Chemistry Courses

Courses

CH 111. Introduction to Chemical Principles. 4 Credits.
Introduction to modern chemistry with emphasis on problem-solving skills and critical thinking. Fundamental mathematical techniques and skills are incorporated to illustrate the quantitative aspects of chemistry.
Prereq: Satisfactory placement test score for MATH 111Z; Coreq: MATH 111Z.

CH 113. The Chemistry of Sustainability. 4 Credits.
Illustrates how chemistry provides innovative materials, processes, and consumer products that support sustainable solutions related to energy utilization, global warming and pollution prevention.
Prereq: MATH 101 or higher; high school chemistry.

CH 196. Field Studies: [Topic]. 1-2 Credits.
Repeatable.

CH 198. Workshop: [Topic]. 1-2 Credits.
Repeatable.

CH 199. Special Studies: [Topic]. 1-5 Credits.
Repeatable.

CH 221. General Chemistry I. 4 Credits.
First term of the three-term university chemistry sequence: components of matter, quantitative relationships, atomic structure, thermochemistry, and major classes of chemical reactions of the elements. Lectures. Students cannot receive credit for both CH 221 and CH 224H. Sequence with CH 222, CH 223.
Prereq: CH 111 or satisfactory placement score; MATH 111Z. Co-req: MATH 112Z; CH 227 or CH 237 recommended.

CH 222. General Chemistry II. 4 Credits.
Second term of the three-term university chemistry sequence: molecular structure, chemical bonding, gases and kinetic molecular theory, intermolecular forces, solutions and kinetics. Lectures. Students cannot receive credit for both CH 222 and CH 225H.
Prereq: CH 221 or CH 224H; MATH 112Z; Concurrent CH 228 or CH 238 recommended.

CH 223. General Chemistry III. 4 Credits.
Third term of the three-term university chemistry sequence: thermodynamics, equilibrium, electrochemistry, nuclear chemistry. Lectures. Students cannot receive credit for both CH 223 and CH 226H. Sequence with CH 221, CH 222.
Prereq: CH 222 or CH 225H; MATH 112Z; Concurrent CH 229 or CH 239 recommended.

CH 224H. Advanced General Chemistry I. 4 Credits.
First-year university chemistry for students with excellent backgrounds in high school chemistry, physics, and mathematics. Chemical structure, reactions, stoichiometry, thermochemistry, and an introduction to quantum chemistry. Students cannot receive credit for both CH 221 and CH 224H. Sequence with CH 225H, CH 226H.
Prereq: satisfactory placement test score; MATH 112Z. Coreq: one from MATH 241, MATH 246, MATH 251, MATH 261; CH 237 recommended.

CH 225H. Advanced General Chemistry II. 4 Credits.
First-year university chemistry for students with excellent backgrounds in high school chemistry, physics, and mathematics. Chemical bonding, states of matter, solutions, kinetics, and nuclear chemistry. Students cannot receive credit for both CH 222 and CH 225H.
Prereq: CH 221 or CH 224H; one from MATH 241, MATH 246, MATH 251, MATH 261. Coreq: one from MATH 242, MATH 247, MATH 252, MATH 262. Concurrent CH 238 recommended.

CH 226H. Advanced General Chemistry III. 4 Credits.
First-year university chemistry for students with excellent backgrounds in high school chemistry, physics, and mathematics. Chemical equilibrium, acid-base chemistry, thermodynamics, and electrochemistry. Students cannot receive credit for both CH 223 and CH 226H.
Prereq: CH 222 or CH 225H; one from MATH 242, MATH 247, MATH 252, MATH 262. Coreq: one from STAT 243Z, MATH 247, MATH 253, MATH 263. Concurrent CH 239 recommended.

CH 227. General Chemistry Laboratory. 2 Credits.
First term of the three-term laboratory sequence: basic laboratory skills, quantitative relationships, qualitative analysis, calorimetry.
Prereq: MATH 111Z. Co-req: MATH 112Z. Pre- or coreq: CH 221 or CH 224H.

CH 228. General Chemistry Laboratory. 2 Credits.
Second term of the three-term laboratory sequence: graphical analysis, spectroscopy, spectrophotometry, gas laws, chromatography, kinetics.
Prereq: CH 227 or CH 237; MATH 111Z; coreq: CH 222 or CH 225H; MATH 112Z.

CH 229. General Chemistry Laboratory. 2 Credits.
Third term of the three-term laboratory sequence: synthesis, equilibrium, acids and bases, volumetric analyses, electrochemistry, nuclear chemistry.
Prereq: CH 228 or CH 238; MATH 112Z; coreq: CH 223 or CH 226H.

CH 237. Advanced General Chemistry Laboratory. 2 Credits.
First-year university laboratory course for students with a strong high school laboratory experience. Projects in analytical and inorganic chemistry emphasize the use of quantitative glassware, gravimetric and volumetric analysis, acid-base and precipitation reactions.
Prereq: MATH 112Z; coreq: CH 221 or CH 224H.

CH 238. Advanced General Chemistry Laboratory. 2 Credits.
Projects in inorganic and biochemistry with a focus on absorption spectroscopy, synthesis of coordination compounds, and measuring initial rates of reaction.
Prereq: CH 227 or CH 237; one from MATH 241, MATH 246, MATH 251, MATH 261; coreq: CH 222 or CH 225H.

CH 239. Advanced General Chemistry Laboratory. 2 Credits.
Projects in biochemistry and inorganic chemistry involving enzymology, mechanisms of reactions, kinetics, and visible absorption spectroscopy.
Prereq: CH 228 or CH 238; one from MATH 242, MATH 247, MATH 252, MATH 262; coreq: CH 223 or CH 226H.

CH 331. Organic Chemistry I. 4 Credits.
Structure, properties, and bonding of organic molecules.
Prereq: CH 223 or CH 226H. Concurrent CH 337 recommended.

CH 335. Organic Chemistry II. 4 Credits.
Reactions and mechanisms of organic chemistry.
Prereq: CH 331 or CH 341. Concurrent CH 338 recommended.

CH 336. Organic Chemistry III. 4 Credits.
Organic chemistry of biomolecules with a focus on chemical aspects.
Prereq: CH 335 or CH 342.

CH 337. Organic Chemistry Laboratory. 3 Credits.
Principles and techniques of laboratory practice in organic chemistry.
Prereq: CH 229 or CH 239; pre- or coreq: CH 331.

CH 338. Organic Chemistry Laboratory. 3 Credits.
Principles and techniques of laboratory practice in organic chemistry.
Prereq: CH 331 or CH 341, CH 337; pre- or coreq: CH 335.

CH 341. Majors Track Organic Chemistry I. 4 Credits.
Structure, properties, and bonding of organic molecules. Provides a rigorous foundation appropriate for chemistry and biochemistry majors as they become chemical practitioners. Sequence with CH 342, CH 343.
Prereq: CH 223 or CH 226H. Concurrent CH 337 recommended.

CH 342. Majors Track Organic Chemistry II. 4 Credits.
Focuses on mechanisms and reactions of common organic functional groups. Sequence with CH 341, CH 343.
Prereq: CH 331 (with grade of B– or better) or CH 341. Concurrent CH 348 recommended.

CH 343. Majors Track Organic Chemistry III. 4 Credits.
Incorporates topics from the recent chemistry literature. Sequence with CH 341, CH 342.
Prereq: CH 335 (with grade of B– or better) or CH 342. Concurrent CH 349 recommended.

CH 348. Organic Chemistry Laboratory for Majors. 4 Credits.
Problem solving in the organic chemistry laboratory. Sequence with CH 337, CH 349.
Prereq: CH 337; CH 331 or CH 341; coreq: CH 342.

CH 349. Organic Chemistry Lab for Majors. 4 Credits.
Organic chemistry laboratory projects. Two-dimensional nuclear magnetic resonance techniques. Sequence with CH 337, CH 348.
Prereq: CH 348; coreq: CH 343.

CH 360. Physiological Biochemistry. 4 Credits.
For preprofessional health science students. Topics include protein structure and function, enzyme mechanisms, central metabolism and bioenergetics, integration and regulation of metabolism by hormone action. Students cannot receive credit for both CH 360 and CH 462.
Prereq: CH 336 or CH 343; BI 214 or 282H recommended.

CH 399. Special Studies: [Topic]. 1-5 Credits.
Repeatable.

CH 399L. Special Studies: [Topic]. 3 Credits.
Repeatable.

CH 401. Research: [Topic]. 1-21 Credits.
Repeatable. Introduction to methods of chemical investigation. For advanced undergraduates by arrangement with individual faculty members.

CH 403. Thesis. 1-12 Credits.
Repeatable. Open to students eligible to work for a bachelor's degree with honors in chemistry or biochemistry.
Prereq: Honors majors.

CH 405. Reading and Conference: [Topic]. 1-21 Credits.
Repeatable.

CH 406. Field Studies: [Topic]. 1-21 Credits.
Repeatable.

CH 407. Seminar: [Topic]. 1-5 Credits.
Biochemistry seminar for undergraduates who have completed or are enrolled in CH 461, CH 462, CH 463. No graduate credit. Repeatable.

CH 408. Laboratory Projects: [Topic]. 1-12 Credits.
Repeatable.

CH 409. Terminal Project. 1-12 Credits.
Repeatable.

CH 410. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

CH 410L. Experimental Course: [Topic]. 4 Credits.
Repeatable.

CH 411. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to chemical thermodynamics.
Prereq: two years of college chemistry (except for physics majors), PHYS 201, 202, 203; MATH 253; MATH 256, MATH 281, MATH 282 strongly recommended.

CH 412. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to statistical mechanics and rate processes.
Prereq: two years of college chemistry (except for physics majors); CH 411; PHYS 201, 202, 203; MATH 253; MATH 256, MATH 281, MATH 282 strongly recommended.

CH 413. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to quantum chemistry.
Prereq: two years of college chemistry (except for physics majors), PHYS 201, 202, 203; MATH 253; MATH 256, MATH 281, MATH 282 strongly recommended.

CH 417. Physical Chemistry Laboratory. 4 Credits.
Experiments in thermodynamics, modern electronic measurements, computer modeling, and data reduction.
Pre or coreq: CH 411.

CH 418. Physical Chemistry Laboratory. 4 Credits.
Experiments in statistical mechanics, chemical kinetics, plasma chemistry, and mass spectrometry.
Prerequisite CH 417; Pre or coreq: CH 412.

CH 419. Physical Chemistry Laboratory. 4 Credits.
Experiments molecular spectroscopy, quantum chemistry, and laser-excited chemical and physical processes to illustrate theoretical principles.
Prereq: CH 417; pre or coreq: CH 413.

CH 420. Physical Organic Chemistry I. 4 Credits.
Modern physical organic chemistry including chemical bonding, acid-base chemistry, thermochemistry, noncovalent interactions, and introduction to computational chemistry. Sequence with CH 421.
Prereq: CH 336.

CH 421. Physical Organic Chemistry II. 4 Credits.
Modern physical organic chemistry including tools to study reaction mechanisms, kinetic analysis, isotope effects, and qualitative molecular orbital theory. Sequence with CH 420.
Prereq: CH 420.

CH 429. Instrumental Analysis. 5 Credits.
Use of instrumental methods for quantitative determinations of unknown chemical samples.
Prereq: CH 417.

CH 431. Inorganic Chemistry. 4 Credits.
Introduction to group theory for molecular symmetry; syntheses, structures, reactions, and reaction mechanisms of coordination complexes and organometallic complexes.

CH 432. Inorganic Chemistry. 4 Credits.
Bioinorganic chemistry: metals in biological systems; coordination chemistry, reactions, spectroscopy, metalloclusters, and synthetic modeling.
Prereq: CH 431 recommended.

CH 433. Inorganic Chemistry. 4 Credits.
Solid-state inorganic chemistry: solid-state structure and its determination; the electrical, magnetic, and mechanical properties of materials and their physical description.
Prereq: CH 431 recommended.

CH 441. Quantum Chemistry. 4 Credits.
The principles of time-independent quantum mechanics and their application to model atomic and molecular systems.
Prereq: CH 413 or equivalent.

CH 442. Quantum Chemistry and Spectroscopy. 4 Credits.
Molecular structure theory, perturbation theory, time-dependent quantum mechanics, theory of spectra, selection rules.
Prereq: CH 441 or equivalent.

CH 443. Quantum Chemistry and Spectroscopy. 4 Credits.
Experimental spectra of atomic and molecular systems and surfaces.
Prereq: CH 442 or equivalent.

CH 445. Statistical Mechanics. 4 Credits.
Molecular basis of thermodynamics. Applications to the calculation of the properties of noninteracting and weakly interacting systems.
Prereq: CH 413 or equivalent.

CH 446. Chemical Kinetics: [Topic]. 4 Credits.
Description and interpretation of the time evolution of chemical systems. Repeatable.
Prereq: CH 413 or equivalent.

CH 447. Computational Chemistry. 4 Credits.
Introduction to modern computational methods used to understand the properties of molecules.
Prereq: CH 411, 412; or PHYS 353.

CH 451. Advanced Organic-Inorganic Chemistry. 4 Credits.
Principles of organic-inorganic reaction dynamics; kinetics and mechanisms, linear free-energy relationships, isotope effects, substitution reactions, dynamic behavior of reactive intermediates, electron transfer chemistry.
Prereq: CH 336 or equivalent.

CH 452. Advanced Organic Chemistry—Stereochemistry and Reactions. 4 Credits.
Principles and applications of stereochemistry; reagents and reactions, with mechanisms, used in contemporary organic synthesis; examples taken from the current literature.

CH 454. Advanced Electrochemistry. 4 Credits.
Advanced topics in electrochemistry including fundamental concepts (thermodynamics, kinetics, transport) and applications (analytical techniques, electrolysis, batteries).
Prereq: CH 411.

CH 461. Biochemistry. 4 Credits.
Structure and function of macromolecules.
Prereq: CH 336 or CH 343.

CH 462. Biochemistry. 4 Credits.
Metabolism and metabolic control processes. Energy and sensory transduction mechanisms.
Prereq: CH 461.

CH 463. Biochemistry. 4 Credits.
Mechanisms and regulation of nucleic acid and protein biosynthesis. Other current topics in biochemical genetics.
Prereq: CH 461/561; or CH 360 with a grade of B- or better.

CH 464. RNA Biochemistry. 4 Credits.
Introduction to the diverse field of RNA biochemistry.
Prereq: CH 463.

CH 465. Physical Biochemistry. 4 Credits.
Physical chemical properties of biological macromolecules; forces and interactions to establish and maintain macromolecular conformations; physical bases of spectroscopic, hydrodynamic, and rapid-reaction investigative techniques. Offered alternate years.
Prereq: CH 461.

CH 466. Structural Biochemistry. 4 Credits.
Protein and nucleic acid structures and energetics. Structure determination by x-ray crystallography and nuclear magnetic resonance. Computational methods for structural analysis. Offered alternate years.
Prereq: CH 461.

CH 467. Biochemistry Laboratory. 4 Credits.
Methods of modern molecular biology and protein purification.
Co-req: CH 461

CH 468. Cellular Biochemistry. 4 Credits.
This course surveys scientific discovery at the interface between cell biology and biochemistry. Emphasis will be placed on understanding how scientists visualize, quantify, and interpret how biochemical reactions are orchestrated in complex biological systems. Relationships between protein structure, function, and emergent properties will be defined.
Prereq: CH 461.

CH 503. Thesis. 1-16 Credits.
Repeatable.

CH 507. Seminar: [Topic]. 1-5 Credits.
Biochemistry seminar for undergraduates who have completed or are enrolled in CH 461, 462, 463. No graduate credit. Repeatable.

CH 508. Workshop: [Topic]. 1-21 Credits.
Repeatable.

CH 510. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

CH 510L. Experimental Course: [Topic]. 4 Credits.
Repeatable.

CH 511. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to chemical thermodynamics.

CH 512. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to statistical mechanics and rate processes.

CH 513. Physical Chemistry. 4 Credits.
Methods of physics applied to chemical problems, including inorganic, organic, and biochemistry. Introduction to quantum chemistry.

CH 517. Physical Chemistry Laboratory. 4 Credits.
Experiments in thermodynamics, modern electronic measurements, computer modeling, and data reduction.
Pre- or coreq: CH 511.

CH 518. Physical Chemistry Laboratory. 4 Credits.
Experiments in statistical mechanics, chemical kinetics, plasma chemistry, and mass spectrometry.
Pre or coreq: CH 512.

CH 519. Physical Chemistry Laboratory. 4 Credits.
Experiments in molecular spectroscopy, quantum chemistry, and laser-excited chemical and physical processes to illustrate theoretical principles.
Pre or coreq: CH 513.

CH 520. Physical Organic Chemistry I. 4 Credits.
Modern physical organic chemistry including chemical bonding, acid-base chemistry, thermochemistry, noncovalent interactions, and introduction to computational chemistry. Sequence with CH 521.

CH 521. Physical Organic Chemistry II. 4 Credits.
Modern physical organic chemistry including tools to study reaction mechanisms, kinetic analysis, isotope effects, and qualitative molecular orbital theory. Sequence with CH 520.
Prereq: CH 520.

CH 531. Inorganic Chemistry. 4 Credits.
Introduction to group theory for molecular symmetry; syntheses, structures, reactions, and reaction mechanisms of coordination complexes and organometallic complexes.

CH 532. Inorganic Chemistry. 4 Credits.
Bioinorganic chemistry: metals in biological systems; coordination chemistry, reactions, spectroscopy, metalloclusters, and synthetic modeling.
Prereq: CH 531 recommended.

CH 533. Inorganic Chemistry. 4 Credits.
Solid-state inorganic chemistry: solid-state structure and its determination; the electrical, magnetic, and mechanical properties of materials and their physical description.
Prereq: CH 531 recommended.

CH 541. Quantum Chemistry. 4 Credits.
The principles of time-independent quantum mechanics and their application to model atomic and molecular systems.
Prereq: CH 513 or equivalent.

CH 542. Quantum Chemistry and Spectroscopy. 4 Credits.
Molecular structure theory, perturbation theory, time-dependent quantum mechanics, theory of spectra, selection rules.
Prereq: CH 541 or equivalent.

CH 543. Quantum Chemistry and Spectroscopy. 4 Credits.
Experimental spectra of atomic and molecular systems and surfaces.
Prereq: CH 542 or equivalent.

CH 545. Statistical Mechanics. 4 Credits.
Molecular basis of thermodynamics. Applications to the calculation of the properties of noninteracting and weakly interacting systems.
Prereq: CH 513 or equivalent.

CH 546. Chemical Kinetics: [Topic]. 4 Credits.
Description and interpretation of the time evolution of chemical systems. Repeatable.
Prereq: CH 513 or equivalent.

CH 547. Computational Chemistry. 4 Credits.
Introduction to modern computational methods used to understand the properties of molecules.

CH 551. Advanced Organic-Inorganic Chemistry. 4 Credits.
Principles of organic-inorganic reaction dynamics; kinetics and mechanisms, linear free-energy relationships, isotope effects, substitution reactions, dynamic behavior of reactive intermediates, electron transfer chemistry.
Prereq: CH 336 or equivalent.

CH 552. Advanced Organic Chemistry—Stereochemistry and Reactions. 4 Credits.
Principles and applications of stereochemistry; reagents and reactions, with mechanisms, used in contemporary organic synthesis; examples taken from the current literature.

CH 554. Advanced Electrochemistry. 4 Credits.
Advanced topics in electrochemistry including fundamental concepts (thermodynamics, kinetics, transport) and applications (analytical techniques, electrolysis, batteries).

CH 561. Biochemistry. 4 Credits.
Structure and function of macromolecules.

CH 562. Biochemistry. 4 Credits.
Metabolism and metabolic control processes. Energy and sensory transduction mechanisms.
Prereq: CH 561.

CH 563. Biochemistry. 4 Credits.
Mechanisms and regulation of nucleic acid and protein biosynthesis. Other current topics in biochemical genetics.
Prereq: CH 561.

CH 564. RNA Biochemistry. 4 Credits.
Introduction to the diverse field of RNA biochemistry.

CH 565. Physical Biochemistry. 4 Credits.
Physical chemical properties of biological macromolecules; forces and interactions to establish and maintain macromolecular conformations; physical bases of spectroscopic, hydrodynamic, and rapid-reaction investigative techniques. Offered alternate years.

CH 566. Structural Biochemistry. 4 Credits.
Protein and nucleic acid structures and energetics. Structure determination by x-ray crystallography and nuclear magnetic resonance. Computational methods for structural analysis. Offered alternate years.
Prereq: CH 561.

CH 567. Biochemistry Laboratory. 4 Credits.
Methods of modern molecular biology and protein purification.

CH 568. Cellular Biochemistry. 4 Credits.
This course surveys scientific discovery at the interface between cell biology and biochemistry. Emphasis will be placed on understanding how scientists visualize, quantify, and interpret how biochemical reactions are orchestrated in complex biological systems. Relationships between protein structure, function, and emergent properties will be defined.

CH 601. Research: [Topic]. 1-16 Credits.
Repeatable.

CH 603. Dissertation. 1-16 Credits.
Repeatable.

CH 605. Reading and Conference: [Topic]. 1-16 Credits.
Repeatable.

CH 606. Field Studies: [Topic]. 1-16 Credits.
Repeatable.

CH 607. Seminar: [Topic]. 1-5 Credits.
Repeatable. Seminars offered in biochemistry, chemical physics, materials science, molecular biology, neuroscience, organic-inorganic chemistry, and physical chemistry.

CH 608. Workshop: [Topic]. 1-16 Credits.
Repeatable.

CH 609. Terminal Project. 1-16 Credits.
Repeatable.

CH 610. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

CH 610L. Experimental Course: [Topic]. 2 Credits.
Repeatable.

CH 623. Organic-Inorganic Chemistry Journal Club. 1-2 Credits.
Repeatable. Preparation and delivery of colloquium-style lectures in organic-inorganic chemistry based on papers from the literature.

CH 624. Physical Chemistry Journal Club. 1 Credit.
Repeatable. Preparation and delivery of colloquium-style lectures in physical chemistry based on papers from the literature. Repeatable for maximum of 12 credits.

CH 662. Advanced Biochemistry. 4 Credits.
Detailed consideration of enzyme mechanisms, macromolecular structure, protein-nucleic acid interactions, and selected aspects of biological synthesis.

CH 667. Polymers: Synthesis, Characterization, Processing. 4 Credits.
Methods of polymer synthesis and characterization; kinetics and mechanisms of the principal polymerization reactions. Introduction to mechanical properties and fabrication techniques.

CH 668. Physical Chemistry of Polymers and Coatings. 4 Credits.
Statistical and thermodynamic models for the equilibrium configuration, conformation, structure, mechanical properties, and phase transitions of polymer solutions, dense melts, liquid crystals.

CH 669. Polymer Synthesis and Characterization Laboratory. 4 Credits.
Preparation and physical characterization of polymers; emphasis on polymers of commercial interest.

CH 670. Industrial Polymer Projects Laboratory. 4 Credits.
Polymer industry–focused projects with emphasis on formulation and optimization of adhesives, coatings, thermoplastics, thermosets, drug delivery systems, biopolymers, personal care products.
Prereq: CH 667, CH 668, CH 669.

CH 677M. Semiconductor Device Physics. 4 Credits.
Introduction to the theory behind semiconductors. Elementary theory of inorganic solids; electronic structures and transport properties. Basic theory of devices including diodes, transistors, mosfets, and optoelectronic devices. Offered only in summer. Sequence with PHYS 678M, PHYS 679M. Multilisted with PHYS 677M.

CH 678M. Semiconductor Processing and Characterization Technology. 4 Credits.
Introduction to the techniques required to make semiconductors and test their properties. Solid-state and surface chemistry of inorganic semiconductors as it pertains to microelectronic devices. Offered only in summer. Multilisted with PHYS 678M.
Prereq: CH 677M.

CH 679M. Device Processing and Characterization Laboratory. 4 Credits.
Students use theory and techniques learned to design, fabricate, and test a device that performs a specific function, with an emphasis on wafer processing and device realization. Offered only in summer. Sequence with CH 677M, CH 678M. Multilisted with PHYS 679M.
Prereq: CH 678M.

CH 680. Electronics and Vacuum Systems. 4 Credits.
Introduction to modern electronic components, circuits, basic vacuum theory, vacuum failure modes, measurement systems, and troubleshooting.

CH 681. Introduction to Electron Microscopy. 4 Credits.
Introduction to theory and best practices for applying scanning electron (SEM) and transmission electron microscopy (TEM) in materials science.

CH 682. Electron Microprobe Analysis. 4 Credits.
Introduction to the theory and operation of instrumentation for electron microprobe analysis (EPMA) in materials science and geochemistry.

CH 683. Surface Analysis. 4 Credits.
Introduction to theory and best practices for surface analysis techniques (XPS and ToF-SIMS), with focus on applications for materials science.

CH 685. Advanced Transmission Electron Microscopy. 4 Credits.
Advanced theory and practices for using transmission electron microscopy, as applied to materials science.
Prereq: CH 681.

CH 686. Advanced Scanning Electron Microscopy. 4 Credits.
Advanced theory and practices for using focused ion beam and scanning electron microscopy in research and nanofabrication.
Prereq: CH 681.

CH 687. Advanced Surface Analysis. 4 Credits.
Advanced theory and practices for surface analysis spectroscopy, as applied to materials science.
Prereq: CH 683.

CH 689. Chemistry Professional Development. 1 Credit.
Students will develop their awareness of pathways for professional development in chemical technology and identify strategic areas for pursuing growth. Working with the instructors, they will design a plan to explore their strengths and interests and identify career opportunities.

CH 690. Numerical Simulation in Electrochemistry. 2 Credits.
Modern finite-element simulation software is widely used in engineering to predict system performance/properties or in science to understand complex system behavior. Students will learn use industry standard software suites to simulate electrochemical cells and devices to predict performance and develop an understanding of underlying phenomena.
Prereq: CH 454 or CH 554 is prereq or co-req.

CH 691. Analytical Electrochemistry Laboratory. 2 Credits.
This course will focus on typical three-electrode electrochemical experiments and laboratory techniques that form the basis for analytical electrochemistry and for building the basic electrochemistry knowledge and intuition with respect to thermodynamics, kinetics and mass transport.
Prereq: CH 454 or CH 554 is prereq or co-req.

CH 692. Electrochemical Device Engineering. 4 Credits.
This course examines the operational principles of electrochemical energy storage devices (batteries and capacitors), energy conversion devices (fuel cells, electrolyzers), and bioelectrochemical interfaces. The emphasis is on materials and device design based on fundamental chemistry and physics concepts that govern the properties and performance.
Prereq: CH 454 or CH 554.

CH 693. Electrochemical Device Laboratory. 4 Credits.
Students will work in small teams to build battery devices, electrolyzers for the production of chemicals and/or fuels, fuel cells, and biological interfaces. They will test the performance and response of these devices compared to theory and modelling, applying experimental design and statistical analysis methods.
Prereq: CH 454 or CH 554; Pre- or Coreq: CH 692.

CH 694. Applied Electrochemistry Projects Laboratory. 4 Credits.
This course requires students to work in teams to solve open-ended research and development projects in electrochemistry. The applied research and development projects for the course come from industry partners, national laboratories, and academic research laboratories.
Prereq: CH 454 or CH 554.

CH 695. External Graduate Internship. 1-10 Credits.
Student will complete internships in industry, a national laboratory, or other research setting to provide opportunities to make connections between the theory and practice of academic study and the practical application of that study in a professional environment.