# CHEMISTRY AND BIOCHEMISTRY (CHEM)

**CHEM 10091 Foundations of Chemistry (3 Credit Hours)**
For achieving a qualifying score on the appropriate Advanced Placement (AP) or International Baccalaureate (IB) exam, students earn credit for this course as the exam credit equivalent of CHEM 10101. This course covers forms, properties, and separation of matter; atomic structure and periodicity; nuclear chemistry; chemical bonding and structure; reactivity with applications to acid-base and oxidation-reduction reactions; and chemistry of carbon and living systems. This course is not open to students who have taken the equivalent of CHEM 10171 or 10181.

**CHEM 10097 Introduction to Chemical Principles (4 Credit Hours)**
For achieving a qualifying score on the appropriate Advanced Placement (AP) or International Baccalaureate (IB) exam, students earn credit for this course as the exam credit equivalent of CHEM 10171. This one-semester course, offered in the Fall, provides a thorough grounding in the fundamental principles governing chemical structure and reactivity. It is accompanied by laboratory work and by a tutorial section. Topics to be discussed include the quantum mechanical structure of atoms, models of chemical bonding, chemical equilibrium, acidity and basicity, and thermochemistry and thermodynamics. Recommended for students in the College of Engineering, College of Science, and for all pre-professional students.

**CHEM 10098 General Chemistry 1 (3 Credit Hours)**
For students transferring general chemistry credit from another institution. This course is the first of a two-semester general chemistry sequence providing a thorough grounding in the fundamental principles governing chemical structure and reactivity. Topics to be discussed could include the quantum mechanical structure of atoms, models of chemical bonding, chemical equilibrium, acidity and basicity, thermochemistry and thermodynamics, chemical kinetics, and electrochemistry.
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 10099 General Chemistry 2 (3 Credit Hours)**
For students transferring general chemistry credit from another institution. This course is the second of a two-semester general chemistry sequence providing a thorough grounding in the fundamental principles governing chemical structure and reactivity, equivalent to CHEM 10171. Topics to be discussed could include the quantum mechanical structure of atoms, models of chemical bonding, chemical equilibrium, acidity and basicity, thermochemistry and thermodynamics, chemical kinetics, and electrochemistry.
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 10101 Foundations of Chemistry (3 Credit Hours)**
This course covers forms, properties, and separation of matter; atomic structure and periodicity; nuclear chemistry; chemical bonding and structure; reactivity with applications to acid-base and oxidation-reduction reactions; and chemistry of carbon and living systems.
This course is not open to students who have taken the equivalent of CHEM 10171 or 10181.
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Science college may **not** enroll.

**CHEM 10104 Forensic Chemistry (3 Credit Hours)**
This three-credit course introduces non-science majors to aspects of chemistry and biochemistry as applied to law enforcement. Topics include legal and scientific standards of proof, biometrics, drug detection, crime scene investigation, case studies and guest speakers. Students do several lab experiments using modern analytical instrumentation.
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 10122 General Chemistry: Fundamental Principles and Biological Processes (3 Credit Hours)**
This one-semester course (taught in Spring semester) completes a two-semester chemistry sequence for many engineering and science majors. Fundamental principles of chemistry lead into key themes of modern biochemistry, including biomolecular structure and function, and the basics of biotechnology. This course is not recommended for students who will consider further coursework in chemistry or biochemistry.
Prerequisites: (CHEM 10171 or CHEM 10097 or CHEM 10181)

**CHEM 10171 Introduction to Chemical Principles (3 Credit Hours)**
This one-semester course, offered in the Fall, provides a thorough grounding in the fundamental principles governing chemical structure and reactivity. It is accompanied by laboratory work and by a tutorial section. Topics to be discussed include the quantum mechanical structure of atoms, models of chemical bonding, chemical equilibrium, acidity and basicity, and thermochemistry and thermodynamics. Recommended for students in the College of Engineering, College of Science, and for all pre-professional students.
*Corequisites:* CHEM 11171, CHEM 12171
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 10172 Organic Structure and Reactivity (3 Credit Hours)**
This class, generally taught in the Spring, is the first semester of a two-semester organic chemistry sequence intended for students in biological sciences and pre-professional studies. It is accompanied by laboratory work and by a tutorial section. The course provides a solid foundation in organic structure and bonding, spectroscopy, and Lewis acid/base reactions. These concepts are then applied to understand substitution and elimination reactions with a focus on mechanism and factors governing selectivity. A section of this course, taught in the Fall semester, is intended for chemical engineering students.
Prerequisites: CHEM 10171 or CHEM 10097 or CHEM 10181
*Corequisites:* CHEM 12172
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 10176 Organic Chemistry for Chemical and Biomolecular Engineers (3 Credit Hours)**
This course is intended for students having a major in Chemical and Biomolecular Engineering. This course will provide an overview of traditional topics in organic chemistry in a one-semester format. Numerous applications to biochemistry are included, and as such, the course will provide appropriate preparation for a course in introductory biochemistry. Cannot have taken CHEM 10172 or CHEM 10182.
Prerequisites: CHEM 10171 or CHEM 10181 or CHEM 10097 or EG 10014 (may be taken concurrently) or EG 10015 (may be taken concurrently) or EG 10016 (may be taken concurrently)
*Corequisites:* CHEM 12176
Enrollment is limited to students with a program in Chemical Engineering.

**CHEM 10181 Introduction to Chemical Principles (4 Credit Hours)**
This course provides a thorough grounding in the fundamental principles governing chemical structure and reactivity. Topics to be discussed include the quantum mechanical structure of atoms, models of chemical bonding, chemical equilibrium, acidity and basicity, and thermochemistry and thermodynamics. Recommended for students with a special interest in the subject, especially those intending to major in chemistry or biochemistry. Lectures will be supplemented with a weekly tutorial session.
*Corequisites:* CHEM 11181, CHEM 12181
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 10182 Organic Structure and Mechanism (4 Credit Hours)**
Basic principles of organic chemistry, including fundamental aspects of organic and biological structures and bonding, stereochemistry, the effect of structure on physical and chemical properties, and applications of spectroscopic methods to assign structures. A detailed analysis of organic chemical reactivity, including reactive intermediates and mechanistic principles. Introductory applications of reactions in synthesis. Intended primarily for chemistry and biochemistry majors. Lectures will be supplemented with a weekly tutorial session.
Prerequisites: CHEM 10171 or CHEM 10097 or CHEM 10181
*Corequisites:* CHEM 11182, CHEM 12182
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 11098 General Chemistry 1 Lab (1 Credit Hour)**
For students transferring general chemistry credit from another institution. This course is the first of a two-semester general chemistry laboratory sequence providing a thorough grounding in the fundamental laboratory principles.

**CHEM 11099 General Chemistry 2 Lab (1 Credit Hour)**
For students transferring general chemistry credit from another institution. This course is the second of a two-semester general chemistry laboratory sequence providing a thorough grounding in the fundamental laboratory principles, equivalent to CHEM 11171.

**CHEM 11171 Introduction to Chemical Principles Laboratory (1 Credit Hour)**
This lab involves experimental work to accompany Chem 10171 lecture.
*Corequisites:* CHEM 10171, CHEM 12171

**CHEM 11172 Organic Structure and Reactivity Laboratory (1 Credit Hour)**
Experimental work to accompany CHEM 10172.

**CHEM 11176 Structure and Reactivity Lab for Chemical and Biomolecular Engineers (0 Credit Hours)**
Experimental work to accompany CHEM 10176. Intended for Chemical and Biomolecular Engineering Students.
*Corequisites:* CHEM 10176, CHEM 12176
Enrollment is limited to students with a program in Chemical Engineering.

**CHEM 11181 Introduction to Chemical Principles Laboratory (0 Credit Hours)**
A laboratory to accompany CHEM 10181 that will stress quantitative measurements.
*Corequisites:* CHEM 10181, CHEM 12181

**CHEM 11182 Organic Structure and Mechanism Laboratory (0 Credit Hours)**
A laboratory to accompany CHEM 10182 that will emphasize fundamental organic techniques.
*Corequisites:* CHEM 10182

**CHEM 12122 General Chemistry: Fundamental Principles & Biological Processes - Tutorial (0 Credit Hours)**
Tutorial that accompanies the CHEM 10122 course.
*Corequisites:* CHEM 10122

**CHEM 12171 Introduction to Chemical Principles Tutorial (0 Credit Hours)**
Tutorial section to accompany Chem 10171.
*Corequisites:* CHEM 10171, CHEM 11171

**CHEM 12172 Structure and Reactivity tutorial (0 Credit Hours)**
Tutorial section to accompany Chem 10172.
*Corequisites:* CHEM 10172

**CHEM 12176 Organic Chemistry for Chemical and Biomolecular Engineers - Tutorial (0 Credit Hours)**
This tutorial will accompany CHEM 10176 and is intended for students having a major in Chemical and Biomolecular Engineering.
*Corequisites:* CHEM 10176
Enrollment is limited to students with a program in Chemical Engineering.

**CHEM 12181 Introduction to Chemical Principles Tutorial (0 Credit Hours)**
Tutorial that accompanies Chem 10181.
*Corequisites:* CHEM 10181, CHEM 11181

**CHEM 12182 Organic Structure and Mechanism - Tutorial (0 Credit Hours)**
Tutorial that accompanies CHEM 10182.
*Corequisites:* CHEM 10182

**CHEM 13171 Chemistry Problem Solving Skills (2 Credit Hours)**
This is a two-credit course taught in tandem with the chemistry lecture. The aims of this course are to provide students with the tools to become independent learners and to build a community of learners through demonstrating and discussing effective study habits and university-level study skills. Topics include preparing for class/lab, getting the most out of a lecture, how to read a science text book, concept cards and concept mapping, talk-throughs, test preparation, successful study groups, and self-analysis and monitoring one's learning. Students who complete this course should be able to exercise active study strategies, have increased confidence in how to approach their studies for upper-level courses, and grow in their abilities to think critically, analyze concepts, synthesize information, propose and test hypotheses, and problem solve.
*Corequisites:* CHEM 10171

**CHEM 13172 Chemistry Problem Solving Skills (1 Credit Hour)**
This is a one-credit course taught in tandem with the chemistry lecture. The aims of this course are to provide students with the tools to learn organic chemistry, and to build a community of learners through collective engagement with the material of organic chemistry. Topics include how to use the textbook effectively in concert with lecture, note-taking and engagement in lecture, how to study effectively in groups and by oneself, visualization of chemical structures in three-dimensions, how to sift through extraneous information to zero in on essential information, and how to build conceptual models and use them to analyze problems.
*Corequisites:* CHEM 10172, CHEM 11172, CHEM 12172

**CHEM 14171 Introduction to Chemical Principles (3-4 Credit Hours)**
This one-semester course, offered in the Fall, provides a thorough grounding in the fundamental principles governing chemical structure and reactivity. It is accompanied by laboratory work and by a tutorial section. Topics to be discussed include the quantum mechanical structure of atoms, models of chemical bonding, chemical equilibrium, acidity and basicity, and thermochemistry and thermodynamics. Recommended for students in the College of Engineering, College of Science, and for all pre-professional students.
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 14172 Chemical Principles Tutorial (0 Credit Hours)**
Tutorial section to accompany Chem 10171/14171

**CHEM 20098 Organic Chemistry I (3 Credit Hours)**
For students transferring organic chemistry credit from another institution. This course is the first of a two-semester sequence providing a thorough grounding in the basic principles of organic chemistry. Topics covered could include fundamental aspects of organic and biological structures and bonding, stereochemistry, the effect of structure on physical and chemical properties, applications of spectroscopic methods to assign structures, chemical reactivity, and mechanistic principles, and applications in synthesis.

**CHEM 20099 Organic Chemistry II (3 Credit Hours)**
For students transferring organic chemistry credit from another institution. This course is the second of a two-semester sequence providing a thorough grounding in the basic principles of organic chemistry. Topics covered could include fundamental aspects of organic and biological structures and bonding, stereochemistry, the effect of structure on physical and chemical properties, applications of spectroscopic methods to assign structures, chemical reactivity, and mechanistic principles, and applications in synthesis.

**CHEM 20103 Only Connect Chemistry & Art (3 Credit Hours)**
Only Connect Chemistry and Art is a course that integrates human experiences by exploring the intersection of art and chemistry. In this course, we will explore how these two disciplines are connected and discover how the ways of knowing practiced in each of these fields have much in common. In many ways, art and chemistry enrich each other and, at a deeper level, have a common approach to inquiry. Art and science involve observation, experimentation, and interpretation. They combine image and structure to communicate the complexity of ideas and find ways of knowing the world. At their heart, they both involve creative acts.
Satisfies the following University Core Requirements: WKIN - Core Integration

**CHEM 20204 Environmental Chemistry (3 Credit Hours)**
Discussion of basic chemical processes occurring in the environment, particularly those relating to the impact of humanity's technological enterprise.
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 20262 Mathematical Methods for the Chemical Sciences (3 Credit Hours)**
This course provides chemistry and biochemistry majors with mathematical background, chemical context, and problem-solving methods for problems that involve differential equations, linear algebra, and probability and statistics. Students will also be introduced to problem solving using scientific computing through, for example, Python, MATLAB, or Mathematica.
Prerequisites: MATH 10560
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

**CHEM 20273 Organic Reactions and Applications (3 Credit Hours)**
A second semester covering the basic principles of organic chemistry, including structure, bonding, physical and chemical properties, reactive intermediates, and reaction mechanisms. Additional emphasis on applications of reactions in synthesis and relationships to biochemical systems and other associated areas of current interest. Intended primarily for pre-professional and biological science majors. This course is generally taken in the Fall semester with the laboratory CHEM 21273.
Prerequisites: CHEM 10172 or CHEM 10182
*Corequisites:* CHEM 22273

**CHEM 20274 Chemistry across the Periodic Table (3 Credit Hours)**
Chemistry course which completes the 2-year chemistry sequence for students in the College of Science and pre-professional students. Extends principles of chemistry with an in-depth look at the periodic table and an emphasis on bioinorganic chemistry. Topics include: bonding across the periodic table, chemistry of the s and p block elements, d-block elements and coordination chemistry, and kinetics, catalysis, and redox/electrochemistry with applications to biological systems. This course is generally taken in the Spring semester with the laboratory CHEM 21274.
Prerequisites: CHEM 10172 or CHEM 10176 or CHEM 10182 or CHEM 20273 or CHEM 20283

**CHEM 20283 Organic Reactions and Applications (3 Credit Hours)**
A second semester covering the basic principles of organic chemistry, including structures, bonding, physical and chemical properties, reactive intermediates, and reaction mechanisms. Additional emphasis on applications of reactions in synthesis and relationships to biochemical systems and other associated areas of current interest. Intended primarily for chemistry and biochemistry majors.
Prerequisites: CHEM 10182
*Corequisites:* CHEM 21283
Satisfies the following University Core Requirements: WKST-Core Science & Technology

**CHEM 20284 Chemistry Across the Periodic Table (3 Credit Hours)**
This course will extend general principles of chemistry with an in-depth view of the rest of the periodic table. Topics covered include: bonding across the periodic table, chemistry of the s- and p-blocks, d-block and coordination chemistry, as well as chemical reactivity, kinetics, catalysis, and redox/electrochemistry.
Prerequisites: CHEM 20273 or CHEM 20283
*Corequisites:* CHEM 21284

**CHEM 21098 Organic Chemistry I Laboratory (1 Credit Hour)**
For students transferring organic chemistry credit from another institution. This course is the first of a two-semester organic chemistry laboratory sequence providing a thorough grounding in the fundamental laboratory principles of organic chemistry.

**CHEM 21099 Organic Chemistry II Laboratory (1 Credit Hour)**
For students transferring organic chemistry credit from another institution. This course is the second of a two-semester organic chemistry laboratory sequence providing a thorough grounding in the fundamental laboratory principles of organic chemistry.

**CHEM 21273 Organic Reactions and Applications Laboratory (1 Credit Hour)**
Experiments to accompany CHEM 20273
Prerequisites: CHEM 11172 or CHEM 11182

**CHEM 21274 Chemistry Across the Periodic Table Laboratory (1 Credit Hour)**
Experiments to accompany CHEM 20274.
Prerequisites: (CHEM 11172 or CHEM 11182)

**CHEM 21283 Organic Reactions and Applications Laboratory (1 Credit Hour)**
A laboratory to accompany CHEM 20283 that will emphasize organic techniques and synthesis.

**CHEM 21284 Chemistry Across the Periodic Table Laboratory (1 Credit Hour)**
A laboratory to accompany CHEM 20284 emphasizing inorganic synthesis and studies of chemical reactivity.
*Corequisites:* CHEM 20284

**CHEM 22273 Organic Reactions & Applications Tutorial (0 Credit Hours)**
Tutorial section to accompany Chem 20273.
*Corequisites:* CHEM 20273

**CHEM 23201 Chemistry Seminar (1 Credit Hour)**
To be taken fall semester of the sophomore year. Introduction to the communication of scientific knowledge.
Course may be repeated.
Enrollment is limited to students with a major in Biochemistry or Chemistry.

**CHEM 23202 Chemistry Seminar (1 Credit Hour)**
To be taken either semester of the sophomore through senior years. Introduction to the communication of scientific knowledge.
Prerequisites: CHEM 23201
Course may be repeated.
Enrollment is limited to students with a major in Biochemistry, Chemistry/Business, Chemistry/Computing or Chemistry.

**CHEM 23203 Chemistry Seminar (1 Credit Hour)**
Introduction to the communication of scientific knowledge.
Prerequisites: CHEM 23201
Course may be repeated.
Enrollment is limited to students with a major in Biochemistry, Chemistry/Business, Chemistry/Computing or Chemistry.

**CHEM 23212 Biochemistry Seminar (0 Credit Hours)**
A zero-credit seminar course offered in the fall term for sophomore biochemistry majors only. The seminar seeks to acquaint the biochemistry majors with 1) the biochemistry faculty members; 2) the types of research programs in biochemistry that are being carried out in the department; and 3) some general biochemistry concepts. Each meeting will be conducted by a different member of the biochemistry faculty.
Enrollment is limited to students with a major in Chemistry.

**CHEM 23273 Chemistry Problem-Solving Skills (1 Credit Hour)**
This is a one-credit course taught in tandem with the chemistry lecture. The aims of this course are to provide students with the tools to learn organic chemistry, and to build a community of learners through collective engagement with the material of organic chemistry. Topics include how to use the textbook effectively in concert with lecture, note-taking and engagement in lecture, how to study effectively in groups and by oneself, visualization of chemical structures in three-dimensions, how to sift through extraneous information to zero in on essential information, and how to build conceptual models and use them to analyze problems.
*Corequisites:* CHEM 20273

**CHEM 24310 History of Medicinal Chemistry & Drug Development (3 Credit Hours)**
This class constitutes a survey of the history of medicinal chemistry and drug development. The course will begin by briefly looking at ancient medicines of the antiquity and middle-ages before highlighting the modern-era discovery of groundbreaking drugs and medicinal practices and culminate with an outlook on both industrial and academic research structure. Various drug classes, their structures features and mechanisms of action will be discussed at a level that requires organic chemistry 1 (but not biochemistry) as a prerequisite. This includes a unit on pharmacology & toxicology where students will learn how to assess both the safety and efficacy of drugs. The processes governing modern day pharmaceutical drug development and the different phases of clinical research will also be discussed in this context. This course is recommended for pre-medical students or students pursuing careers in the health sector as well as Chemistry students interested in a career in drug development. This is a study abroad course that will be taught in Germany during Summer 2025. Lectures will be supplemented with field trips to various science and medicine museums/sites of interest and tours of research and development of German Pharmaceutical companies in Berlin, Frankfurt and Munich. See syllabus for details.

**CHEM 25171 Gen Chem Problems (0 Credit Hours)**
This course is intended for upper class undergraduate students who are currently serving as Huddle leaders in a General Chemistry lecture course (instructor approval is required for enrollment). The purpose of this course is to engage in problem-solving and review current topics from the corresponding General Chemistry lecture in preparation for assisting undergraduate learners in peer-facilitated study groups.
Prerequisites: SC 25000 (may be taken concurrently)
Course may be repeated.

**CHEM 30301 Molecular Neuroscience (3 Credit Hours)**
This course will cover the chemical basis of neuronal transmission. This course will first be offered to upper-level NSBH majors, but will eventually become one of the three core courses for Neuroscience and Behavior majors. This course will be the most "chemistry-oriented" of the three core NSBH classes.
Prerequisites: ((CHEM 10172 and CHEM 11172) or (CHEM 10182 and CHEM 11182)) and BIOS 10172 and (NSBH 20450)

**CHEM 30321 Physical Chemistry I (3 Credit Hours)**
A rigorous course in the fundamentals of physical chemistry, including chemical thermodynamics, kinetics, quantum mechanics, and the elements of atomic and molecular structure.
Prerequisites: (MATH 10560 or MATH 10092 or MATH 10850 or MATH 20550 or MATH 10093) and (PHYS 30220 or PHYS 10320 or PHYS 10096 or PHYS 10094 or PHYS 20330 or CHEM 20262)
Enrollment limited to students in the College of Science college.

**CHEM 30322 Physical Chemistry II (3 Credit Hours)**
For science majors only. Second semester of Physical Chemistry. A rigorous course in the fundamentals of physical chemistry, including chemical thermodynamics, kinetics, quantum mechanics, and the elements of atomic and molecular structure.
Prerequisites: CHEM 30321

**CHEM 30324 Physical Chemistry for Engineers (3 Credit Hours)**
A course in the fundamentals of physical chemistry, emphasizing theoretical and experimental aspects of reaction kinetics, an introduction to quantum theory and a critical appreciation of the nature of the chemical bond. The course also explores how spectroscopic techniques allow us to gain insight into the structure and properties of molecules.
Prerequisites: (CHEM 10171 or CHEM 10097 or CHEM 10181) and (PHYS 10320 or PHYS 10094)
Enrollment limited to students in the College of Engineering college.

**CHEM 30331 Chemistry in Service of the Community (3 Credit Hours)**
Students will learn about the analytical principles and laboratory procedures needed to measure lead in paint, dust, soil, and water. Class discussions will cover experimental design, new methods for lead detection, how lead acts in the body and brain, the epidemiology of lead exposure, and the medical and regulatory responses to lead. Each student will propose and carry out an analytical chemistry research project aimed at reducing the harms caused by lead in our community.
Prerequisites: (CHEM 11171 or CHEM 11181) and (CHEM 11172 or CHEM 11182)

**CHEM 30333 Analytical Chemistry I (3 Credit Hours)**
Introduction to the principles, theory, and applications of analytical chemistry. Course covers modern mehods for separation of mixtures, quantitative and qualitative analysis and trace analysis.
Prerequisites: CHEM 10097 or CHEM 10172 or CHEM 10176 or CHEM 10182
*Corequisites:* CHEM 31333
Enrollment is limited to students with a major in Biochemistry, Chemistry/Business, Chemical Engineering or Chemistry.

**CHEM 30338 Physical Biochemistry (3 Credit Hours)**
This course provides a rigorous grounding in physical chemistry for the undergraduate biochemistry majors at Notre Dame. The course introduces core concepts of physical chemistry pertinent to the behavior of biological molecules. The emphasis is on thermal physics, with an introduction to biological spectroscopy. Students will learn how the principles of molecular physics illuminate the mechanisms and evolution of biological molecules and our abilities to manipulate them.
Prerequisites: CHEM 20262 and (PHYS 30210 or PHYS 10310) and (PHYS 30220 (may be taken concurrently) or PHYS 10320 (may be taken concurrently))

**CHEM 30341 Fundamentals of Biochemistry (3 Credit Hours)**
This course is offered for undergraduate biochemistry majors and is generally taken in the junior year. The course covers the basic chemical and physical principles of the primary biomolecules: protein, carbohydrates, lipids and nucleic acids. The structures and properties of these molecules and their relevance to biological processes will be integrated.
Prerequisites: (CHEM 20273 or CHEM 20283)
Students cannot enroll who have a major in Biochemistry.

**CHEM 30342 Intermediary Metabolism (3 Credit Hours)**
This course is offered for undergraduate biochemistry majors. The course is a study of the major metabolic processes involving energy storage and utilization, emphasizing the relationships between biomolecular structure and metabolic function. Throughput, regulation, and integration of pathways are presented.
Prerequisites: CHEM 30341

**CHEM 30351 Materials Chemistry for Energy, Electronics, and Sustainability (3 Credit Hours)**
This class discusses the underlying chemical and physical principles of solid-state materials that give rise to their unique properties that set them apart from molecular species, including: charge transport, light absorption/emission, surface chemistry, and magnetism and other collective electronic phenomena. Further, a portion of the course will focus on spectroscopic and diffraction-based methods for analyzing materials, whose study will reinforce understanding of materials' underlying structure-property relationships.
Prerequisites: CHEM 10171 or PHYS 10320

**CHEM 31322 Physical Chemistry Laboratory (2 Credit Hours)**
A course in the experimental aspects of physical chemistry using modern techniques of measurement. The laboratory includes thermodynamic, kinetic measurements, spectroscopic measurements, and measurements in reaction dynamics.
Prerequisites: CHEM 30321
*Corequisites:* CHEM 30322

**CHEM 31333 Analytical Chemistry Laboratory (1 Credit Hour)**
A laboratory course in the techniques of analytical chemistry.
Prerequisites: CHEM 30333 (may be taken concurrently)

**CHEM 31341 Fundamentals of Biochemistry Laboratory (2 Credit Hours)**
This course is designed to let students explore some of the techniques that are utilized in characterizing proteins, lipids, carbohydrates and nucleic acids. It exposes students to modern biochemical and instrumental methods for elucidating the structural and functional properties of these important types of molecules. Biochemistry majors only.

**CHEM 33301 Drug Detectives Lab Seminar (1 Credit Hour)**
This course is a one credit lab seminar in which the students will evaluate the quality of suspicious medications from around the world. The students will learn about the economic and regulatory issues that enable low quality drugs to be sold. In lab, they will detect and document whether adulterants, degradation, or substitute active pharmaceutical ingredients are present in a sample. The results the students obtain will help improve the quality of medicine in low resource settings.
Prerequisites: (CHEM 20273 or CHEM 20283) and (CHEM 21273 or CHEM 21283)

**CHEM 34320 Physical Chemistry Laboratory (0-1 Credit Hours)**
Physical Chemistry: A general course, including chemical thermodynamics, basic quantum chemistry and spectroscopy, polymers and colloids, and kinetics.

**CHEM 34321 Physical Chemistry (3-6 Credit Hours)**
CHEM 30060 Quantum Mechanics at UCD, CH 2000 Chemistry II at TCD. Quantum Mechanics. Failures of classical mechanics, particle-wave duality. Uncertainty principle, particle in a box, tunnelling. Harmonic oscillator and vibrational motion. Angular momentum and rotational motion. Pauli principle. Born-Oppenheimer approximation.Molecular Spectroscopy. Electromagnetic radiation, the interactions between electromagnetic radiation and atoms and molecules. Rotational spectra, rigid and non-rigid rotors, rotational spectra of molecules. Vibrational spectra, harmonic and anharmonic oscillators, vibrational-rotational spectra of molecules. Electronic spectra, atomic and molecular absorption and emission spectra, vibrational-electronic spectra, Franck-Condon principle.

**CHEM 34322 Thermodynamics and Reaction Kinetics (3 Credit Hours)**
Physical Chemistry: A general course, including chemical thermodynamics, basic quantum chemistry and spectroscopy, polymers and colloids, and kinetics

**CHEM 34324 Physical Chemistry for Engineers (3 Credit Hours)**
This module introduces the background to our current understanding of atomic structure and describes the modern view of the atom in terms of quantum theory. The quantum theory is applied to the electronic structure of the elements and is used to demonstrate how the chemical and physical properties of elements are related to the arrangement of the electrons in atoms. The quantum approach is then applied to understand the ways in which atoms form bonds with each other in molecules and how different modes of bonding can affect the structure, shape and properties of molecules. Finally, the range of interactions that can occur between atoms and molecules are explored and the roles that such interactions play in determining the properties of various materials are examined.

**CHEM 34330 Analytical Chemistry Lab (0-2 Credit Hours)**
Analytical Chemistry : Chemistry of stratosphere. Ozone chemistry -Chapman model. Spectroscopy of O2 and O3. Quantum yields of photochemical reactions. Determination of ozone concentration. Effect of pollutants. HOX, CIOX and NOX cycle. Role of aerosols. Analytical Chemistry : Overview of the analytical method. Survey of analytical techniques. Calibration curves. Sources and types of error in analytical measurements. Simple statistical techniques and ideas applied to data analysis in analytical chemistry. Analytical Chemistry : Aim: to establish the principles determining the natural background of elements, particularly in the aquatic environment. References are made to the "Brent Spar" episode, and to "black smokers".)

**CHEM 34333 Analytical Chemistry (3-4 Credit Hours)**
Study of Selected topics in industrial and applied chemistry. HT - Hong Kong, China (HKUST) Fundamental and practical aspects of chemical analysis, including titrimetric, electrical, optical and mass spectroscopic methods, analytical separations by chromatography.

**CHEM 34342 Intermediary Metabolism (3 Credit Hours)**
This course examined key metabolic pathways and associated enzymes in the interconversion and storage of cellular energy. Students participated in various lectures, tutorials and laboratory practicals learning about the regulation and molecular mechanisms in processes such as carbohydrate metabolism, fatty acid synthesis and oxidation, ketone body synthesis and oxidation, amino acid metabolism, nitrogen disposal, electron transport chain and oxidative phosphorylation, and photosynthesis. HT - Hong Kong, China In this course, students will learn the principle of bioenergetics as well as major biochemical pathways and regulatory mechanisms involved in intermediary metabolism. The course encompasses the following topics: Energetics of life, introduction to metabolism and experimental analysis of metabolism; Carbohydrate metabolism; Lipid metabolism; Metabolism of nitrogenous compounds; Nucleotide metabolism; Integration and control of metabolic processes. In addition, students are acquainted with daily examples applicable to topics taught in the course.

**CHEM 40200 Unlocking the Secrets of Rare Cancers: Mutations and Targeted Therapies (3 Credit Hours)**
This course will provide students with in-depth understanding of the research involved with development of targeted therapies for rare cancers. Through lectures by faculty experts, active discussion, and group work, students will develop skills to evaluate the clinical presentation of rare cancers, assess the effects of specific mutations on cancer cells and their regulatory networks, and investigate current treatments and novel targeted therapies based on this information to propose potentially effective treatments for patients. Prior completion of CHEM 40420 strongly encouraged.
Prerequisites: ((CHEM 10171 or CHEM 10172 or CHEM 10122) or (CHEM 10181 and CHEM 10182) and (BIOS 10161 or BIOS 20201 or BIOS 10171) and (BIOS 10162 or BIOS 20202 or BIOS 10172))

**CHEM 40301 Environmental Exposures and the Nervous System (3 Credit Hours)**
This course will be an upper-level elective describing how environmental exposures can affect human health and disease, particularly as it relates to the nervous system. This is a three-credit course intended for upper-level students with a background in neuroscience, which includes NSBH majors from CoS and CoA&L as well as Biochemistry majors with a Neuro concentration.
Prerequisites: CHEM 30301 or NSBH 30301
Satisfies the following University Core Requirements: WRIT - Writing Intensive

**CHEM 40404 Neuropharmacology (3 Credit Hours)**
This course will cover how exogenous drugs interact with the nervous system to produce immediate and long-term chemical, systems, and subjective effects. This will be an upper-level elective course for NSBH majors or other students who have an interest in Neuropharmacology.
Prerequisites: ((CHEM 10172 and CHEM 11172) or (CHEM 10182 and CHEM 11182)) and (SC 20450 and SC 21450) and (BIOS 20202 or BIOS 20201 or BIOS 10172) and (CHEM 40420 or CHEM 30341 or CHEM 30301)

**CHEM 40420 Principles of Biochemistry (3 Credit Hours)**
A general treatment of the various areas of modern biochemistry including protein structure and function, bioenergetics, molecular basis of genetic and developmental processes, cellular mechanisms and intermediary metabolism.
Prerequisites: CHEM 10172 or CHEM 10176 or CHEM 10182 or CHEM 20273 or CHEM 20283

**CHEM 40426 The Chemistry of Fermentation & Distillation (3 Credit Hours)**
This course is an overview of the chemical and physical processes that take place during the fermentation and distillation of alcoholic beverages. This course is intended as a science elective for science and engineering students who have had at least one year of chemistry at Notre Dame. It will provide an overview of chemical concepts needed to understand the molecules, reactions, separations, and physical transformations during the production of wine, beer, and distilled spirits, but it will also discuss fermentation in a broader culinary, cultural, and industrial context.
Prerequisites: CHEM 10172 or CHEM 10182 or CHEM 10122

**CHEM 40435 Electrochemistry and Electrochemical Engineering (3 Credit Hours)**
This course addresses the fundamentals and applications of technologies that rely on heterogeneous electron transfer reactions. The first part of the course addresses fundamental aspects of electron transfer reactions at electrified interfaces, including band structure of metals and semiconductors, electrochemical potentials, electron transfer kinetics and Marcus theory, potential step and potential sweep experiments, hydrodynamic electrochemistry, potentiometry and ion-selective electrodes, impedance measurements, and electrochemical instrumentation. The second part of the course addresses applications to energy storage (batteries, fuel cells, supercapacitors), energy conversion (photovoltaics), bioelectrochemistry, including neurochemistry, corrosion, and electrolysis and electroplating.

**CHEM 40436 Instrumental Methods of Analysis (3 Credit Hours)**
This course provides an understanding of how instrumentation used in the laboratory works. Modern science relies on advanced instrumentation to detect and analyze chemical compounds. In the class, instrument design is broken down into fundamental components, such as signal filtering, detection, and analysis. The origins of different chemical signals as well as the strengths and limitations of different techniques are addressed.
Prerequisites: CHEM 20274 or CHEM 20284

**CHEM 40438 Polymer Chemistry: from Principle to Practice (3 Credit Hours)**
This course offers the basic physical and organic chemistry knowledge in polymerization reactions. Topics to be covered include mechanisms of polymerization reactions; polymerization kinetics and thermodynamics; relationship of physical properties to structure and composition; correlations of applications with chemical constitution; functional polymers for medicines and electronics. The course is recommended for students with special interest in polymer materials and future plan on polymer research and professional studies.
Prerequisites: CHEM 30322 or CHEM 30324 or CHEM 30337

**CHEM 40443 Inorganic Chemistry (3 Credit Hours)**
Group Theory, Molecular Orbital Theory, structure, and spectroscopy are used as vehicles for the examination of inorganic, organometallic, and solid state chemistry.
Prerequisites: (CHEM 20284 or CHEM 20274) and (CHEM 30324 or CHEM 30322)

**CHEM 40531 Hallmarks of Cancer & Therapy (3 Credit Hours)**
Topics in the course include major mechanisms or "hallmarks" that promote carcinogenesis and impact cancer therapy, the contributions of the epithelium and tumor microenvironment to epithelial cancer progression, and the mechanisms of action or potential limitations of described cancer therapies. Using primary literature, students also will learn to evaluate a scientific paper and articulate major elements of scientific writing. This cancer overview course is designed for all graduate students with an interest in cancer research regardless of the extent of their biology or cancer biology background.

**CHEM 40534 Methods in Biochemistry (3 Credit Hours)**
Survey of biochemical methods used to evaluate macromolecular structure, function, and concentration; and properties of cells, tissues, and organisms. Course is based predominantly on primary literature.

**CHEM 40560 Chemical Biology (3 Credit Hours)**
This graduate course will approach biological subjects with an intension of integrating them with chemistry in a seamless manner. Knowledge of biology at the freshman level and of one year of organic chemistry will be a pre-requisite. This course is intended for graduate students aspiring to do studies at the interface of chemistry, biochemistry and biology. The course is also open to advanced undergraduates (senior level).

**CHEM 40570 Structural Biology (3 Credit Hours)**
Structural biology relates the three-dimensional, atomic-level structures of biological macromolecules to their function and is a key pillar of research in biomolecular science and engineering. This course provides students with an understanding of structural biology, including the principles of macromolecular structures and the major techniques of structural biology, including X-ray crystallography, cryo-electron microscopy, nuclear magnetic resonance, and computational modeling. Students will see how structural biology is used to gain insight into biological and biochemical mechanisms, how structures guide the development of therapeutics, and how structural organization scales across biology.
Prerequisites: CHEM 30341 or CHEM 40420

**CHEM 40610 Organometallic Chemistry (3 Credit Hours)**
Structure and reactions of organometallic compounds and applications to synthetic and catalytic reactions.

**CHEM 40614 Advanced Inorganic Chemistry (3 Credit Hours)**
A course in modern inorganic chemistry, incorporating the chemistry of clusters, organometallic chemistry, bioinorganic chemistry and photochemistry. Emphasis is placed on a molecular orbital approach to topics in main group and transition metal chemistry. Aspects of solid-state chemistry are also included.

**CHEM 40616 Solid State and Materials Chemistry (3 Credit Hours)**
A survey of synthesis, structure (geometric and electronic), spectroscopy, dynamic properties, and reactivity of solid state compounds of the main group and transition metal elements.

**CHEM 40618 Chemical Crystallography (3 Credit Hours)**
Outline: This course will cover the theoretical and practical aspects of Small Molecule X-ray Crystallography. There will be both lecture and laboratory sessions with this course. Topics covered include: crystal growth, the diffraction experiment, space group analysis, symmetry, structure solution and refinement, powder diffraction, use of typical software for diffraction studies. The laboratory session will cover the practical aspects of crystal selection and the use of X-ray diffractometers.

**CHEM 40630 Intermediate Organic Chemistry (3 Credit Hours)**
Intermediate organic chemistry provides the foundation for the advanced physical organic and advanced synthetic organic chemistry courses for first year graduate students in all areas of concentration. Emphasis will be placed upon fundamental aspects of organic reactivity and structure including reactive intermediates, reaction mechanisms, stereochemical principles, conformational analysis, and molecular orbital theory.

**CHEM 40631 Physical Organic Chemistry (3 Credit Hours)**
Covalent and non-covalent bonding in organic molecules, reactive intermediates and reaction mechanisms.

**CHEM 40632 Advanced Organic Synthesis (3 Credit Hours)**
The chemistry of organic functional groups including preparations, reactions, interconversions and transformations. Reagent and reaction design with emphasis on chemo-, regio-, and stereoselectivity including asymmetric synthesis.

**CHEM 40634 Structural Elucidation (3 Credit Hours)**
The interpretation of data from NMR, IR, MS, UV-Vis, and X-ray crystallography with an emphasis on the practical, rather than the theoretical point of view. (Spring)

**CHEM 40648 Special Topics in Physical Chemistry (1-3 Credit Hours)**
Current topics of modern experimental physical chemistry. Recent special topic offerings have included: Nanotechnology, Time-dependent Spectroscopy, Machine Learning for Chemists.

**CHEM 40649 Quantum Mechanics (3 Credit Hours)**
A survey of quantum mechanics at an intermediate level, oriented toward problems of chemical interest. Relevant mathematical concepts are developed, including Dirac notation, matrix algebra, orthogonal functions, and commutator relations. Topics covered include harmonic oscillators, central field problems, wave packets, angular momentum, and approximation methods.

**CHEM 40650 Computational Chemistry I (3 Credit Hours)**
An overview of the fundamental theory, methodology, and applications of computational chemistry. Topics include molecular dynamics and Monte Carlo simulations, as well as a wide range of quantum chemistry methods. Applications center on organic molecules and biological systems such as proteins and DNA. Hands-on computer experience is an integral part of these courses. (Fall and spring)

**CHEM 41443 Advanced Inorganic Chemistry Laboratory (2 Credit Hours)**
The preparation of main group inorganic, coordination and organometallic compounds, including air-sensitive manipulations and the use of vacuum-line techniques. Characterization of inorganic compounds by spectroscopic and electrochemical methods.
Prerequisites: CHEM 40443 (may be taken concurrently)

**CHEM 44404 Neuropharmacology of Great Britain (3 Credit Hours)**
In "Neuropharmacology in Great Britain," you will learn about the basic tenants of pharmacology and classes of drugs that affect the brain, with particular emphasis on drugs that have been important in Great Britain's culture and history.

**CHEM 44405 Neuropharmacology (3 Credit Hours)**
This course will cover how exogenous drugs interact with the nervous system to produce immediate and long-term chemical, systems, and subjective effects. This will be an upper-level elective course for NSBH majors or other students who have an interest in Neuropharmacology.
Prerequisites: (CHEM 10172 and CHEM 11172) or (CHEM 10182 and CHEM 11182 and BIOS 10172 and SC 20450 and SC 21450)

**CHEM 44420 Principles of Biochemistry (3 Credit Hours)**
This module forms part of the stage 2 core curriculum in the BSc degree programme in Biochemistry and a number of related disciplines. The course introduces students to the fundamental building blocks for the molecules of life: proteins, carbohydrates and lipids, and gives the student information on the utilisation and manipulation of these molecules by the cell emphasising how molecular structure dictates the functional properties of these molecules. The concept of biochemical catalysis and the properties of enzymes will be introduced. Additionally, the course describes basic biochemical methods for the purification, identification and manipulation of these compounds. Main topics include: nucleic acids, amino acids, protein structure, carbohydrates, lipids and membrane structure; enzymes and cofactors; enzyme mechanism, kinetics and regulation. BIOC 20050 Principles of Biochemistry at UCD

**CHEM 44423 Biomolecular Sciences (3 Credit Hours)**
Main topics include: amino acids, protein structure, carbohydrates, lipids and membrane structure; enzymes and cofactors; enzyme mechanism, kinetics and regulation, energy metabolism, amino acid and lipid metabolism, introduction to molecules and processes of the immune response.

**CHEM 44434 Physical Methods of Chemistry (3 Credit Hours)**
A course in molecular structure examined through the theory and interpretation of spectra. The focus is on infrared spectroscopy, mass spectrometry, nuclear magnetic resonance spectroscopy, and X-ray crystallography, with exposure to other techniques such as two-dimensional NMR, Raman spectroscopy, optical spectroscopy, and electron spin resonance.

**CHEM 44437 Chemistry of Materials (3 Credit Hours)**
An introduction to inorganic and organic materials will be given which includes the design and function of commodity polymers and selected high-performance and functional materials. Examples include polymers for microelectronic and biomedical uses, structure and composition of high-temperature superconductors and the design and function of photovoltaic cells. Taught as CHEM 30090 at UCD.

**CHEM 44498 Special Studies: Undergraduate Research (2,3 Credit Hours)**
Taught at a host institution. SCI 30010 Introduction to Scientific Research at UCD; This module introduces students to the principles of scientific research through attachment to an active research group in the College of Science. Students will become active members of a research group and work under the direction of the group's Principal Investigator. Students will learn about the research focus of the group and conduct independent research into the scientific literature of relevance to the group's activity. They will shadow a member of the research team in the laboratory and master one basic and one advanced laboratory skill. Based on the research activity of the research group, students will learn about developing a research hypothesis and designing experiments to test the hypothesis. Using data generated by themselves and/or the group, students will learn how to analyse the research data and, where appropriate, how to determine whether the differences between control and test data are significantly different from each other. Students will also learn how to write a scientific abstract and a scientific report as well how to make a scientific presentation. IC Galway description: The Scientific Research Experience module is a 3-(Notre Dame) credit module, in which students can undertake hands-on tasks to gain expertise in experimental observations and analytical techniques using contemporary technologies and approaches. Students are required to conduct at least 8-10 hours of practical work per week over the semester, meet regularly with their faculty mentors, and complete any relevant health and safety and/or ethics training. Students will receive a grade based on the completion of the required research commitment, quality of discussions with mentors, and assessment of a background paper and final report describing the research experience.

**CHEM 44610 Organometallic and Solid State Chemistry (3 Credit Hours)**
Main group organometallic chemistry of elements from groups 1, 2, 13 and 14 will be discussed in detail, while the organometallic chemistry of the metallic and metalloid elements of groups 12, 15 and 16 will be mentioned. In addition, metal-metal bonding and metal-oxygen bonding will be treated as special topics. The structures of polyoxometallates and chromium diacetate will be presented, which both will be synthesised in the practical part of the course in addition to a metallocene compound and their acetylation products. Organozirconocene and sandwich-type metallocene complexes and their chemistry, transition metal carbonyl chemistry and homogeneous hydrogenations will be presented. Structure and reactivity of transition metal carbene compounds will be outlined.

**CHEM 44616 Modern Methods and Applications of Catalysis (3 Credit Hours)**
Modern Methods and Applications of Catalysis.This module will introduce students to recent developments in catalytic chemistry of use in synthetic chemistry. Many transition metals mediate synthetic transformations and the most useful are those that do so using catalytic amounts of metal, normally bound to ligands which help to solubilise the complexes. The ligands employed also can serve to accelerate catalysis and in special cases can be of use in asymmetric synthesis. This course is divided into three sections, the first of which describes the applications of Pd-catalysis to modern organic synthesis. Emphasis will be placed on Heck reaction, cross-couplings, aryl aminations and ether formations, CO insertions and allylic substitution. The second section features recent advances in hydroformylation and olefin metathesis. The final section outlines the applications and mechanisms of organocatalysis, with an emphasis on asymmetric transformations.

**CHEM 46495 Directed Readings - Photochemistry: From Basics to Applications (1 Credit Hour)**
Course will cover modern theories of photochemistry, the diversity of photochemical reactions of organic compounds, as well as their applications. It will cover the interplay between light and molecules - from fundamental principles of photochemistry to cutting-edge applications in chemistry, the biomedical field and material science. Prerequisite: Organic Chemistry
Prerequisites: CHEM 10172

**CHEM 46497 Directed Readings (0.5-10 Credit Hours)**
In-depth study of topics not covered or only briefly covered in other courses. Readings, problems and reports.
Course may be repeated.

**CHEM 48498 Undergraduate Research (0-3 Credit Hours)**
Research in collaboration with members of the faculty. A written progress report must be submitted each semester, and all participating students must make an oral presentation of their work in the spring semester of senior year. To obtain approval to register, students must submit a research application via this online form: https://nd.qualtrics.com/jfe/form/SV_dgmj6GRka3Gi54a
Course may be repeated.

**CHEM 48499 Undergraduate Research (1 Credit Hour)**
For internships taken during the preceding or succeeding term. Credit toward graduation for up to two internships is available for Chemistry or biochemistry students upon departmental approval. At the completion of the internship, students are expected to write a reflection paper, and participate in one virtual panel discussion on experiential learning opportunities.
Course may be repeated.

**CHEM 48500 Research Thesis in Chemistry and Biochemistry (1 Credit Hour)**
A course in scientific writing to produce a thesis that describes work undertaken in the course of an undergraduate research project. Through written drafts of a thesis that are critiqued by the thesis director, skills in organizing and presenting scientific data, scientific literacy, and writing are enhanced.