester Program, including internships in science policy. Students interested in industry often supplement their studies with coursework in business administration or pursue an M.B.A. after graduation.

The career paths of our graduates reflect this diversity. Recent alumni are working as software engineers at Bloomberg in London and MasterCard, in Healthcare Technical Services at Epic Systems, as research scientists at Eli Lilly, and as clinical research assistants at Children's Hospital of Pittsburgh. Others are pursuing graduate degrees—such as an M.S. in Materials Science and Engineering at Stanford, or law school at UCLA. Many have entered Ph.D. programs in fields like biomaterials, nuclear engineering, polymer science, and chemistry at institutions including Stanford, UC Berkeley, Yale, MIT, and the University of Illinois at Urbana–Champaign. These alumni often remain actively involved with the department, returning to speak with current students about their career paths and offering guidance through the Undergraduate Seminar Program and other networking opportunities.

Degree Pathways

The Department of Chemistry offers three undergraduate degrees: the **Bachelor of Science (B.S.) in Chemistry**, the **Bachelor of Science (B.S.) in Chemistry with a Biological Chemistry Track**, and the **Bachelor of Arts (B.A.) in Chemistry**.

The B.A. degree includes a substantial number of free electives, approximately one-third of the total coursework. These electives may be taken in any department across the university, making the degree especially flexible for students with interdisciplinary interests or those planning careers in education, law, policy, or health-related fields.

The B.S. degrees are more structured and technically focused. Electives in these programs are often chosen from chemistry or related fields such as biology, physics, mathematics, chemical engineering, biomedical engineering, materials science, or computer science. However, students are not restricted to technical courses and may pursue electives in other areas to expand the breadth of their undergraduate experience.

In both the B.S. and B.A. programs, students typically complete the core technical requirements by the end of their junior year. This allows flexibility in the senior year to develop a focused area of specialization or to pursue broader intellectual interests.

Carnegie Mellon has one of the strongest polymer science programs in the world. The undergraduate options in polymer science, materials chemistry, environmental chemistry, management, and computational chemistry offer focused training that is particularly valuable for an industrial career. For example, the computational chemistry option builds expertise in scientific computing, a skill highly sought after in pharmaceutical and biotechnology fields. Across all programs, students gain experience with modern computational tools and have access to state-of-the-art instrumentation through both coursework and undergraduate research.

The department also offers the B.S. in Chemistry with a Biological Chemistry Track in recognition of the growing overlap between chemistry and the biological sciences. Increasingly, synthetic chemicals are used as molecular probes, diagnostic tools, and therapeutic agents. At the same time, new spectroscopic, structural, and scanning probe methods capable of resolving detail at the level of single molecules are driving innovation in this space. The Biological Chemistry Track prepares students to thrive at this interface, combining a strong foundation in core chemistry with advanced, research-driven lecture courses and a specialized bioorganic chemistry laboratory. Students who complete the track gain exposure to emerging research directions and acquire experimental skills relevant to both academic and industrial applications.

Students interested in graduate studies in chemistry are encouraged to enroll in graduate-level courses as undergraduates. Others may pursue immediate employment, often supported by one or more of the department's formal B.S. options. Many students also combine their chemistry studies with business courses or pursue further professional training such as an M.B.A.

Opportunities for Research, Honors, and Combined Degrees

The Department of Chemistry offers an honors program for highly motivated undergraduates who want to engage in advanced, research-intensive study. The **B.S. in Chemistry with Departmental Honors** includes at least one graduate-level chemistry course, completion of a research project, and the writing and defense of an undergraduate honors thesis.

An extended path is available through the **B.S. in Chemistry with Departmental Honors and a Master of Science (M.S.) in Chemistry**. This advanced program requires five graduate-level chemistry courses and a more in-depth research thesis. It is particularly well suited for students preparing for careers in industry. With sufficient advanced placement credit or by taking heavier course loads, students can complete this combined honors and M.S. degree in eight semesters, including research during one or two summers. This integrated program aligns well with current industry demand, where many positions are available at the bachelor's and master's levels.

Additional Majors, Minors, and Dual Degrees

Students may pursue **additional majors (double majors)** with nearly any department at the university, provided they can accommodate the course requirements. In general, students must fulfill all requirements for both majors, though some overlapping content may allow for substitutions.

Students may also choose to complete a **minor** in another discipline. Most minor requirements are described in the catalog under the respective departments. It is strongly recommended that students consult with the relevant department early in their planning to understand current requirements and develop a viable schedule.

Dual degree programs allow students to earn two separate undergraduate degrees from two different departments at Carnegie Mellon. These programs require at least 90 additional units beyond the first degree, as well as completion of the core requirements for both colleges if they span different academic units.

Five-Year Combined Programs

Several **five-year programs** are available for students interested in earning both a B.S. in Chemistry and a Master of Science degree in an applied or interdisciplinary field. Current options include Health Care Policy and Management, Materials Science and Engineering, Biomedical Engineering, and the Colloids, Polymers, and Surfaces program.

Study Abroad

Students interested in spending a semester or year abroad can do so without delaying graduation. With thoughtful planning, the chemistry curriculum can accommodate one or two semesters of international study within the standard eight-semester timeline.

One formal exchange option is a two-semester program at École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. Some students also choose to study at Carnegie Mellon's campus in Qatar. Others have spent time at universities across Europe, Asia, Africa, Australia, and New Zealand during the academic year or over summer and spring breaks.

The chemistry department works closely with students to help integrate study abroad into their academic plans. To explore options and stay on track for graduation, students should speak with their academic advisor and the MCS Study Abroad Advisor in the Office of International Education.

Undergraduate Research Opportunities

One of the most compelling features of the Department of Chemistry is the opportunity for students to engage with research early and often. Chemistry majors interact with leading research scientists not only in advanced courses but also in entry-level classes and through hands-on research experiences.

Undergraduate laboratory instruction takes place in a state-of-the-art teaching facility located in Doherty Hall. Participation in research is strongly encouraged, and students may begin as early as their first year through research shadowing experiences. Interested students should consult with the Director of Undergraduate Studies to start the process of identifying a research mentor.

Over the past ten years, approximately 90 to 98 percent of graduating chemistry majors have conducted research for pay or credit as part of their undergraduate experience. Those who do not participate typically choose not to.

Students have been highly successful in securing competitive funding for their work. Many receive Small Undergraduate Research Grants (SURG) or Summer Undergraduate Research Fellowships (SURF) from the university. Each year, several students are also awarded International SURF (iSURF) funding to conduct summer research with collaborators abroad.

Faculty in the Department of Chemistry are leading the way in the use of computer-controlled instrumentation for synthesis and analysis of chemical compounds. In addition to automated science capabilities in individual labs, Chemistry faculty and students are helping lead the University's efforts in integrating artificial intelligence with automated science (https://ai.cmu.edu/research-and-policy-impact/ai-for-science/) through a new multimillion dollar laboratory in the Bakery Square neighborhood of Pittsburgh. In addition to use in research, our faculty are developing automated experiments to be performed in both required and elective courses, thereby introducing students to the growing use of automation and computation in conjunction with experimental science.

Program Outcomes

The faculty members of the Department of Chemistry have approved the following as a statement of our learning outcomes for recipients of an undergraduate degree in chemistry.

Upon graduation recipients of the BS or BA degree in Chemistry will be able to:

Foundational Knowledge/Theory

- **Apply** quantitative and computational reasoning to solve chemical problems, including the use of modern computational tools.
- **Apply** fundamental theories and models to analyze and predict the behavior of molecular systems.
- **Demonstrate** integration of knowledge from different subdisciplines of chemistry through the analysis of interdisciplinary problems that connect chemistry to fields such as biology, environmental science and sustainability, materials science, nanotechnology, and engineering.

Practical/Experimental

- **Design and interpret** experiments to analyze and synthesize chemical systems, incorporating modern instrumentation, data analysis techniques, reaction pathway development, and yield optimization.
- **Select and operate** appropriate instrumentation for chemical analysis, demonstrating an understanding of its principles, capabilities, and limitations.
- **Formulate** testable research questions; **design** experimental methods to investigate them; and **justify** methodological choices using relevant scientific principles.
- **Follow** established protocols and regulations to ensure the safe handling, use, and disposal of chemicals and chemical equipment.

Communication

- **Communicate** chemical concepts, experimental results, and scientific arguments clearly and effectively in both written and oral formats, adapting to scientific and non-scientific audiences.
- **Locate, critically evaluate, and synthesize** scientific literature to support research, properly acknowledging prior work and adhering to ethical standards in scientific communication.

Society and Ethics

- **Evaluate** the societal, environmental, and ethical implications of chemistry, applying professional standards, principles of sustainability, and ethical integrity to scientific and industrial practices. This includes an awareness of sustainability science and emerging public health issues such as endocrine disruption, and their relevance to chemical research, development, and regulation.

Professional Development

- **Demonstrate** awareness of career pathways in chemistry and related fields by creating a professional development plan, attending career-related events, or seeking mentorship.

B.S. in Chemistry (and requirements for additional major in chemistry)

The Bachelor of Science (B.S.) in Chemistry is the most commonly awarded undergraduate degree in the department. It provides strong preparation for graduate study or for employment in research, development, or analytical roles in industry. The curriculum includes foundational coursework in organic, physical, inorganic, and analytical chemistry, and it emphasizes hands-on laboratory training using modern instrumentation.

Curriculum Planning and Course Scheduling

The curriculum and sample schedule presented here are intended for students who matriculate in Fall 2025. Students who entered in prior years should consult their degree audit and speak with the Director of Undergraduate Studies to confirm the requirements that apply to them.

The B.S. in Chemistry curriculum offers flexibility, allowing students to tailor their schedules to include electives, minors, or an additional major. While it is recommended that core technical courses be completed early, students may choose to delay some requirements to accommodate other interests or programs.

When planning your schedule, be aware that many required chemistry courses are offered only once per academic year. For example:

Fall-only courses:

- 09-219 Modern Organic Chemistry
- 09-321 Laboratory III: Molecular Design and Synthesis
- 09-323 Bioorganic Chemistry Laboratory
- 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry

Spring-only courses:

- 09-220 Modern Organic Chemistry II
- 09-331 Modern Analytical Instrumentation
- 09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry
- 09-348 Inorganic Chemistry

Course Scheduling Note: Occasionally, a course that is typically offered in the fall may be shifted to the spring (or vice versa) due to departmental curriculum changes or faculty availability. Students are encouraged to consult the department and their advisor each semester to confirm course timing and build a long-term plan that anticipates such changes and accommodates personal goals such as study abroad, research, or double majoring.

Technical and Non-Technical Requirements

MCS Core Technical Requirements

Chemistry majors must complete a minimum of four technical courses outside of chemistry to satisfy the MCS core technical breadth requirement.

These include courses in physics, biology, computer science, and mathematics:

Technical Breadth Requirements		Units
33-121	Physics I for Science Students	12
33-122	Physics II for Biological Sciences & Chemistry Students	9
03-121	Modern Biology	9
or 03-231	Honors Biochemistry	
or 03-232	Biochemistry I	
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
or 02-120	Undergraduate Programming for Scientists	
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
		60

Students are encouraged to complete these technical core requirements by the end of their fifth semester. AP credit may not be used to fulfill the core technical breadth requirements, though it can satisfy prerequisites for chemistry courses. If a student fulfills an entire category (e.g., physics or biology) solely through AP credit, they must take an approved upper-level course in that area to meet the core requirement.

Non-Technical General Education Requirements

All students in the Mellon College of Science (MCS) must complete a set of non-technical breadth requirements totaling a minimum of 75 units. These include communication, humanities and social sciences, global and cultural perspectives, and wellness:

Required Courses:

- 76-101 Interpretation and Argument (9 units)
- Arts, Humanities, and Social Sciences: Four courses totaling a minimum of 36 units
- Cultural/Global Understanding: One approved course (minimum 9 units)
- Science and Society: One approved course (minimum 6 units)
- Engage Sequence (5 total):
  - ENGAGE in Wellness
    - 38-230 ENGAGE in Wellness: Looking Inward (1 unit)
    - 38-330 ENGAGE in Wellness: Looking Outward (1 unit)
    - 38-430 ENGAGE in Wellness: Looking Forward (1 unit)
  - 38-110 ENGAGE in Service (1 unit)
  - 38-220 ENGAGE in the Arts (2 units)
- First-Year Seminars
  - 38-101 EUREKA!: Discovery and Its Impact (6 units)
  - 99-101 Core@CMU (3 units)

Important Notes:

- The Science and Society and ENGAGE requirements must be completed no later than the penultimate semester.
- Students may not double count courses across general education categories. For example, a course used to fulfill the Science and Society requirement may not also count toward the Cultural/Global Understanding category or the 36 units required in Arts, Humanities, and Social Sciences.

Overlap with Chemistry Electives:

Some chemistry courses approved for general education requirements may also count as chemistry electives. For example:

- Science and Society + Chemistry Elective:
  - 09-510 Chemistry and Sustainability (or graduate version,09-710 Chemistry and Sustainability)
  - 09-381 Environmental Systems on a Changing Planet
  - 09-403 Hooked: The Chemical Basis of Drug Addiction

(Only one of these may count toward the 18 units of chemistry electives.)

- Cultural/Global Understanding + Chemistry Elective:
  - 09-227 The Culture of Color: Dyes, Chemistry, and Sustainability

A current list of approved courses in these categories is maintained by the MCS Dean's Office:

https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/index.html (https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/)

Sample Schedule by Year (First–Senior)

First Year

Fall		Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-115	Introduction to Undergraduate Research in Chemistry	2
21-120	Differential and Integral Calculus	10
33-121	Physics I for Science Students	12
76-101	Interpretation and Argument	9
38-101	EUREKA!: Discovery and Its Impact	6
99-101	Core@CMU	3
		52

Planning Tip: Students interested in majoring in chemistry who have a strong chemistry background should enroll in 09-107 Honors Chemistry: Fundamentals, Concepts and Applications rather than 09-105 Introduction to Modern Chemistry I. Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II via a prerequisite waiver.

There are some elective laboratory courses offered for MCS students in the first year including 03-117 Frontiers, Analysis, and Discovery in Biological Sciences or 09-101 Introduction to Experimental Chemistry and 09-115 Introduction to Undergraduate Research in Chemistry. While not required for the major, we strongly encourage students who are interested in early research engagement to register for 09-115 Introduction to Undergraduate Research in Chemistry. This course introduces students to research within the department and includes laboratory safety and hazardous waste training, which are often necessary for working in scientific labs at CMU. It is included in the sample schedule above to highlight this opportunity.

The maximum units allowed during the first semester is 54; therefore, students wishing to take a lab should take an alternate technical course to Physics I such as 15-110 Principles of Computing or 03-121 Modern Biology so that their unit total is lower.

Spring		Units
09-106	Modern Chemistry II	10
09-116	Undergraduate Research Shadowing in Chemistry	2
or 09-101	Introduction to Experimental Chemistry	
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
33-121	Physics I for Science Students	12
or 03-121	Modern Biology	
or 15-110	Principles of Computing	
xx-xxx	Arts, Humanities and Social Sciences Course 1	9
xx-xxx	Free Elective	9
		52

Planning Tip: Chemistry majors who place out of 09-106 Modern Chemistry II can take 09-348 Inorganic Chemistry , 09-510 Chemistry and Sustainability or 09-381 Environmental Systems on a Changing Planet as a chemistry elective. 09-381 Environmental Systems on a Changing Planet is especially recommended for students pursuing the Environmental and Sustainability Studies minor. 09-510 Chemistry and Sustainability will serve as both a Chemistry elective as well as a MCS Science and Society requirement. Please note that 09-291 Environmental Systems on a Changing Planet does not count toward chemistry electives.

The sample schedule above also includes laboratory electives. Students wishing to actively engage in research should take 09-116 Undergraduate Research Shadowing in Chemistry, which pairs them with a research group in the department for half a semester. With a faculty mentor's recommendation, students may continue in the same lab through 09-445 Undergraduate Research. Those who want focused hands-on experience in a chemistry lab environment may consider 09-101 Introduction to Experimental Chemistry. Students interested in biology-based lab work may also take 03-117 Frontiers, Analysis, and Discovery in Biological Sciences.

Sophomore Year

Fall		Units
09-201	Undergraduate Seminar I	1
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12

33-122	Physics II for Biological Sciences & Chemistry Students Course is a prerequisite for 09-331, normally taken in the spring of the junior year	9
xx-xxx	Arts, Humanities and Social Sciences Course 2	9
		41

Spring		Units
09-202	Undergraduate Seminar II: Safety and Environmental Issues for Chemists	1
09-220	Modern Organic Chemistry II	10
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-348	Inorganic Chemistry	10
38-230	ENGAGE in Wellness: Looking Inward	1
xx-xxx	Arts, Humanities and Social Sciences Course 3	9
		43

Planning Tip: Students pursuing careers in the health professions or following the Biological Chemistry Track may wish to take 03-232 Biochemistry I in the Spring semester and delay 09-348 Inorganic Chemistry to the spring of their senior year.

Junior Year

Fall		Units
09-301	Undergraduate Seminar III	1
09-231	Mathematical Methods for Chemists	9
09-321 or 09-323	Laboratory III: Molecular Design and Synthesis Bioorganic Chemistry Laboratory	12
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
38-330	ENGAGE in Wellness: Looking Outward	1
xx-xxx	Arts, Humanities and Social Sciences Course 4	9
		41

Spring		Units
09-302	Undergraduate Seminar IV	1
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-331	Modern Analytical Instrumentation	9
xx-xxx	Cultural/Global Understanding Requirement	9
xx-xxx	Approved Science and Society elective. This course can be scheduled at any point during your studies but prior to your final semester..	6-9
		46-49

Planning Tip:

1. 09-231 Mathematical Methods for Chemists is a co-requisite for 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry and a prerequisite for 09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry.
2. 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry is a prerequisite for 09-322 Laboratory IV: Molecular Spectroscopy and Dynamics .
3. While 09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry and 09-331 Modern Analytical Instrumentation are often taken alongside 09-322 Laboratory IV: Molecular Spectroscopy and Dynamics, they are **not** required co-requisites. Students should consult with an advisor if they plan to shift any of these courses to senior year.
4. Students pursuing careers in the health professions or following the Biological Chemistry Track may wish to take 09-403 Hooked: The Chemical Basis of Drug Addiction in the Fall semester of their Junior year. It will fulfill both a Chemistry elective as well as a Science and Society elective

Students may spread out junior-level courses across the junior and senior years to balance their academic load and research commitments. Work closely with your academic advisor to map out a schedule that fits your goals

Senior Year

Fall		Units
09-401	Undergraduate Seminar V	1
09-xxx	Chemistry Elective (see notes on electives)	9
38-110	ENGAGE in Service	1
38-220	ENGAGE in the Arts	2
38-430	ENGAGE in Wellness: Looking Forward	1
xx-xxx	Free Electives	30
		44

Spring		Units
09-402	Undergraduate Seminar VI	3
09-xxx	Chemistry Elective (see notes on electives)	9
xx-xxx	Free Electives	27
		39

Planning Tip: The senior year is designed to provide maximum flexibility. Use this time to deepen your training through electives, conduct independent research, or prepare for graduate school, professional programs, or job applications. Be mindful of not overloading your final semester and aim to complete general education requirements, including all ENGAGE courses, before your last term.

Unit Summary and Graduation Requirements for the B.S. in Chemistry (and Additional Major)

Chemistry Requirements

A minimum of 160 units must come from chemistry-specific courses:

Required Chemistry Courses*		Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-219	Modern Organic Chemistry	10
09-220	Modern Organic Chemistry II	10
09-231	Mathematical Methods for Chemists	9
09-331	Modern Analytical Instrumentation	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-348	Inorganic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-xxx	Chemistry Seminars	8
09-xxx	Chemistry Electives	18
		160

Note: These courses, along with 33-121 Physics I for Science Students and33-122 Physics II for Biological Sciences & Chemistry Students , are also required for students pursuing an additional major in chemistry.

Chemistry Electives (minimum 18 units required)

Chemistry electives are intended to enhance a student's technical knowledge in chemistry. These may include:

- 09-445 Undergraduate Research
- Most 09-3xx or higher chemistry courses (undergraduate or graduate)
- 03-231 Honors Biochemistry or 03-232 Biochemistry I

09-435 Independent Study Chemistry may only be used with permission of the Director of Undergraduate Studies.

Some interdisciplinary courses (e.g., 39-xxx) may count toward chemistry electives only if they have significant chemical content and are approved in advance by the Director of Undergraduate Studies.

In some cases, chemistry electives may also satisfy general education requirements such as Science and Society or Cultural/Global Understanding, but students should consult with an advisor to confirm eligibility and avoid double-counting within the same category.

Students should check with the chemistry department and the course-offering department each semester to confirm which courses are available and approved for elective credit.

Quick Guide: Choosing Chemistry Electives by Interest Area

Chemistry electives give you the flexibility to explore topics that align with your interests, deepen your technical training, or prepare you for specific career paths. Below are some common focus areas and electives that support them.

Interest Area	Suggested Chemistry Electives
Sustainability and Environmental Chemistry	**09-510 Chemistry and Sustainability, 09-381 Environmental Systems on a Changing Planet, 09-529 Introduction to Sustainable Energy and Science**
Biological and Health Applications	**03-231 Biochemistry I or 03-232 Biochemistry I, 09-403 Hooked: The Chemical Basis of Drug Addiction, 09-737 Medicinal Chemistry and Drug development**
Computational Chemistry and Modeling	**09-563 Molecular Modeling and Computational Chemistry, 09-615 Computational Modeling. Statistical Analysis and Machine Learning in Science, 09-616 Neural Networks & Deep Learning in Science**
Materials and Nanoscience	**09-509 Physical Chemistry of Macromolecules, 09-507 Nanoparticles, 09-760 The Molecular Basis of Polymer Mechanics**

Residency Requirement for Chemistry Courses

All chemistry courses required for the B.S. that are numbered 09-2xx or higher must be taken at Carnegie Mellon University. Exceptions must be requested in advance and approved by the Director of Undergraduate Studies. Approval is typically granted only under unusual or extenuating circumstances.

To plan your electives effectively, consult with your academic advisor and check semester availability with the chemistry department.

Other Required Courses and Electives

Other Requirements	Units
Biology (Modern Biology or Biochemistry)	**9**
Computer Science	**10**
Mathematics	**20**
Physics	**21**
Interpretation and Argument	**9**
Arts, Humanities and Social Sciences Courses	**36**
Cultural/Global Understanding	**9**
EUREKA! (First-year seminar)	**6**
Science and Society requirement	**6**
ENGAGE in Service	**1**
ENGAGE in Wellness Courses (three courses)	**3**
ENGAGE in the Arts	**2**
Core@CMU	**3**
Free Electives	**65**
Minimum number of units required for the degree:	**360**

Free Electives

Free electives include any Carnegie Mellon course, except those in science or engineering that are specifically intended for non-majors.

A maximum of 9 units total from the following categories may count toward the free elective requirement:

- Physical Education (P.E.)
- StuCo (Student College)
- ROTC

Students are encouraged to use free electives to pursue minors, deepen technical training, explore other disciplines, or prepare for future academic and career goals.

There is no separate "technical elective" requirement in the B.S. in Chemistry curriculum. However, students may choose to take advanced technical courses in chemistry or related fields as part of their free electives.

Additional Notes on Degree Requirements

Minimum Total Units

The B.S. in Chemistry degree requires a minimum of 360 units. Most students complete this requirement within 41–50 units per semester. Students are strongly encouraged to take additional electives in subjects of personal or professional interest to enrich their undergraduate experience.

AP Credit and Unit Overlap

Some students may need to complete more than 360 units to graduate, especially if they repeat coursework for which they received AP credit. For example, a student who received AP credit for but takes 09-105 or 09-107 at CMU will only receive 10 units toward the requirement — not 20. The duplicate units will not count toward the degree total.

Transfer Students and Course Substitutions

Students who transfer into the department and have taken 09-217 Organic Chemistry I and/or 09-218 Organic Chemistry II must complete 09-435 Independent Study Chemistry (1 unit per course) under the supervision of the 09-219 Modern Organic Chemistry and/or 09-220 Modern Organic Chemistry II instructor(s) to cover missing content.

Students who have taken 09-207 Techniques in Quantitative Analysis and/or 09-208 Techniques for Organic Synthesis and Analysis must enroll in a 3-unit transition course:

- 09-215 Chemistry Tech I to Lab I Transition (for 09-207 Techniques in Quantitative Analysis)
- 09-216 Chemistry Tech II to Lab II Transition (for 09-208 Techniques for Organic Synthesis and Analysis)

B.S. in Chemistry/Biological Chemistry Track

The B.S. in Chemistry/Biological Chemistry is ideal for students preparing for graduate work in biochemistry, molecular biology, or biomedical fields, or for those pursuing careers in pharmaceuticals, healthcare, or biotechnology. This degree combines the rigorous core of the B.S. in Chemistry with expanded study in biology and biochemistry.

In addition to the standard chemistry curriculum, students complete biology and biochemistry courses and a novel laboratory course that models the drug discovery process. The program emphasizes research readiness and interdisciplinary thinking at the intersection of chemistry and the life sciences.

Curriculum Planning and Course Scheduling

The curriculum and sample schedule presented here are intended for students who matriculate in Fall 2025. Students who entered in prior years should consult their degree audit and speak with the Director of Undergraduate Studies to confirm the requirements that apply to them.

The B.S. in Chemistry/Biological Chemistry track requires early and careful planning. Students are strongly encouraged to complete required technical courses at the earliest opportunity to ensure timely progress through the curriculum. Some flexibility exists to postpone certain courses in favor of electives, especially when coordinating a minor or additional major. However, such adjustments must take into account the sequencing and availability of key chemistry courses, which are often offered only once per academic year:

For example:

Fall-only courses:

- 09-219 Modern Organic Chemistry
- 09-321 Laboratory III: Molecular Design and Synthesis
- 09-323 Bioorganic Chemistry Laboratory
- 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry

Spring-only courses:

- 09-220 Modern Organic Chemistry II
- 09-331 Modern Analytical Instrumentation

- 09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry
- 09-348 Inorganic Chemistry

Course Scheduling Note: Occasionally, a course that is typically offered in the fall may be shifted to the spring (or vice versa) due to departmental curriculum changes or faculty availability. Students are encouraged to consult the department and their advisor each semester to confirm course timing and build a long-term plan that anticipates such changes and accommodates personal goals such as study abroad, research, or double majoring.

Technical and Non-Technical Requirements

MCS Core Technical Requirements

Chemistry majors must complete a minimum of four technical courses outside of chemistry to satisfy the MCS core technical breadth requirement. These include courses in physics, biology, computer science, and mathematics:

Technical Breadth Requirements		Units
33-121	Physics I for Science Students	12
33-122	Physics II for Biological Sciences & Chemistry Students	9
03-121	Modern Biology	9
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
or 02-120	Undergraduate Programming for Scientists	
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
		60

Students are encouraged to complete these technical core requirements by the end of their fifth semester. AP credit may not be used to fulfill the core technical breadth requirements, though it can satisfy prerequisites for chemistry courses. If a student fulfills an entire category (e.g., physics or biology) solely through AP credit, they must take an approved upper-level course in that area to meet the core requirement.

Note:
Unlike the standard B.A. in Chemistry and the B.S. in Chemistry , students in the Biological Chemistry track are **required** to take 03-121 Modern Biology to satisfy the MCS biology requirement. Alternatives such as 03-231 Honors Biochemistry or 03-232 Biochemistry I do not substitute for this requirement in the core as they are also required for this degree path.

Non-Technical General Education Requirements

All students in the Mellon College of Science (MCS) must complete a set of non-technical breadth requirements totaling a minimum of 75 units. These include communication, humanities and social sciences, global and cultural perspectives, and wellness:

Required Courses:

- 76-101 Interpretation and Argument (9 units)
- Arts, Humanities, and Social Sciences: Four courses totaling a minimum of 36 units
- Cultural/Global Understanding: One approved course (minimum 9 units)
- Science and Society: One approved course (minimum 6 units)
- Engage Sequence (5 total):
  - ENGAGE in Wellness
    - 38-230 ENGAGE in Wellness: Looking Inward (1 unit)
    - 38-330 ENGAGE in Wellness: Looking Outward (1 unit)
    - 38-430 ENGAGE in Wellness: Looking Forward (1 unit)
  - 38-110 ENGAGE in Service (1 unit)
  - 38-220 ENGAGE in the Arts (2 units)
- First-Year Seminars
  - 38-101 EUREKA!: Discovery and Its Impact (6 units)
  - 99-101 Core@CMU (3 units)

Important Notes:

- The Science and Society and ENGAGE requirements must be completed no later than the penultimate semester.
- Students may not double count courses across general education categories. For example, a course used to fulfill the Science and Society requirement may not also count toward the Cultural/Global Understanding category or the 36 units required in Arts, Humanities, and Social Sciences.

Overlap with Chemistry Courses:

Some chemistry courses are approved for general education requirements. For example:

- Science and Society :
  - 09-510 Chemistry and Sustainability (or graduate version, 09-710 Chemistry and Sustainability)
  - 09-381 Environmental Systems on a Changing Planet
  - 09-403 Hooked: The Chemical Basis of Drug Addiction

Of this list, only 09-403 Hooked: The Chemical Basis of Drug Addiction will count as a biological chemistry elective.

- Cultural/Global Understanding :
  - 09-227 The Culture of Color: Dyes, Chemistry, and Sustainability

A current list of approved courses in these categories is maintained by the MCS Dean's Office:

https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/index.html (https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/)

Sample Schedule by Year (First–Senior)

First Year

Fall		Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-115	Introduction to Undergraduate Research in Chemistry	2
21-120	Differential and Integral Calculus	10
33-121	Physics I for Science Students	12
76-101	Interpretation and Argument	9
38-101	EUREKA!: Discovery and Its Impact	6
99-101	Core@CMU	3
		52

Planning Tip: Students interested in majoring in chemistry who have a strong chemistry background should enroll in 09-107 Honors Chemistry: Fundamentals, Concepts and Applications rather than 09-105 Introduction to Modern Chemistry I. Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II via a prerequisite waiver.

There are some elective laboratory courses offered for MCS students in the first year including 03-117 Frontiers, Analysis, and Discovery in Biological Sciences or 09-101 Introduction to Experimental Chemistry and 09-115 Introduction to Undergraduate Research in Chemistry. While not required for the major, we strongly encourage students who are interested in early research engagement to register for 09-115 Introduction to Undergraduate Research in Chemistry. This course introduces students to research within the department and includes laboratory safety and hazardous waste training, which are often necessary for working in scientific labs at CMU. It is included in the sample schedule above to highlight this opportunity.

The maximum units allowed during the first semester is 54; therefore, students wishing to take a lab should take an alternate technical course to Physics I such as 15-110 Principles of Computing or 03-121 Modern Biology so that their unit total is lower.

Spring		Units
09-106	Modern Chemistry II	10
09-116	Undergraduate Research Shadowing in Chemistry	2
or 09-101	Introduction to Experimental Chemistry	
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
33-121	Physics I for Science Students	12
or 03-121	Modern Biology	
or 15-110	Principles of Computing	
xx-xxx	Arts, Humanities and Social Sciences Course 1	9
xx-xxx	Free Elective	9
		52

Planning Tip: Chemistry majors who place out of 09-106 Modern Chemistry II can take 09-348 Inorganic Chemistry or 09-381 Environmental

Systems on a Changing Planet as a chemistry elective. 09-381 Environmental Systems on a Changing Planet is especially recommended for students pursuing the Environmental and Sustainability Studies minor. Please note that 09-291 Environmental Systems on a Changing Planet does not count toward chemistry electives.

In the B.S. Chemistry track, students are given the option of taking 09-510 Chemistry and Sustainability as a chemistry elective. Students interested in sustainability should certainly consider this course, as it fulfills both a chemistry elective and the MCS Science and Society requirement. In the B.S. in Chemistry/Biological Chemistry track, however, 09-510 Chemistry and Sustainability does not count toward the biological chemistry elective requirement. Instead, 09-403 Hooked: The Chemical Basis of Drug Addiction fulfills both a biological chemistry elective and the Science and Society requirement. If a student takes both 09-510 Chemistry and Sustainability and 09-403 Hooked: The Chemical Basis of Drug Addiction, only one may be used to fulfill the Science and Society requirement. 09-403 Hooked: The Chemical Basis of Drug Addiction is offered in the Fall semesters.

The sample schedule above also includes laboratory electives. Students wishing to actively engage in research should take 09-116 Undergraduate Research Shadowing in Chemistry, which pairs them with a research group in the department for half a semester. With a faculty mentor's recommendation, students may continue in the same lab through 09-445 Undergraduate Research. Those who want focused hands-on experience in a chemistry lab environment may consider 09-101 Introduction to Experimental Chemistry. Students interested in biology-based lab work may also take 03-117 Frontiers, Analysis, and Discovery in Biological Sciences.

Sophomore Year

Fall		Units
09-201	Undergraduate Seminar I	1
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
33-122	Physics II for Biological Sciences & Chemistry Students Course is a prerequisite for 09-331, normally taken in the spring of the junior year	9
03-220	Genetics	9
xx-xxx	Arts, Humanities and Social Science Course I	9
		50

Spring		Units
09-202	Undergraduate Seminar II: Safety and Environmental Issues for Chemists	1
09-220	Modern Organic Chemistry II	10
09-222	Laboratory II: Organic Synthesis and Analysis	12
03-232	Biochemistry I	9
38-230	ENGAGE in Wellness: Looking Inward	1
xx-xxx	Arts, Humanities and Social Sciences Course 3	9
		42

Planning Tip: Students pursuing careers in the health professions or following the Biological Chemistry Track may wish to take 03-232 Biochemistry I in the Spring semester and delay 09-348 Inorganic Chemistry to the spring of their senior year.

Junior Year

Fall		Units
09-301	Undergraduate Seminar III	1
09-231	Mathematical Methods for Chemists	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-323	Bioorganic Chemistry Laboratory	12
38-330	ENGAGE in Wellness: Looking Outward	1
xx-xxx	Arts, Humanities and Social Sciences Course 4	9
		41

Spring		Units
09-302	Undergraduate Seminar IV	1
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-331	Modern Analytical Instrumentation	9
xx-xxx	Cultural/Global Understanding Requirement	9
xx-xxx	Approved Science and Society elective. This course can be scheduled at any point during your studies but prior to your final semester..	6-9
		46-49

Planning Tip:

1. 09-231 Mathematical Methods for Chemists is a co-requisite for 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry and a prerequisite for 09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry.
2. 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry is a prerequisite for 09-322 Laboratory IV: Molecular Spectroscopy and Dynamics .
3. While 09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry and 09-331 Modern Analytical Instrumentation are often taken alongside 09-322 Laboratory IV: Molecular Spectroscopy and Dynamics, they are **not** required co-requisites. Students should consult with an advisor if they plan to shift any of these courses to senior year.
4. Students pursuing careers in the health professions or following the Biological Chemistry Track may wish to take 09-403 Hooked: The Chemical Basis of Drug Addiction in the Fall semester of their Junior year. It will fulfill both a Chemistry elective as well as a Science and Society elective

Students may spread out junior-level courses across the junior and senior years to balance their academic load and research commitments. Work closely with your academic advisor to map out a schedule that fits your goals

Senior Year

Fall		Units
09-401	Undergraduate Seminar V	1
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
or 09-718	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	
or 09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
or 09-719	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
09-xxx	Biological Chemistry Elective (see notes on electives)	9
38-110	ENGAGE in Service	1
38-220	ENGAGE in the Arts	2
38-430	ENGAGE in Wellness: Looking Forward	1
xx-xxx	Free Electives	21
		44

Spring		Units
09-402	Undergraduate Seminar VI	3
09-348	Inorganic Chemistry	10
09-xxx	Biological Chemistry Elective (see notes on electives)	18
xx-xxx	Free Electives	18
		49

Planning Tip: The senior year is designed to provide maximum flexibility. Use this time to deepen your training through electives, conduct independent research, or prepare for graduate school, professional programs, or job applications. Be mindful of not overloading your final semester and aim to complete general education requirements, including all ENGAGE courses, before your last term.

Unit Summary and Graduation Requirements for the B.S. in Chemistry/Biological Chemistry Track

Chemistry Requirements

A minimum of 187 units must come from chemistry-specific courses:

Required Chemistry Courses*	Units	Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-219	Modern Organic Chemistry	10
09-220	Modern Organic Chemistry II	10

03-231	Honors Biochemistry	9
or 03-232	Biochemistry I	
09-231	Mathematical Methods for Chemists	9
09-331	Modern Analytical Instrumentation	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-348	Inorganic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-323	Bioorganic Chemistry Laboratory	12
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
or 09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
09-xxx	Chemistry Seminars	8
09-xxx	Biological Chemistry Electives	27
		187

Note: These courses, along with 33-121 Physics I for Science Students and33-122 Physics II for Biological Sciences & Chemistry Students , are also required for students pursuing an additional major in chemistry.

Biological Chemistry Electives (minimum 27 units required)

A list of currently approved biological chemistry electives is provided below. Students must complete at least three courses totaling 27 units or more. Of these, **at least two must be chemistry courses**; a maximum of one course may be taken in biology or physics. Exceptions must be approved by the Director of Undergraduate Studies.

With prior approval, **one semester of 09-445 Undergraduate Research** may be used to fulfill one biological chemistry elective, provided it is part of a sustained research experience that demonstrates depth of engagement in the area.

		Units
09-403	Hooked: The Chemical Basis of Drug Addiction	9
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
or 09-718	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	
or 09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
or 09-719	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
09-521	Metals in Biology: Function and Reactivity	6
09-522	Kinetics and Mechanisms of Chemical and Enzymatic Reactions	9
09-530	Chemistry of Gene Expression	9
or 09-730	Chemistry of Gene Expression	
09-538	Exposure and Risk Assessment for Environmental Pollutants	9
or 09-738	Exposure and Risk Assessment for Environmental Pollutants	
09-737	Medicinal Chemistry and Drug Development	12
03-220	Genetics	9
03-221	Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	9
03-230	Intro to Mammalian Physiology	9
03-344	Experimental Biochemistry	12
03-362	Cellular Neuroscience	9
03-366	Neuropharmacology: Drugs, Brain and Behavior	9
03-390	Molecular and Cellular Immunology	9
03-391	Microbiology	9
03-435	Cancer Biology	9
03-439	Introduction to Biophysics	10
03-442	Molecular Biology	9
03-729	Entrepreneurship and protein-based drug development	6
03-740	Advanced Biochemistry	12
03-871	Structural Biophysics	12
33-441	Introduction to Biophysics	10

- Chemistry courses required for the B.S. (numbered 09-2xx or higher) must be taken at Carnegie Mellon. Exceptions are granted only under unusual or extenuating circumstances, with prior approval from the Director of Undergraduate Studies.

To plan your electives effectively, consult with your academic advisor and check semester availability with the chemistry department.

Other Required Courses and Electives

Other Requirements	Units
Biology (Modern Biology or Biochemistry)	**9**
Computer Science	**10**
Mathematics	**20**
Physics	**21**
Interpretation and Argument	**9**
Arts, Humanities and Social Sciences Courses	**36**
Cultural/Global Understanding	**9**
EUREKA! (First-year seminar)	**6**
Science and Society requirement	**6**
ENGAGE in Service	**1**
ENGAGE in Wellness Courses (three courses)	**3**
ENGAGE in the Arts	**2**
Core@CMU	**3**
Free Electives	**38**
Minimum number of units required for the degree:	**360**

Free Electives

Free electives include any Carnegie Mellon course, except those in science or engineering that are specifically intended for non-majors.

A maximum of 9 units total from the following categories may count toward the free elective requirement:

- Physical Education (P.E.)
- StuCo (Student College)
- ROTC

Students are encouraged to use free electives to pursue minors, deepen technical training, explore other disciplines, or prepare for future academic and career goals.

There is no separate "technical elective" requirement in the B.S. in Chemistry curriculum. However, students may choose to take advanced technical courses in chemistry or related fields as part of their free electives.

Additional Notes on Degree Requirements

Minimum Total Units

The B.S. in Chemistry degree requires a minimum of 360 units. Most students complete this requirement within 41–50 units per semester. Students are strongly encouraged to take additional electives in subjects of personal or professional interest to enrich their undergraduate experience.

AP Credit and Unit Overlap

Some students may need to complete more than 360 units to graduate, especially if they repeat coursework for which they received AP credit. For example, a student who received AP credit for but takes 09-105 or 09-107 at CMU will only receive 10 units toward the requirement — not 20. The duplicate units will not count toward the degree total.

Transfer Students and Course Substitutions

Students who transfer into the department and have taken 09-217 Organic Chemistry I and/or 09-218 Organic Chemistry II must complete 09-435 Independent Study Chemistry (1 unit per course) under the supervision of the 09-219 Modern Organic Chemistry and/or 09-220 Modern Organic Chemistry II instructor(s) to cover missing content.

Students who have taken 09-207 Techniques in Quantitative Analysis and/or 09-208 Techniques for Organic Synthesis and Analysis must enroll in a 3-unit transition course:

- 09-215 Chemistry Tech I to Lab I Transition (for 09-207 Techniques in Quantitative Analysis)
- 09-216 Chemistry Tech II to Lab II Transition (for 09-208 Techniques for Organic Synthesis and Analysis)

B.A. in Chemistry

The Bachelor of Arts (B.A.) in Chemistry offers a strong foundation in chemical principles while allowing for greater curricular flexibility. Compared to the B.S. degree, several chemistry, math, and other technical course requirements are replaced by free electives. This structure makes the B.A. an excellent choice for students interested in double majoring, particularly with departments in the College of Humanities and Social Sciences, College of Fine Arts, or the Tepper School of Business, though a second major is not required.

The B.A. is also well-suited for students pursuing careers in dentistry, pharmacy, or other fields that benefit from broader undergraduate preparation and more coursework outside of chemistry. Students may pursue one or more of the optional tracks available to B.S. degree candidates, provided they complete the necessary coursework.

Curriculum Planning and Course Scheduling

The curriculum and sample schedule presented here are intended for students who matriculate in Fall 2025. Students who entered in prior years should consult their degree audit and speak with the Director of Undergraduate Studies to confirm the requirements that apply to them.

The B.A. in Chemistry curriculum provides flexibility in designing personalized academic pathways, especially for students exploring minors, additional majors, or study abroad. While it is recommended to complete core technical courses early, students may choose to delay certain requirements to meet broader academic goals.

When planning your schedule, note that several key chemistry courses are offered only once per year. For example:

Fall-only courses:

- 09-219 Modern Organic Chemistry
- 09-321 Laboratory III: Molecular Design and Synthesis
- 09-323 Bioorganic Chemistry Laboratory

Spring-only courses:

- 09-220 Modern Organic Chemistry II
- 09-331 Modern Analytical Instrumentation
- 09-348 Inorganic Chemistry

Course Scheduling Note: Occasionally, a course that is typically offered in the fall may be shifted to the spring (or vice versa) due to departmental curriculum changes or faculty availability. Students are encouraged to consult the department and their advisor each semester to confirm course timing and build a long-term plan that anticipates such changes and accommodates personal goals such as study abroad, research, or double majoring.

Technical and Non-Technical Requirements

MCS Core Technical Requirements

To fulfill the MCS technical breadth requirement, chemistry majors must complete a minimum of four non-chemistry technical courses. Approved options include:

Technical Breadth Requirements		Units
33-121	Physics I for Science Students	12
33-122	Physics II for Biological Sciences & Chemistry Students	9
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
or 02-120	Undergraduate Programming for Scientists	
21-120	Differential and Integral Calculus	10
03-121	Modern Biology	9
or 03-231	Honors Biochemistry	
or 03-232	Biochemistry I	
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
		60

Students are encouraged to complete these technical core requirements by the end of their fifth semester. AP credit may not be used to fulfill the core technical breadth requirements, though it can satisfy prerequisites for chemistry courses. If a student fulfills an entire category (e.g., physics or biology) solely through AP credit, they must take an approved upper-level course in that area to meet the core requirement.

Non-Technical General Education Requirements

All students in the Mellon College of Science (MCS) must complete a set of non-technical breadth requirements totaling a minimum of 75 units. These include communication, humanities and social sciences, global and cultural perspectives, and wellness:

Required Courses:

- 76-101 Interpretation and Argument (9 units)
- Arts, Humanities, and Social Sciences: Four courses totaling a minimum of 36 units
- Cultural/Global Understanding: One approved course (minimum 9 units)
- Science and Society: One approved course (minimum 6 units)
- Engage Sequence (5 total):
  - ENGAGE in Wellness
    - 38-230 ENGAGE in Wellness: Looking Inward (1 unit)
    - 38-330 ENGAGE in Wellness: Looking Outward (1 unit)
    - 38-430 ENGAGE in Wellness: Looking Forward (1 unit)
  - 38-110 ENGAGE in Service (1 unit)
  - 38-220 ENGAGE in the Arts (2 units)
- First-Year Seminars
  - 38-101 EUREKA!: Discovery and Its Impact (6 units)
  - 99-101 Core@CMU (3 units)

Important Notes:

- The Science and Society and ENGAGE requirements must be completed no later than the penultimate semester.
- Students may not double count courses across general education categories. For example, a course used to fulfill the Science and Society requirement may not also count toward the Cultural/Global Understanding category or the 36 units required in Arts, Humanities, and Social Sciences.

Overlap with Chemistry Electives:

Some chemistry courses approved for general education requirements may also count as chemistry electives. For example:

- Science and Society + Chemistry Elective:
  - 09-510 Chemistry and Sustainability (or graduate version, 09-710 Chemistry and Sustainability)
  - 09-381 Environmental Systems on a Changing Planet
  - 09-403 Hooked: The Chemical Basis of Drug Addiction

(Only one of these may count toward the 18 units of chemistry electives.)

- Cultural/Global Understanding + Chemistry Elective:
  - 09-227 The Culture of Color: Dyes, Chemistry, and Sustainability

A current list of approved courses in these categories is maintained by the MCS Dean's Office:

https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/index.html (https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/)

Sample Schedule by Year (First–Senior)

These schedules represent one possible path through the B.A. in Chemistry. Students should work closely with their academic advisor to develop an individualized plan that supports their goals, including study abroad, second majors, or research opportunities.

First Year

Fall		Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
21-120	Differential and Integral Calculus	10
33-121	Physics I for Science Students	12
76-101	Interpretation and Argument	9
38-101	EUREKA!: Discovery and Its Impact	6
99-101	Core@CMU	3
		50

Planning Tip: Students interested in majoring in chemistry who have a strong chemistry background should enroll in 09-107 Honors Chemistry: Fundamentals, Concepts and Applications rather than 09-105 Introduction to Modern Chemistry I. Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II via a prerequisite waiver.

There are some elective laboratory courses offered for MCS students in the first year including 03-117 Frontiers, Analysis, and Discovery in Biological Sciences , 09-115 Introduction to Undergraduate Research in Chemistry or 09-101 Introduction to Experimental Chemistry . The maximum units allowed during the first semester is 54; therefore, students wishing to take a lab should take an alternate technical course to Physics I such as 15-110 Principles of Computing or 03-121 Modern Biology so that their unit total is lower.

Spring		Units
09-106	Modern Chemistry II	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
33-121	Physics I for Science Students	12
or 03-121	Modern Biology	
or 15-110	Principles of Computing	
or 15-112	Fundamentals of Programming and Computer Science	
or 02-120	Undergraduate Programming for Scientists	
xx-xxx	Arts, Humanities and Social Sciences Course 1	9
xx-xxx	Free Elective	9
		50

Planning Tip: Chemistry majors who place out of 09-106 Modern Chemistry II can take 09-348 Inorganic Chemistry , 09-510 Chemistry and Sustainability or 09-381 Environmental Systems on a Changing Planet as a chemistry elective. 09-381 Environmental Systems on a Changing Planet is especially recommended for students pursuing the Environmental and Sustainability Studies minor. 09-510 Chemistry and Sustainability will serve as both a Chemistry elective as well as a MCS Science and Society requirement. Please note that 09-291 Environmental Systems on a Changing Planet does not count toward chemistry electives.

Sophomore Year

Fall		Units
09-201	Undergraduate Seminar I	1
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
33-122	Physics II for Biological Sciences & Chemistry Students Course is a prerequisite for 09-331, normally taken in the spring of the junior year	9
xx-xxx	Arts, Humanities and Social Sciences Course 2	9
		41

Spring		Units
09-202	Undergraduate Seminar II: Safety and Environmental Issues for Chemists	1
09-220	Modern Organic Chemistry II	10
09-222	Laboratory II: Organic Synthesis and Analysis	12
38-230	ENGAGE in Wellness: Looking Inward	1
xx-xxx	Arts, Humanities and Social Sciences Course 3	9
xx-xxx	Free Elective	9
		42

Planning Tip: Students pursuing careers in the health professions may wish to take 03-232 Biochemistry I in the Spring semester .

Junior Year

Fall		Units
09-301	Undergraduate Seminar III	1
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	
38-330	ENGAGE in Wellness: Looking Outward	1
xx-xxx	Free Elective	9
xx-xxx	Arts, Humanities and Social Sciences Course 4	9
03-121	Modern Biology	9
or 15-110	Principles of Computing	
or 15-112	Fundamentals of Programming and Computer Science	
or 02-120	Undergraduate Programming for Scientists	
		41

Spring		Units
09-302	Undergraduate Seminar IV	1
09-331	Modern Analytical Instrumentation	9
09-348	Inorganic Chemistry	10
xx-xxx	Cultural/Global Understanding Requirement	9
xx-xxx	Approved Science and Society elective. This course can be scheduled at any point during your studies but prior to your final semester..	6-9
xx-xxx	Free Elective	9
		44-47

Planning Tip:

Students pursuing careers in the health professions may wish to take 09-403 Hooked: The Chemical Basis of Drug Addiction in the Fall semester of their Junior year. It will fulfill both a Chemistry elective as well as a Science and Society elective.

Students may spread out junior-level courses across the junior and senior years to balance their academic load and research commitments. Work closely with your academic advisor to map out a schedule that fits your goals

Senior Year

Fall		Units
09-401	Undergraduate Seminar V	1
09-xxx	Chemistry Elective (see notes on electives)	9
38-110	ENGAGE in Service	1
38-220	ENGAGE in the Arts	2
38-430	ENGAGE in Wellness: Looking Forward	1
xx-xxx	Free Electives	30
		44

Spring		Units
09-402	Undergraduate Seminar VI	3
09-xxx	Chemistry Elective (see notes on electives)	9
xx-xxx	Free Electives	38
		50

Planning Tip: The senior year is designed to provide maximum flexibility. Use this time to deepen your training through electives, conduct independent research, or prepare for graduate school, professional programs, or job applications. Be mindful of not overloading your final semester and aim to complete general education requirements, including all ENGAGE courses, before your last term.

Unit Summary and Graduation Requirements for the B.A. in Chemistry

Chemistry Requirements

A minimum of 121 units must come from chemistry-specific courses:

Required Chemistry Courses*		Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-219	Modern Organic Chemistry	10
09-220	Modern Organic Chemistry II	10
09-331	Modern Analytical Instrumentation	9
09-348	Inorganic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	
09-xxx	Chemistry Seminars	8
09-xxx	Chemistry Electives	18
		121

Lab Substitution Option
09-322 Laboratory IV: Molecular Spectroscopy and Dynamics may be taken in place of 09-321 Laboratory III: Molecular Design and Synthesis or 09-323 Bioorganic Chemistry Laboratory. However, students must complete the

necessary prerequisites and corequisites: 09-231 Mathematical Methods for Chemists , 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry, and 09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry . In such cases, 09-344 Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry and09-345 Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry **will** count as chemistry electives toward the B.A. degree.

Residency Requirement for Chemistry Courses
All chemistry courses required for the B.A. that are numbered 09-2xx or higher must be taken at Carnegie Mellon University. Exceptions must be requested in advance and approved by the Director of Undergraduate Studies. Approval is typically granted only under unusual or extenuating circumstances.

Chemistry Electives (minimum 18 units required)

Chemistry electives are intended to enhance a student's technical knowledge in chemistry. These may include:

- 09-445 Undergraduate Research
- Most 09-3xx or higher chemistry courses (undergraduate or graduate)
- 03-231 Honors Biochemistry or 03-232 Biochemistry I

09-435 Independent Study Chemistry may only be used with permission of the Director of Undergraduate Studies.

Some interdisciplinary courses (e.g., 39-xxx) may count toward chemistry electives only if they have significant chemical content and are approved in advance by the Director of Undergraduate Studies.

In some cases, chemistry electives may also satisfy general education requirements such as Science and Society or Cultural/Global Understanding, but students should consult with an advisor to confirm eligibility and avoid double-counting within the same category.

Students should check with the chemistry department and the course-offering department each semester to confirm which courses are available and approved for elective credit.

Quick Guide: Choosing Chemistry Electives by Interest Area

Chemistry electives give you the flexibility to explore topics that align with your interests, deepen your technical training, or prepare you for specific career paths. Below are some common focus areas and electives that support them.

Interest Area	Suggested Chemistry Electives
Sustainability and Environmental Chemistry	**09-510 Chemistry and Sustainability, 09-381 Environmental Systems on a Changing Planet, 09-529 Introduction to Sustainable Energy and Science**
Biological and Health Applications	**03-231 Biochemistry I or 03-232 Biochemistry I, 09-403 Hooked: The Chemical Basis of Drug Addiction, 09-737 Medicinal Chemistry and Drug development**
Computational Chemistry and Modeling	**09-563 Molecular Modeling and Computational Chemistry, 09-615 Computational Modeling. Statistical Analysis and Machine Learning in Science, 09-616 Neural Networks & Deep Learning in Science**
Materials and Nanoscience	**09-509 Physical Chemistry of Macromolecules, 09-507 Nanoparticles, 09-760 The Molecular Basis of Polymer Mechanics**

Chemistry courses required for the B.S. (numbered 09-2xx or higher) must be taken at Carnegie Mellon. Exceptions are granted only under unusual or extenuating circumstances, with prior approval from the Director of Undergraduate Studies.

To plan your electives effectively, consult with your academic advisor and check semester availability with the chemistry department.

Other Required Courses and Electives

Other Requirements	Units
Biology (Modern Biology or Biochemistry)	**9**
Computer Science	**10**
Mathematics	**20**
Physics	**21**
Interpretation and Argument	**9**
Arts, Humanities and Social Sciences Courses	**36**
Cultural/Global Understanding	**9**
EUREKA! (First-year seminar)	**6**
Science and Society requirement	**6**
ENGAGE in Service	**1**
ENGAGE in Wellness Courses (three courses)	**3**
ENGAGE in the Arts	**2**
Core@CMU	**3**
Free Electives	**104**
Minimum number of units required for the degree:	**360**

Free Electives

Free electives include any Carnegie Mellon course, except those in science or engineering that are specifically intended for non-majors.

A maximum of 9 units total from the following categories may count toward the free elective requirement:

- Physical Education (P.E.)
- StuCo (Student College)
- ROTC

Students are encouraged to use free electives to pursue minors, deepen technical training, explore other disciplines, or prepare for future academic and career goals.

Additional Notes on Degree Requirements

Minimum Total Units

The B.A. curriculum typically requires students to take between 40 and 50 units per semester to meet the 360-unit graduation minimum. In practice, many students exceed this minimum as they explore electives in other disciplines or pursue additional majors. Students are strongly encouraged to take extra elective courses in whatever subjects they wish, to enrich their background and enhance their educational experience.

AP Credit and Unit Overlap

Some students may need to complete more than 360 units to graduate, especially if they repeat coursework for which they received AP credit. For example, a student who received AP credit for but takes 09-105 or 09-107 at CMU will only receive 10 units toward the requirement — not 20. The duplicate units will not count toward the degree total.

Transfer Students and Course Substitutions

Students who transfer into the department and have taken 09-217 Organic Chemistry I and/or 09-218 Organic Chemistry II must complete 09-435 Independent Study Chemistry (1 unit per course) under the supervision of the 09-219 Modern Organic Chemistry and/or 09-220 Modern Organic Chemistry II instructor(s) to cover missing content.

Students who have taken 09-207 Techniques in Quantitative Analysis and/or 09-208 Techniques for Organic Synthesis and Analysis must enroll in a 3-unit transition course:

- 09-215 Chemistry Tech I to Lab I Transition (for 09-207 Techniques in Quantitative Analysis)
- 09-216 Chemistry Tech II to Lab II Transition (for 09-208 Techniques for Organic Synthesis and Analysis)

Options for the Bachelor's Degrees in Chemistry

The Bachelor of Science in Chemistry allows students to take a range of elective courses, particularly in the junior and senior years, in chemistry and other disciplines. Students may choose to focus these electives in a particular area of interest by completing one of several recommended **options**. Each option provides a structured group of electives that complements the B.S. in Chemistry and offers additional depth in a specialized area not covered by the standard curriculum.

Options are **noted on the student's transcript** (but not on the diploma) and are recognized with a certificate awarded by the Department of Chemistry at Commencement.

For each option, students should refer to the Bachelor of Science or Bachelor of Arts degree requirements described earlier in the catalog. The **core chemistry requirements remain unchanged**. However, the option-specific courses should be taken as electives and are listed within each option's description.

Chemistry courses taken as part of an option may also count toward the chemistry elective requirement for the B.S. degree. In some cases, option courses may fulfill MCS technical core requirements or, for example, nontechnical core requirements in the Management Option. However, students should note that there is **very limited ability to count a course toward both an option and a minor or additional major in a closely related field**.

Students are encouraged to **consult with their academic advisor** or the advisor for the relevant department to clarify any potential overlap or restrictions.

BIOCHEMISTRY OPTION		Units
03-231/232	Honors Biochemistry (or Biochemistry)	9
09-518/718	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
or 09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
or 09-719	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	
xx-xxx	2 Electives in Biochemistry	
Elective courses may be chosen from the following list. (Other courses listed as electives for the Biological Chemistry Track may be possible with permission.)		
03-344	Experimental Biochemistry	12
09-445	Undergraduate Research 9 units of 09-445 can count towards this option if part of a longer term immersion in a relevant area and approved by the Director of Underraduate Studies	Var.
09-530	Chemistry of Gene Expression	9
or 09-730	Chemistry of Gene Expression	
09-737	Medicinal Chemistry and Drug Development	12
03-439	Introduction to Biophysics	10
09-519/719	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	9
or 09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	
or 09-718	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	
03-740	Advanced Biochemistry	12

POLYMER SCIENCE OPTION		Units
09-502/741	Organic Chemistry of Polymers	9
09-760	The Molecular Basis of Polymer Mechanics	12
Two Electives in Polymer Science		9
Elective courses may be chosen from the following list		
09-445	Undergraduate Research 9 units of 09-445 can count towards this option if part of a longer term immersion in a relevant area and approved by the Director of Undergraduate Studies	9
09-509/715	Physical Chemistry of Macromolecules	9
09-736	Metal Mediated Chemical Reactions	12
27-477	Introduction to Polymer Science and Engineering	9
Other upper level courses in chemistry, biomedical engineering, materials science engineering or the colloids, polymers and surfaces program may be used with permission of the Director of Undergraduate Studies		

MATERIALS CHEMISTRY OPTION		Units
27-100	Engineering the Materials of the Future	12
27-201	Structure of Materials	9
Two Elective Courses of at least 9 units each from the list below		
27-202	Defects in Materials	9
09-445	Undergraduate Research 9 units of 09-445 can count towards this option if part of a longer term immersion in a relevant area and approved by the Director of Undergraduate Studies	9
09-502/741	Organic Chemistry of Polymers	9
09-507/707	Nanoparticles	9
09-509/715	Physical Chemistry of Macromolecules	9
09-723	Proximal Probe Techniques: New Tools for Nanoscience & Nanotechnology	12
27-xxx	MSE course approved by Director of Undergraduate Studies	

ENVIRONMENTAL CHEMISTRY OPTION		Units
09-510/710	Chemistry and Sustainability	9
or 09-381	Environmental Systems on a Changing Planet	
09-524	Environmental Chemistry	9
or 09-724	Environmental Chemistry	
Two elective courses of at least 9 units each from the list below		
09-445	Undergraduate Research 9 units of 09-445 can count towards this option if part of a longer term immersion in a relevant area and approved by the Director of Undergraduate Studies	Var.
09-225	Climate Change: Chemistry, Physics and Planetary Science	9
09-529/729	Introduction to Sustainable Energy Science	9
09-538/738	Exposure and Risk Assessment for Environmental Pollutants	9
19-440	Combustion and Air Pollution Control	9
12-651	Air Quality Engineering	9
12-657	Water Resource Systems Engineering	9

MANAGEMENT OPTION		Units
70-100	Global Business Global Business is intended for first-year and sophomore students only. Juniors and seniors interested in pursuing the management option must replace the course with a constrained elective as defined for the Minor in Business Administration.	9
73-102	Principles of Microeconomics	9
70-122	Introduction to Accounting	9
Tepper Constrained Elective: As defined in the 2024-25 Undergraduate Catalog these must be one of the following courses: 70-311, 70-371, 70-381, or 70-391		9

COMPUTATIONAL CHEMISTRY OPTION		Units
15-112	Fundamentals of Programming and Computer Science	12
15-122	Principles of Imperative Computation	12
or 15-150	Principles of Functional Programming	
21-127	Concepts of Mathematics	12
09-563/763	Molecular Modeling and Computational Chemistry	9
xx-xxx	One Upper Level Computational Elective Course of at least 9 units from the list below	
09-615	Computational Modeling, Statistical Analysis and Machine Learning in Science	12
09-621	Welcome to the Future Lab - Science in the Cloud Must be taken with 09-623	6
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-213	Introduction to Computer Systems	12
33-241	Introduction to Computational Physics	9
02-250	Introduction to Computational Biology	12

B.S. in Chemistry with Departmental Honors

Students with a strong interest in research are encouraged to consider the Departmental Honors program by the beginning of their junior year. This program integrates a modified B.S. curriculum with sustained faculty mentorship and an independent research project, culminating in a written thesis and formal defense.

Curriculum Requirements

The honors curriculum follows the standard B.S. degree sequence with the following modifications:

- One of the two required chemistry electives must be a 12-unit graduate-level course (numbered 09-7xx or higher)

- At least two free electives, totaling a minimum of 18 units, must be undergraduate research (typically 09-445 Undergraduate Research)
- Students must complete 09-455 Honors Thesis (6 units)

Students are encouraged to pursue more than the minimum research requirement. Summer research support may be available through stipends from a research advisor or competitive programs such as the Summer Undergraduate Research Fellowship (SURF (https://www.cmu.edu/uro/summer%20research%20fellowships/SURF/)).

Eligibility and Application

Students typically apply for candidacy by the end of their penultimate semester. Applications are available through the department Canvas site for chemistry majors or can be e-mail to ug-chem@andrew.cmu.edu. To be accepted, students should have:

- A QPA of at least 3.2 in coursework
- Demonstrated significant progress in undergraduate research
- A statement of support from their research advisor

Thesis Committee

Once accepted, students must assemble a Thesis Committee to guide and evaluate their work. The committee consists of:

- The student's research advisor
- One member of the Undergraduate Program Committee, appointed by the Director of Undergraduate Studies
- A third faculty member, selected by the student and advisor. This person may be from another department or institution and may hold a tenure-track, teaching-track, or research-track appointment

Please note that it is the student's responsibility to confirm participation of the third committee member.

A shared Box folder will be created for each candidate. This folder will house the completed application, written work, and presentation materials. It will be accessible to the student, the Undergraduate Program Committee, and the Thesis Committee.

The Thesis and Defense

The honors thesis must be a clear, formal exposition of the student's independent research. It should reflect at least 18 units of work in 09-445 and make a substantive contribution to the field. This may include:

- The discovery of a new phenomenon
- A novel method or technique
- A study that deepens understanding of an existing topic

The student will present their research in a public oral presentation, followed by a private defense with the Thesis Committee. A complete draft of the thesis must be submitted to committee members at least one week prior to the scheduled defense.

Defenses are typically scheduled for April or early May for May graduates. Alternate timelines apply for August or December graduates. The Undergraduate Academic Program Coordinator will work closely with each student and their committee to schedule the defense and coordinate logistics.

Graduation with Honors

Students who fulfill all requirements, including the research, coursework, thesis, and successful defense, will graduate with both **Departmental Honors** and **MCS College Honors**. These distinctions celebrate the student's initiative, academic strength, and commitment to research. Both honors will be noted on the transcript. However, only **University Honors**, based on overall academic performance, appear on the diploma.

Honors B.S./M.S. Program in Chemistry

Overview

The Honors B.S./M.S. Program in Chemistry offers students the opportunity to earn both a Bachelor of Science in Chemistry with Departmental Honors and a Master of Science in Chemistry, typically within four years. This program is distinctively research-intensive and is best suited for students who have made significant progress on an independent research project early in their undergraduate career. Students admitted to this program are expected to demonstrate initiative, deep engagement with the scientific literature, and the ability to work at a level comparable to a beginning graduate student.

Only students pursuing the B.S. in Chemistry or the B.S. in Chemistry/Biological Chemistry Track are eligible for this program. It is not open to students in the B.A. program. Applications are typically submitted in the second half of the sophomore year but must be received no later than the first semester of the junior year. Later applications are only considered under exceptional circumstances and may require an extension into a fifth year.

Eligibility and Application

To be eligible for admission to the Honors B.S./M.S. program, students must:

- Have a QPA of 3.2 or higher
- Demonstrate significant and sustained progress in undergraduate research
- Have a faculty research advisor in place
- Show evidence that their research has the potential to lead to a master's thesis. This may include a novel method or technique, the discovery of a new phenomenon, or a study that advances understanding in a particular field.

Students apply by submitting the BS/MS Honors Program application form, available on the Chemistry undergraduate Canvas site. This form requires:

- A brief description (1000 words or fewer) of the student's research accomplishments and goals for the thesis
- A projected timeline for completion of the thesis work and writing
- A statement of support from the research advisor

Once submitted, applications are reviewed by a subset of the Undergraduate Program Committee. If the written application is deemed competitive, the student will be invited to deliver an oral presentation. This oral presentation is a key component of the application process. It should be at least 30 minutes long and include:

- A clear explanation of the research question or purpose
- Background literature and scientific context
- Results to date
- A detailed plan and timeline for completion

Presentations must include appropriate visual materials. After the presentation and discussion, the committee will confer privately to evaluate whether the student is prepared to meet the expectations of the program. Students are typically notified of the committee's decision within 48 hours. While most students are accepted after this stage, the committee may, in rare cases, recommend deferral or alternative research pathways (such as the Departmental Honors track) if the project is not yet sufficiently developed.

Thesis Committee

Upon acceptance, the student must form a Thesis Committee to oversee their academic and research progress. This committee will replace the Undergraduate Program Committee for the remainder of the student's degree. The committee must include:

- The student's research advisor
- One member of the Undergraduate Program Committee, appointed by the Director of Undergraduate Studies
- A third faculty member selected jointly by the student and their advisor (this individual may be from another department or institution and may hold a tenure-track, teaching-track, or research-track position)

The student is responsible for securing the participation of the third member and notifying the Director of Undergraduate Studies and Undergraduate Academic Program Coordinator. A shared Box folder will be created for each student to store key documents, including the application materials, written reports, and thesis drafts.

Coursework Requirements

The B.S./M.S. Honors degree requires the completion of **five** graduate-level chemistry courses. These are typically 12-unit courses numbered 09-7xx or 09-8xx. Two 6-unit minis at these levels may also be combined to fulfill one course requirement.

While 09-6xx courses are sometimes offered at the graduate level, some (such as 09-611 Chemical Thermodynamics) are considered remedial and do not count toward the B.S./M.S. requirement, due to significant overlap with undergraduate content. Others, such as those associated with the M.S. in Science or Engineering and Public Policy or the Future Lab initiative, may

be accepted with approval from the Director of Undergraduate Studies. Examples include:

- 09-615 Computational Modeling, Statistical Analysis and Machine Learning in Science
- 09-616 Neural Networks & Deep Learning in Science

To support interdisciplinary study, up to three of the five required graduate courses may be fulfilled using advanced undergraduate chemistry electives (09-5xx). These courses must be 9 units each and approved by the Director of Undergraduate Studies. While 09-5xx courses can be appropriate in some contexts, the 09-7xx versions are generally preferred, as they include additional assignments or projects that build skills important for graduate-level work.

Students must:

- Earn a **grade of C or better** in each of the five qualifying courses and in 09-455 Honors Thesis.
- Maintain a minimum QPA of 3.2 overall and 3.0 average across the five graduate (or approved 09-5xx) courses, 09-445 Undergraduate Research and 09-455 Honors Thesis.

Research and Progress Expectations

Students in the B.S./M.S. program are expected to maintain a level of rigor, independence, and productivity that exceeds the Departmental Honors requirements. This includes:

- A minimum of 30 units of 09-445 Undergraduate Research (most students exceed this requirement)
- Active participation in research group meetings and departmental seminars
- Summer research after the sophomore and junior years (10 weeks each summer is strongly encouraged). Students are typically supported by their research group or through competitive programs such as the Summer Undergraduate Research Fellowship (SURF) (https://www.cmu.edu/uro/summer%20research%20fellowships/SURF/)
- Presentation of research at Meeting of the Minds, typically during the junior year

In addition, students are expected to meet with their Thesis Committee regularly, at least once every three months and at the start of their final semester. One week before each meeting, students must submit the following materials:

- A 3–5 page written summary of research progress
- A one-page outline of remaining work
- Presentation slides for discussion

These meetings serve as formal checkpoints to assess progress, identify challenges, and support the student in achieving timely completion of the thesis.

Thesis and Defense

Students in the B.S./M.S. program must complete a formal thesis based on original research that meets the standards of a Master of Science degree in chemistry. The thesis should demonstrate independence, technical rigor, and depth of understanding in a specific field. While publication is not required, the research should be of a quality and scope that could reasonably lead to publication in a peer-reviewed scientific journal.

To support timely and successful completion, students are expected to follow the timeline below:

Late Junior Year and Summer (prior to final year):

- Students should have completed a substantial portion of their research by the end of the junior year.
- A thorough literature review should be conducted over the summer in preparation for the thesis introduction.
- Preliminary organization of thesis chapters (e.g., outlining sections, figures, tables) is encouraged.

Semester Before Final Semester:

- Continue research and begin assembling thesis materials, including figures, data, and chapter outlines, in preparation for formal writing.
- Draft a full literature review and begin writing the thesis introduction.
- A progress meeting must be scheduled with the Thesis Committee during the first two weeks of the final semester. This meeting is used to assess whether the project is on track for a Master's-level thesis. If the committee determines that sufficient progress has not been made, students may either extend their timeline for completion, or transition to the Departmental Honors track, provided those requirements are met.

Start of Final Semester:

- Submit a draft of the thesis introduction and a detailed outline of the methods, results, and discussion sections to the Thesis Committee and Undergraduate Program Coordinator.
- Use committee feedback to guide final writing and remaining experimental work.

Two Months Before Intended Defense Date:

- Submit a full draft or substantial sections of the thesis to the research advisor for feedback. This should allow time for revision before sharing with the full committee.

At Least One Week Before Defense:

- Submit the advisor-approved final version of the thesis to all committee members. Missing this deadline will result in the defense being rescheduled.

Defense:

- Deliver a public oral presentation (30–40 minutes), followed by audience Q&A.
- Participate in a private defense with the Thesis Committee immediately after the presentation.

The thesis should follow a formal scientific structure (abstract, introduction, methods, results, discussion, conclusion) and adhere to ACS Style Guide formatting. While publication is not a graduation requirement, the work must reflect sustained effort, critical thinking, and mastery of the research topic.

Note: While defenses are commonly scheduled in April for May graduates, alternate timelines apply for August or December graduation. The Undergraduate Academic Program Coordinator will work with each student and their committee to ensure timely scheduling and degree certification.

Graduation with Honors

Students who successfully complete all academic, research, and thesis requirements for the program will receive two degrees:

1. A Bachelor of Science in Chemistry with Departmental Honors
2. A Master of Science in Chemistry

Both degrees are awarded at the same time, and students will receive a separate diploma for each. Departmental Honors and MCS College Honors will be noted on the official transcript but do not appear on the diploma. Only University Honors, which are based on overall academic performance, are printed on the diploma.

Failure to maintain satisfactory progress in research or coursework, or violations of professional or academic standards, may result in removal from the M.S. portion of the program. In such cases, students may still complete the B.S. or Departmental Honors degree, provided they meet the respective requirements.

Curriculum Planning for the Honors B.S./M.S. in Chemistry

The curriculum and sample schedule presented here are intended for students who matriculate in Fall 2025. Students who entered in prior years should consult their degree audit and speak with the Director of Undergraduate Studies to confirm the requirements that apply to them.

Technical and Non-Technical Requirements

MCS Core Technical Requirements

Chemistry majors must complete a minimum of four technical courses outside of chemistry to satisfy the MCS core technical breadth requirement. These include courses in physics, biology, computer science, and mathematics:

Technical Breadth Requirements		Units
33-121	Physics I for Science Students	12
33-122	Physics II for Biological Sciences & Chemistry Students	9
03-121	Modern Biology	9
or 03-231	Honors Biochemistry	
or 03-232	Biochemistry I	
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
or 02-120	Undergraduate Programming for Scientists	
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
		60

Students are encouraged to complete these technical core requirements by the end of their fifth semester. AP credit may not be used to fulfill the core technical breadth requirements, though it can satisfy prerequisites for chemistry courses. If a student fulfills an entire category (e.g., physics or biology) solely through AP credit, they must take an approved upper-level course in that area to meet the core requirement.

Non-Technical General Education Requirements

All students in the Mellon College of Science (MCS) must complete a set of non-technical breadth requirements totaling a minimum of 75 units. These include communication, humanities and social sciences, global and cultural perspectives, and wellness:

Required Courses:

- 76-101 Interpretation and Argument (9 units)
- Arts, Humanities, and Social Sciences: Four courses totaling a minimum of 36 units
- Cultural/Global Understanding: One approved course (minimum 9 units)
- Science and Society: One approved course (minimum 6 units)
- Engage Sequence (5 total):
  - ENGAGE in Wellness
    - 38-230 ENGAGE in Wellness: Looking Inward (1 unit)
    - 38-330 ENGAGE in Wellness: Looking Outward (1 unit)
    - 38-430 ENGAGE in Wellness: Looking Forward (1 unit)
  - 38-110 ENGAGE in Service (1 unit)
  - 38-220 ENGAGE in the Arts (2 units)
- First-Year Seminars
  - 38-101 EUREKA!: Discovery and Its Impact (6 units)
  - 99-101 Core@CMU (3 units)

Important Notes:

- The Science and Society and ENGAGE requirements must be completed no later than the penultimate semester.
- Students may not double count courses across general education categories. For example, a course used to fulfill the Science and Society requirement may not also count toward the Cultural/Global Understanding category or the 36 units required in Arts, Humanities, and Social Sciences.

Overlap with Chemistry Courses:

Some chemistry courses approved for general education requirements. For example:

- Science and Society :
  - 09-510 Chemistry and Sustainability (or graduate version,09-710 Chemistry and Sustainability)
  - 09-381 Environmental Systems on a Changing Planet
  - 09-403 Hooked: The Chemical Basis of Drug Addiction

(Of this list, 09-710 Chemistry and Sustainability can count both towards the MCS Science and Society requirements and the graduate course requirement for the B.S./M.S. program)

- Cultural/Global Understanding + Chemistry Elective:
  - 09-227 The Culture of Color: Dyes, Chemistry, and Sustainability

A current list of approved courses in these categories is maintained by the MCS Dean's Office:

https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/index.html (https://www.cmu.edu/mcs/undergrad/advising/hss-finearts/)

Sample Schedule by Year (First–Senior)

The suggested schedule below is designed for students pursuing the B.S./M.S. program. Students should consult with the Director of Undergraduate Studies and their research advisor to customize their timeline based on research progress, course availability, and personal goals.

First Year

Fall		Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-115	Introduction to Undergraduate Research in Chemistry	2
21-120	Differential and Integral Calculus	10
33-121	Physics I for Science Students	12
76-101	Interpretation and Argument	9
38-101	EUREKA!: Discovery and Its Impact	6
99-101	Core@CMU	3
		52

Planning Tip: Students interested in majoring in chemistry who have a strong chemistry background should enroll in 09-107 Honors Chemistry: Fundamentals, Concepts and Applications rather than 09-105 Introduction to Modern Chemistry I. Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II via a prerequisite waiver.

There are some elective laboratory courses offered for MCS students in the first year including 03-117 Frontiers, Analysis, and Discovery in Biological Sciences or 09-101 Introduction to Experimental Chemistry and 09-115 Introduction to Undergraduate Research in Chemistry. While not required for the major, we strongly encourage students who are interested in early research engagement to register for 09-115 Introduction to Undergraduate Research in Chemistry. This course introduces students to research within the department and includes laboratory safety and hazardous waste training, which are often necessary for working in scientific labs at CMU. It is included in the sample schedule above to highlight this opportunity.

The maximum units allowed during the first semester is 54; therefore, students wishing to take a lab should take an alternate technical course to Physics I such as 15-110 Principles of Computing or 03-121 Modern Biology so that their unit total is lower.

Spring		Units
09-106	Modern Chemistry II	10
09-116	Undergraduate Research Shadowing in Chemistry	2
or 09-101	Introduction to Experimental Chemistry	
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
33-121	Physics I for Science Students	12
or 03-121	Modern Biology	
or 15-110	Principles of Computing	
xx-xxx	Arts, Humanities and Social Sciences Course 1	9
xx-xxx	Free Elective	9.0
		52

Planning Tip: Chemistry majors who place out of 09-106 Modern Chemistry II can take 09-348 Inorganic Chemistry , 09-510 Chemistry and Sustainability or 09-381 Environmental Systems on a Changing Planet as a chemistry elective. 09-381 Environmental Systems on a Changing Planet is especially recommended for students pursuing the Environmental and Sustainability Studies minor. 09-510 Chemistry and Sustainability will serve as both a Chemistry elective as well as a MCS Science and Society requirement. Please note that 09-291 Environmental Systems on a Changing Planet does not count toward chemistry electives.

The sample schedule above also includes laboratory electives. Students wishing to actively engage in research should take 09-116 Undergraduate Research Shadowing in Chemistry, which pairs them with a research group in the department for half a semester. With a faculty mentor's recommendation, students may continue in the same lab through 09-445 Undergraduate Research. Those who want focused hands-on experience in a chemistry lab environment may consider 09-101 Introduction to Experimental Chemistry. Students interested in biology-based lab work may also take 03-117 Frontiers, Analysis, and Discovery in Biological Sciences.

Sophomore year

Fall		Units
09-219	Modern Organic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-201	Undergraduate Seminar I	1
33-122	Physics II for Biological Sciences & Chemistry Students	9
09-445	Undergraduate Research	9
xx-xxx	Arts, Humanities and Social Science Course I	9
		50

Spring		Units
09-220	Modern Organic Chemistry II	10
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-202	Undergraduate Seminar II: Safety and Environmental Issues for Chemists	1
09-348	Inorganic Chemistry	10
38-230	ENGAGE in Wellness: Looking Inward	1
xx-xxx	Arts, Humanities and Social Science Course I	9
		43

Summer		
		10 weeks of full-time research is strongly encouraged. Students may apply for funding through their research advisor or SURF.

Junior year

Fall		Units
09-301	Undergraduate Seminar III	1
09-231	Mathematical Methods for Chemists	9
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-445	Undergraduate Research	9
38-330	ENGAGE in Wellness: Looking Outward	1
xx-xxx	Arts, Humanities and Social Science Course I	9
		50

Spring		Units
09-302	Undergraduate Seminar IV	1
09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-445	Undergraduate Research	6
09-xxx	Graduate Chemistry Course 1	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-331	Modern Analytical Instrumentation	9
xx-xxx	Arts, Humanities and Social Science Course I	6-9
		52-55

Summer		
		10 weeks of full-time research is strongly encouraged to ensure adequate progress toward the M.S. thesis.

Planning Tips:

The junior year is often when chemistry majors encounter some of the most conceptually rich and mathematically engaging material in the curriculum, including physical chemistry and advanced laboratory techniques. For many students, this is also when research becomes a central focus.

To make the most of this experience, consider how your schedule can support both depth and balance. The senior year includes a number of free electives and flexible space, which can be used to redistribute coursework across semesters. Spreading out junior year requirements over four semesters, instead of concentrating them in just two, is a great way to maintain momentum and quality in both academics and research.

Students should consult with their advisor to discuss an individualized plan to meet their academic goals.

Senior year

Fall		Units
09-401	Undergraduate Seminar V	1
09-445	Undergraduate Research	9
38-430	ENGAGE in Wellness: Looking Forward	1
38-110	ENGAGE in Service	1
99-xxx	Graduate Chemistry Course 2	12
99-xxx	Graduate Chemistry Course 3	12
xx-xxx	Cultural/Global Understanding	9
		45

Spring		Units
09-402	Undergraduate Seminar VI	3
09-455	Honors Thesis	15
38-220	ENGAGE in the Arts	2
09-xxx	Graduate Chemistry Course 4	9
09-xxx	Graduate Chemistry Course 5	9
xx-xxx	Free Elective	9
		47

Note for Students in the B.S. in Chemistry/Biological Chemistry Track

Students pursuing the B.S./M.S. program through the Biological Chemistry Track should follow the same curriculum structure shown above. However, they must ensure that the following core courses are included in their schedule:

- 03-232 Biochemistry I
- 09-323 Bioorganic Chemistry Laboratory
- 09-518 Bioorganic Chemistry: Nucleic Acids and Carbohydrates or 09-519 Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry.

In place of the chemistry electives normally required in the B.S., students should register for graduate-level chemistry courses that satisfy both the Biological Chemistry Track and the M.S. requirements. Approved substitutions include:

- 09-718 Bioorganic Chemistry: Nucleic Acids and Carbohydrates in place of 09-518 Bioorganic Chemistry: Nucleic Acids and Carbohydrates
- 09-719 Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry in place of 09-519 Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry
- 09-730 Chemistry of Gene Expression in place of 09-530 Chemistry of Gene Expression
- 09-738 Exposure and Risk Assessment for Environmental Pollutants in place of 09-538 Exposure and Risk Assessment for Environmental Pollutants

These substitutions help students meet the **graduate course requirement** for the M.S. degree without disrupting the overall B.S. Chemistry/Biological Chemistry Track structure. Research and thesis expectations in the senior year are the same for both the standard Chemistry and the Biological Chemistry Track.

Unit Summary and Graduation Requirements for the B.S./M.S. in Chemistry program

Chemistry Requirements

A minimum of 238 units must come from chemistry-specific courses:

Required Chemistry Courses*	Units	Units
09-105	Introduction to Modern Chemistry I	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-219	Modern Organic Chemistry	10
09-220	Modern Organic Chemistry II	10
09-231	Mathematical Methods for Chemists	9
09-331	Modern Analytical Instrumentation	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-348	Inorganic Chemistry	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
09-222	Laboratory II: Organic Synthesis and Analysis	12
09-321	Laboratory III: Molecular Design and Synthesis	12
or 09-323	Bioorganic Chemistry Laboratory	

09-322	Laboratory IV: Molecular Spectroscopy and Dynamics	12
09-xxx	Chemistry Seminars	8
09-445	Undergraduate Research	30
09-xxx	Graduate Chemistry Courses	51-60
09-455	Honors Thesis	15
		238-247

Residency Requirement for Chemistry Courses

All chemistry courses required for the B.S./M.S. degree that are numbered 09-2xx or higher must be taken at Carnegie Mellon University. Exceptions must be requested in advance and approved by the Director of Undergraduate Studies. Approval is typically granted only under unusual or extenuating circumstances.

To plan your electives effectively, consult with your academic advisor and check semester availability with the chemistry department.

Other Required Courses and Electives

Other Requirements	Units
Biology (Modern Biology or Biochemistry)	**9**
Computer Science	**10**
Mathematics	**20**
Physics	**21**
Interpretation and Argument	**9**
Arts, Humanities and Social Sciences Courses	**36**
Cultural/Global Understanding	**9**
EUREKA! (First-year seminar)	**6**
Science and Society requirement	**6**
ENGAGE in Service	**1**
ENGAGE in Wellness Courses (three courses)	**3**
ENGAGE in the Arts	**2**
Core@CMU	**3**
Free Electives	**6-15**
Minimum number of units required for the degree:	**388**

Free Electives

Free electives include any Carnegie Mellon course, except those in science or engineering that are specifically intended for non-majors.

A maximum of 9 units total from the following categories may count toward the free elective requirement:

- Physical Education (P.E.)
- StuCo (Student College)
- ROTC

Students are encouraged to use free electives to pursue minors, deepen technical training, explore other disciplines, or prepare for future academic and career goals.

There is no separate "technical elective" requirement in the B.S. in Chemistry curriculum. However, students may choose to take advanced technical courses in chemistry or related fields as part of their free electives.

Additional Notes on Degree Requirements

Minimum Total Units

The B.S. /M.S. degree requires a minimum of 388 units. Most students complete this requirement within 41–55 units per semester. Students are strongly encouraged to take additional electives in subjects of personal or professional interest to enrich their undergraduate experience.

AP Credit and Unit Overlap

Some students may need to complete more than 388 units to graduate, especially if they repeat coursework for which they received AP credit. For example, a student who received AP credit for but takes 09-105 or 09-107 at CMU will only receive 10 units toward the requirement — not 20. The duplicate units will not count toward the degree total.

Transfer Students and Course Substitutions

Students who transfer into the department and have taken 09-217 Organic Chemistry I and/or 09-218 Organic Chemistry II must complete 09-435 Independent Study Chemistry (1 unit per course) under the supervision of the 09-219 Modern Organic Chemistry and/or 09-220 Modern Organic Chemistry II instructor(s) to cover missing content.

Students who have taken 09-207 Techniques in Quantitative Analysis and/or 09-208 Techniques for Organic Synthesis and Analysis must enroll in a 3-unit transition course:

- 09-215 Chemistry Tech I to Lab I Transition (for 09-207 Techniques in Quantitative Analysis)
- 09-216 Chemistry Tech II to Lab II Transition (for 09-208 Techniques for Organic Synthesis and Analysis)

Minor in Chemistry

Students pursuing a B.S. or B.A. in another primary department may earn a minor in Chemistry by successfully completing **six** courses, distributed as described below.

To declare the minor, students must notify the Chemistry Department in writing using the MCS Minor Declaration Form. The form is available on the MCS undergraduate advising website and should be submitted to the Chemistry Department Office (DH 1317) or emailed to keishawd@andrew.cmu.edu no later than the end of the add period of your final semester.

If you later decide not to complete the minor, please notify the Director of Undergraduate Studies, Dr. Gizelle Sherwood (gsherwoo@andrew.cmu.edu), so it can be removed from your record.

Note: The introductory chemistry course (either 09-105 Introduction to Modern Chemistry I or 09-107 Honors Chemistry: Fundamentals, Concepts and Applications) is a presumed prerequisite for beginning the minor, but it does not count toward the six required courses.

Course Requirements

A. Four Required Core Courses

09-106	Modern Chemistry II	10
09-221	Laboratory I: Introduction to Chemical Analysis	9-12
or 09-207	Techniques in Quantitative Analysis	
09-217	Organic Chemistry I	9-10
or 09-219	Modern Organic Chemistry	
Choice of one of the following courses:		
09-331	Modern Analytical Instrumentation	9
09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-348	Inorganic Chemistry	10
09-507	Nanoparticles	9
09-529	Introduction to Sustainable Energy Science	9

Note: A course used in **Part A** may not also be used as an elective in **Part B.**

B. Two Elective Courses from the following list.

09-344	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	9
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9
09-348	Inorganic Chemistry	10
09-222	Laboratory II: Organic Synthesis and Analysis	9-12
or 09-208	Techniques for Organic Synthesis and Analysis	
09-218	Organic Chemistry II	9-10
or 09-220	Modern Organic Chemistry II	
03-231/232	Honors Biochemistry	9
09-381	Environmental Systems on a Changing Planet	12
09-403	Hooked: The Chemical Basis of Drug Addiction	9
09-502/741	Organic Chemistry of Polymers	9
09-507/707	Nanoparticles	9
09-510/710	Chemistry and Sustainability	9
09-518/718	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
09-519/719	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	9
09-524/724	Environmental Chemistry	9
09-525	Transition Metal Chemistry	9

09-530/730	Chemistry of Gene Expression	9
09-538/738	Exposure and Risk Assessment for Environmental Pollutants	9
09-563/763	Molecular Modeling and Computational Chemistry	9
09-615	Computational Modeling, Statistical Analysis and Machine Learning in Science	12
09-616	Neural Networks & Deep Learning in Science	12
09-714	Advanced Organic Chemistry	12
09-737	Medicinal Chemistry and Drug Development	12
09-760	The Molecular Basis of Polymer Mechanics	12
09-xxx	Approved Upper Level Chemistry Course (must be 09-3xx or higher but see exclusions noted below)	

Important Policies & Exclusions

1. Courses used to fulfill the Chemistry minor must not be required by your primary major or another declared minor/additional major (except as free electives).
   - Example: Biological Sciences majors may not count 03-231 Honors Biochemistry/03-232 Biochemistry I, 09-208 Techniques for Organic Synthesis and Analysis/09-222 Laboratory II: Organic Synthesis and Analysis, or 09-218 Organic Chemistry II/09-220 Modern Organic Chemistry II toward the minor.
   - Chemical Engineering majors may not count 03-231 Honors Biochemistry/03-232 Biochemistry I, though some may apply one advanced elective depending on course overlap.
2. The following do not count toward the minor: 09-231 Mathematical Methods for Chemists, 09-445 Undergraduate Research, 09-435 Independent Study Chemistry.
3. Chemistry courses taken for the pre-health program may count toward the minor as long as they are not also being used for another major or minor.
4. Transfer credit will only be accepted for: 09-105 Introduction to Modern Chemistry I, 09-106 Modern Chemistry II, 09-217 Organic Chemistry I. All other courses must be completed in residence at Carnegie Mellon

Transfer Credit for Chemistry Courses

1. Requests for transfer credit for chemistry classes taken at other institutions should be made to Dr. Len Vuocolo, Associate Teaching Professor in the Department of Chemistry. Students making such requests should follow the policies and procedures in place within their home colleges in assembling materials for such requests. Consult with your advisor on the appropriate steps.
2. Requests should be placed **before** paying tuition for a class in case transfer credit is denied. Allow 1-2 weeks for approval.
3. At minimum, transfer credit requests must include:
   - A **complete syllabus**, including the textbook used
   - A **detailed list of topic areas**, ideally with a schedule showing how much time is spent on each topic.
   - A statement indicating whether the course is part of the **science major curriculum** at the other institution
   - Be sure to check that the institution uses a **semester system**. Many schools on a quarter system (such as those in the University of California system) spread general and organic chemistry over **three quarters**. In most cases, one quarter-long course is **not equivalent** to one CMU course.
4. The department no longer accepts fully online courses.
5. No transfer credit will be awarded for the laboratory classes required for the chemistry or biology major at Carnegie Mellon University, 09-207, 09-221, 09-208, 09-222, 09-321, 09-323 and 09-322. Requests for transfer credit for 09-101, Introduction to Experimental Chemistry, will be accepted with the appropriate documentation.
6. In assessing the suitability of courses for transfer credit, the following factors are considered:
   - The rigor of the course must be comparable to that offered at Carnegie Mellon. This is usually assessed via the quality of the institution and its chemistry program, the textbook used and the amount of time spent on topic areas. In general, the rate of approval is significantly higher for four-year institutions with science majors as opposed to community colleges.
   - The topic areas should match to a degree of at least 80% those covered in the comparable course at Carnegie Mellon University.
7. 09-105 Introduction to Modern Chemistry I focuses primarily on structure, bonding, interactions (and their influence on properties), and reactions (including quantitative relationships among substances in them). Detailed topics include the following:
   - Radiation and Its Interaction with Matter
   - Quantum Mechanics (wave-particle duality of matter, Heisenberg Uncertainty Principle)
   - Atomic Structure (Schrodinger Model, quantum numbers, interpretation of orbitals and their relative energies)
   - Interpretation of Periodic Table, including the writing of electron configurations, Aufbau Principle, and Hund's Rule
   - Periodic Table Trends in Elemental Properties
   - Photoelectron Spectroscopy
   - Bonding models and their explanation of properties (types of solids, bond polarity, bond energies, and bond lengths)
   - Lewis Structures (octet rule and exceptions; formal charge)
   - Resonance Structures
   - Molecular shapes (including deviations from ideal bond angles)
   - Molecular Polarity (greenhouse gases as application)
   - Interparticle (intermolecular) forces and comparing or predicting relative physical properties from them (chromatography as application)
   - Valence Bond (Localized Electron) and Molecular Orbital Theory
   - Pi Molecular Orbitals (and energy diagrams) of Conjugated Organic Molecules
   - Band Theory of Metals, Semiconductors, and Insulators
   - Determining number of moles and chemical formulas
   - Writing and balancing chemical equations (in particular completing combustion and double displacement reactions – including acid-base and precipitation reactions)
   - Stoichiometry and thermochemical equations (heat evolved in combustion of fuels as application)
   - Stoichiometry – limiting reactant and percentage yield
   - Gases (mainly ideal) and stoichiometric applications involving them
   - Phase transitions
   - Solutions (determining concentrations, dilution problems, stoichiometric applications, application of solubility rules to determine if a precipitate forms)
   - Acid-base reactions, titrations and other stoichiometric applications of acid-base reactions
   - Oxidation Numbers, Redox Reactions/Titrations, and other stoichiometric applications of redox reactions
8. 09-106 Modern Chemistry II focuses primarily on thermodynamics, kinetics and equilibrium. Detailed topic areas include the following.
   - Thermochemistry and Thermodynamics (First, Second, and Third Laws, with gas expansion/compression applications, including reversible, adiabatic processes)
   - Internal energy, enthalpy, entropy, Gibbs Free energy, and determination of spontaneity
   - Kinetics : Determination of rate, order, rate laws (including application of pseudo-rate laws, application of integrated rate law to determine order, relationship between time and amount in a reaction, and half-life
   - Reaction mechanisms – applying fast equilibrium and steady-state approximations to determine rate law consistent with mechanism
   - Chemical Equilibrium : determination of Q and K expressions, determination of direction in which reaction proceeds to achieve equilibrium (using Q and Le Chatelier's principles, quantitative calculations to determine K or amounts at various stages, dependence of K on temperature, relationship between Gibbs Free energy, Q, and K)
   - Acid-Base Equilibria: writing dissociation equilibrium reactions and acid-base "neutralization" reactions, autoionization of water (determination of pH and pOH, use of K_w), writing K_a and K_b expressions from dissociation equilibria, quantitative equilibrium calculations for weak acids and bases, titrations between strong species, strong-weak species, and weak-weak species, buffers (calculations of pH and amounts, including how to make a buffer), polyprotic species (quantitative applications and titrations), solubility and precipitation equilibria, determination of K_{sp} expressions and quantitative applications of those expressions, complex ion formation equilibria, emphasis is placed on equilibrium problems that involve multiple types of simultaneous equilibria
   - Electrochemistry: Electrochemical cell notation and writing half-reactions from it, Faraday constant to connect number of moles

of electrons / reaction amounts with current, connection of Gibbs Free Energy to cell voltage (potential) at equilibrium and non-equilibrium conditions, determination of *K*'s (acid-base, solubility constants) or amounts using Nernst equation in concentration cells (*K* for cell reaction)

9. 09-111 Nanolegos: Chemical Building Blocks takes an applications or systems approach to exploring current significant research and technology, as well as to explaining phenomena and problems in the world around us. The major contexts and phenomena that it explore in applying and connecting chemical concepts are: (1) sustainable energy, (2) charge motion in materials, (3) natural versus engineered catalysts, (4) polymeric materials, and (5) reversible reactions in environmental and biological chemistry. The chemical concepts used to promote an integrated understanding of the above applications and systems are:

- Radiation and Its Interaction with Matter
- Atomic Structure (Schrodinger Model, quantum numbers, interpretation of orbitals and their relative energies)
- Interpretation of Periodic Table, including the writing of electron configurations, Aufbau Principle, and Hund's Rule
- Periodic Table Trends in Elemental Properties
- Photoelectron Spectroscopy
- Bonding models and their explanation of properties (types of solids, bond polarity, bond energies, and bond lengths)
- molecular structures of organic and inorganic compounds
- Resonance Structures
- Molecular shapes
- Molecular Polarity
- Interparticle (intermolecular) forces and comparing or predicting relative physical properties from them
- Multiphase Reaction Stoichiometry (including limiting reactants and percent yield)
- Thermodynamics (First, Second, and Third Laws – applications more toward chemical reactions)
- Acid-Base Chemistry
- Kinetics (phenomenological and mechanistic)
- Electrochemistry (redox reactions; battery technology)
- Equilibrium

10 . 09-101 Introduction to Experimental Chemistry is a seven week (mini) laboratory course that is designed to introduce students to some basic laboratory skills, techniques, and equipment commonly used in experimental chemical investigations. The experiments will apply concepts in organic and inorganic synthesis, quantitative analysis using visible spectrophotometry, kinetics, acid-base chemistry, thermochemistry, and transition metal coordination chemistry. The chemical concepts applied or discovered in the course are:

- molecular polarity and interparticle (intermolecular) forces
- synthesis of substances (empirical formulas, stoichiometry, and percent yield),
- spectrophotometric analysis (dilution and Beer-Lambert Law)
- kinetics (integrated rate laws and Arrhenius equation)
- equilibrium (Law of Mass Action, LeChâtelier's Principle)
- acid-base equilibria
- redox reactions
- thermochemistry (enthalpy, thermochemical equations)
- coordination chemistry
- The Laboratory Skills/Techniques involved are:
- safe lab practices, waste disposal, and chemical hygiene
- data/observation recording in lab notebook
- graphing, analyzing, and interpreting experimental data
- use of top-loading balance
- chromatography (paper or silica plate)
- filtration (gravity and vacuum)
- recrystallization of solids
- titrations (redox and acid-base; use of pH meter)
- making of and dilution of solutions (including quantitative transfer of solute)
- use of volumetric pipet
- use of spectrophotometer
- developing experimental procedures

11. 09-217 Organic Chemistry I is a 9-unit course that is the first half of our two semester sequence in organic chemistry for non-majors. The concepts addressed in the class are listed below. Please take special note of the spectroscopy section. Many institutions do not introduce this topic in the first organic chemistry class. These concepts are especially important if you wish to take the second class, 09-218 Organic Chemistry II, and the organic laboratory class for non-majors, 09-208 Techniques for Organic Synthesis and Analysis. It is possible that you will be offered chemistry elective credit instead of transfer credit for 09-217 Organic Chemistry I if these topics are not addressed sufficiently in the class you submit for approval. The chemistry elective course might, with permission of your advisor, satisfy the organic chemistry requirement for your major, minor or additional major but not satisfy the prerequisite requirement for 09-218 Organic Chemistry II or 09-208 Techniques for Organic Synthesis and Analysis.

Topics:

· **Language of Organic Chemistry:**

o New concepts, chemical terms, and nomenclature.

o Chemical formulas and structural drawing.

o Use of arrows to represent electron flow to describe reaction mechanisms and chemical synthesis.

· **Molecular Structure:**

- Electronic structure and 3-dimensional structure of molecules: geometry.
- Arrangement of atoms in space: stereochemistry.
- Electron density on molecules or bonds is often non-homogeneous: polarity.

· **Spectroscopy:**

- Introduction to spectroscopic tools for structural analysis
- Infrared spectroscopy and molecular vibration. Functional group identification.
- Nuclear Magnetic Resonance (NMR) for structural elucidation from spectra.

· **Properties and Transformations:**

- Discuss properties and transformations of functional groups.
- Reagents that achieve different conversions and mechanisms.
- Introduction to chemical synthesis based on properties of functional groups.

· **Applications:**

- Knowledge can be applied to:
  - Creating new materials.
  - Studying biological processes (e.g., cholesterol biosynthesis).
  - Understanding drug absorption and chemical transformations in the body.
  - Importance of enzymes and catalysts in organic reactions.

· **Learning Goals:**

- Familiarize with above concepts and acquire skills to solve synthetic problems.
- Analyze chemical reactions from different standpoints.

Academic Advising & Mentorship

Choosing a major is about more than classes. It's about finding a community that will support you, challenge you, and help you grow. In the Department of Chemistry, we believe that strong advising, combined with close-knit peer and faculty relationships, is key to your success at CMU and beyond.

All chemistry majors, additional majors, and minors are advised by the Director of Undergraduate Studies, a Teaching Professor of Chemistry who gets to know you and helps guide your path. You'll work with a first-year advisor in the MCS Dean's Office until you declare your major, typically in the spring of your first year.

Our advising philosophy is holistic: your advisor helps with course planning, yes - but also serves as a sounding board for research opportunities, double majors, internships, graduate school applications, and any bumps along the way. You'll see your advisor in the classroom and at department events, not just in office hours.

But advising doesn't stop there. Chemistry at CMU is intentionally small, and that means students regularly connect with faculty, graduate students, and peers who act as informal mentors. Whether it's through research collaborations, TA support, or community events, students build relationships that offer guidance, encouragement, and lasting friendships.

"The Chemistry Department has fostered a fantastic community of learning where we support and challenge each other. I found a lot of friends through my classes. The structure of the curriculum itself helps build that community."

~ 2024 Chemistry B.S. graduate

From National Chemistry Week outreach to Chemistry Murder Mystery dinners, students are seen not just as learners, but as people with interests and energy that help shape the department's culture. Many students say these experiences were central to finding their place at CMU.

Our alumni say it best:

"My favorite thing about the Chemistry Department is its strong sense of community. While the department's small size encourages this, the genuine friendliness and solidarity among students—both within my cohort and across others—is truly special. Some of my closest friends in Chemistry were upperclassmen I met through Chem Murder Mystery, and their guidance through coursework, graduate school applications, and CMU as a whole has been invaluable. The faculty also take the time to know you and are always willing to help, both in and outside the classroom. The support of the Chemistry Department has been a vital factor in my success at CMU, and I am incredibly grateful to have been a part of such a lovely community."
~ 2024 Chemistry B.S. graduate

Faculty

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JAMES PETERSON, Adjunct Associate Professor of Chemistry and Associate Professor of Environmental and Occupational Health at the University of Pittsburgh – Ph.D., University of Essex, UK; Carnegie Mellon, 2004–

Courtesy

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