

# CHEMISTRY (CHEM-UH)

## CHEM-UH - Chemistry: Biophysics Elective (1-6 Credits)

(to be used for substitutions and transfer credit)

**Grading:** Ugrd Abu Dhabi Graded

**Repeatable for additional credit:** Yes

- Bulletin Categories: Chemistry: Biophysics Electives

## CHEM-UH 2010 Organic Chemistry 1 (5 Credits)

*Typically offered Spring*

Organic chemistry is the study of carbon-containing compounds. Organic Chemistry 1 presents the structure and bonding, conformational analysis, stereochemistry, and spectroscopy of organic materials, subjects that partly trace their roots to the development of quantum theory. The topics covered include basic reaction mechanisms, such as substitution and elimination, and the reactions of aliphatic and aromatic hydrocarbons, alcohols, ethers, carbonyl compounds, and carboxylic acids. The course incorporates modern analytical methods that are the cornerstone of contemporary organic chemistry. The laboratory introduces organic chemistry techniques for the separation, purification, identification, and synthesis of organic compounds, incorporating modern analytical methods that are the cornerstone of contemporary organic chemistry.

**Grading:** Ugrd Abu Dhabi Graded

**Repeatable for additional credit:** No

**Prerequisites:** Foundations of Science 1-4.

- Bulletin Categories: Biology Major: Required
- Bulletin Categories: Biology
- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry
- Bulletin Categories: Engineering Crosslisted Courses
- Bulletin Categories: Engineering: Bioengineering SCIENCE Electives
- Crosslisted with: Biology Major: Required
- Crosslisted with: Biology
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Engineering Common Courses (ECC)
- Crosslisted with: Engineering

## CHEM-UH 2201 Advanced Materials (4 Credits)

*Typically offered Fall*

This course will provide an introduction to advanced materials science and engineering, and will emphasize the breadth of this interdisciplinary, rapidly growing field. The synthesis, organization, and processing of materials can enable functional performance. The course material will overview the preparation of both organic and inorganic materials, and will later expand on the available methods for their characterization. Special emphasis will be given to the optimization of materials' performance and the relationship between the structure and properties of materials. The target-oriented design of materials will also be described through the underlying processes, structure, properties, and performance, with particular focus on applications in energy conservation, sustainability and biomedicine. About half of the course will be dedicated to soft materials (polymers, liquid crystals, biomaterials), and the remaining half will focus on hard materials (semiconductors, metals, alloys, and optical materials). Both the science-driven approach (used in materials science, polymer science) and the design-driven approach (used in engineering) will be presented.

**Grading:** Ugrd Abu Dhabi Graded

**Repeatable for additional credit:** No

**Prerequisites:** Foundations of Science 3-4 or PHYS-UH 2115.

- Bulletin Categories: Chemistry: Electives
- Bulletin Categories: Engineering Crosslisted Courses
- Bulletin Categories: Engineering: Bioengineering SCIENCE Electives
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Engineering Common Courses (ECC)
- Crosslisted with: Engineering

## CHEM-UH 3010 Organic Chemistry 2 (5 Credits)

*Typically offered Fall*

Organic Chemistry 2 is a continuation of Organic Chemistry 1, with an emphasis on multifunctional organic compounds and their reactions from both a synthetic as well as a mechanistic viewpoint. The topics include conjugated systems, aromatic compounds, including phenols and aryl halides as well as a thorough discussion of delocalized chemical bonding; aldehydes and ketones; amines; carboxylic acids and their derivatives; and biologically important molecules. The course continues the emphasis on modern analytical methods that are the cornerstone of contemporary organic chemistry.

**Grading:** Ugrd Abu Dhabi Graded

**Repeatable for additional credit:** No

**Prerequisites:** CHEM-UH 2010, MATH-UH 1020 and Foundations of Science 1-6.

- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry
- Bulletin Categories: Engineering Crosslisted Courses
- Bulletin Categories: Engineering: Bioengineering SCIENCE Electives
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Engineering Common Courses (ECC)
- Crosslisted with: Engineering

**CHEM-UH 3011 Physical Chemistry: Thermodynamics and Kinetics (4 Credits)***Typically offered Fall*

This course covers two fundamental concepts in physical chemistry: equilibrium thermodynamics and chemical kinetics, which examine the relationship between energy and matter and rates of reactions, respectively. The definition and the interpretation of basic issues in chemistry, including internal energy, transition states, chemical potential, reaction rates, phase transitions and catalysis, are described in detail.

This course uses an extensive mathematical apparatus. The course provides a firm theoretical and practical knowledge necessary to resolve typical chemical problems by focusing on the deeper understanding of their physical foundation and meaning.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Prerequisites:** Foundations of Science 1-6 Corequisite: CHEM-UH 3012.

- Bulletin Categories: Biology: Biophysics Electives
- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry
- Bulletin Categories: Engineering Crosslisted Courses
- Bulletin Categories: Engineering: Bioengineering SCIENCE Electives
- Bulletin Categories: Physics: Biophysics Electives
- Crosslisted with: Biology Major: Required
- Crosslisted with: Biology
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Engineering Common Courses (ECC)
- Crosslisted with: Engineering
- Crosslisted with: Physics Major: Required
- Crosslisted with: Physics

**CHEM-UH 3012 Physical Chemistry Laboratory: Thermodynamics and Kinetics (2 Credits)***Typically offered Fall*

This laboratory is coupled to the lectures in CHEM-UH 3011 and provides students with the skills required for performing experiments in physical sciences. The course introduces the principles and practices of physicochemical methods in thermodynamics and kinetics, and it continues with introducing more contemporary experimental and computational methods used in analytical, organic, physical, and biological chemistry laboratories. The experiments include thermochemical techniques such as calorimetry to determine the heat exchange during chemical reactions or physical processes, construction and interpretation of phase diagrams of binary and ternary mixtures, measurement and prediction of kinetic rates of chemical reactions, and determination of rate constants. A computational experiment is also included. After this course, students will be able to approach a chemical problem, set up a hypothesis, perform accurate measurements, interpret the results, verify the hypothesis, draw conclusions, and communicate effectively orally and in writing.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Corequisites:** CHEM-UH 3011.

- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry
- Bulletin Categories: Engineering Crosslisted Courses
- Bulletin Categories: Engineering: Bioengineering SCIENCE Electives
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Engineering Common Courses (ECC)
- Crosslisted with: Engineering

**CHEM-UH 3013 Physical Chemistry: Quantum Mechanics and Spectroscopy (4 Credits)***Typically offered Spring*

This course is primarily devoted to quantum mechanics, a theory that currently plays a central role in structural chemistry, theoretical chemistry, and spectroscopy. In contrast to classical mechanics, which describes the interaction of energy and matter on large bodies, quantum mechanics focuses on the interactions of energy and matter at the atomic and subatomic level. Hence, this course provides detailed insight into modern approaches that explain the structure and spectra of atoms and molecules. After completion of this course, students are able to understand the origins and meanings of key chemical concepts, including wave functions, atomic and molecular orbitals, energy levels, hybridization, atomic and molecular spectra, and electron spin. Students are also able to interpret various spectra - electronic, rotational, infrared, and nuclear magnetic resonance - and to correlate these to the structures of atoms and molecules.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Prerequisites:** Foundations of Science 1-6 Corequisite: CHEM-UH 3014.

- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry

**CHEM-UH 3014 Physical Chemistry Laboratory: Quantum Mechanics and Spectroscopy (2 Credits)***Typically offered Spring*

This laboratory course is coupled to the lectures in CHEM-UH 3013 and focuses on the principles and use of modern computational and experimental methods for predicting structure and energy, spectroscopic characterization, and structure determination. The students become familiar with modern instrumental methods such as absorption (ultraviolet-visible) spectroscopy, fluorescence spectroscopy, infrared spectroscopy, nuclear magnetic resonance, and structure analysis by single crystal X-ray diffraction. The students learn how to use and interface analytical equipment, acquire, process and analyze data, and interpret the results. After the completion of this course, students are able to characterize materials by using common analytical methods.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Corequisites:** CHEM-UH 3013.

- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry

**CHEM-UH 3015 Inorganic Chemistry (4 Credits)***Typically offered Spring*

Inorganic chemistry is the study of all elements in the periodic table as well as the compounds they form and the reactions that lead to the formation of new compounds. This course includes the study of structure from atomic level to molecular level. Students will understand how atoms connect to form molecules and how molecules are assembled together to form the structure of materials. This course also studies the properties of elements and of the different compounds they form.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No

- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry

**CHEM-UH 3016 Analytical Chemistry (4 Credits)***Typically offered Fall*

This course will cover both classical analytical chemistry and instrumental methods of analysis in a 14-week period. It will start with the fundamentals of analytical chemistry, which include chemical equilibrium and how it underpins acid-base titrations, complexometry, redox and precipitation titrations, as well as gravimetric methods of analysis. In addition, experimental errors, statistical analysis of data, propagation of uncertainty, distribution of measurements and results, limits of detection, will also be presented. The next section in this course will provide the theoretical basis for the most important and widely used instrumental methods of analysis. This will include atomic spectrometry, molecular spectroscopy, as well as molecular mass spectrometric techniques. The main emphasis will be to explain how instrumental methods can be used to quantitate a variety of analytes present at trace levels in complex samples. This includes the use of some of the most powerful chromatographic techniques which are vital for separating complex mixtures of compounds and analytes in a wide range of sample types.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Corequisites:** CHEM-UH 2010.

- Bulletin Categories: Biology: Biophysics Electives
- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry
- Bulletin Categories: Physics: Biophysics Electives
- Crosslisted with: Biology Major: Required
- Crosslisted with: Biology
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Physics Major: Required
- Crosslisted with: Physics

**CHEM-UH 3020 Biochemistry: Macromolecular Structure and Function (4 Credits)***Typically offered Fall*

Biochemistry investigates the chemical structures, reactions, and processes that occur in living systems. Indeed, the very principles of chemistry, biology, physics, and math converge in the field of biochemistry, and biochemical concepts provide a focal point for many disciplines, including biology, healthcare, the pharmaceutical industry, environmental studies and ecology, and our understanding of evolution. This course opens the study of biochemistry with a rigorous investigation of biological macromolecules, including the structure and function of proteins, nucleic acids, carbohydrates, and lipids. This discussion then leads to the investigation of enzyme structure, including their mechanism of action and their regulation, moving toward a deep understanding of information flow in cells via detailed biochemical studies of replication, transcription, and translation.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Prerequisites:** Foundations of Science 5-6.

- Bulletin Categories: Biology: Biophysics Electives
- Bulletin Categories: Biology: Electives
- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry
- Bulletin Categories: Engineering Required Elective Courses
- Bulletin Categories: Engineering: Bioengineering SCIENCE Electives
- Bulletin Categories: Physics: Biophysics Electives
- Crosslisted with: Biology Major: Required
- Crosslisted with: Biology
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Engineering Common Courses (ECC)
- Crosslisted with: Engineering
- Crosslisted with: Physics Major: Required
- Crosslisted with: Physics

**CHEM-UH 3021 Biochemistry: Metabolism (4 Credits)***Typically offered Spring*

Biochemistry investigates the chemical structures, reactions and processes that occur in living systems. Indeed, the very principles of chemistry, biology, physics, and math converge in the field of biochemistry, and biochemical concepts provide a focal point for many disciplines, including biology, healthcare, the pharmaceutical industry, environmental studies and ecology, and our understanding of evolution. This course opens the study of metabolic pathways by which cells catabolize and metabolize carbohydrates, lipids, and proteins. The course examines the mechanisms of the different reactions that constitute these pathways and the regulatory mechanisms that control their efflux in living systems. Review of scientific literature broadens students' understanding of metabolism in the human body with special focus on human diseases.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Prerequisites:** CHEM-UH 2010.

- Bulletin Categories: Biology: Electives
- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry
- Crosslisted with: Biology Major: Required
- Crosslisted with: Biology
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry

**CHEM-UH 3022 Biochemistry: Experimental Biochemistry (4 Credits)***Typically offered Fall*

Students majoring in life sciences and bioengineering require hands-on experience with variety of biotechnology techniques to better prepare them for a graduate degree or industry. Students will be trained to master biochemical techniques for the manipulate of macromolecules and build a firm understanding of how research is conducted in postgraduate institutions. Inquiry based learning will drive students to learn biophysical tools for the characterization of proteins' structures and functions.

Discussions on fundamental biochemical principles and experimental techniques will assist the students to design and conduct a research project. Students in groups of two will propose a project, run experiments, present data to their peers, and write a final report. First, a protein will be expressed in *E. coli*, purified using column chromatography on a Fast Protein Liquid Chromatography (FPLC) system. Analysis will include kinetic and enzyme mechanistic characterization, structural characterization using circular dichroism (CD) and fluorescence spectroscopy, and thermodynamic stability using Differential Scanning Fluorimetry (DSF) and Differential Scanning Calorimetry (DSC).

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Corequisites:** CHEM-UH 3020.

- Bulletin Categories: Biology: Biophysics Electives
- Bulletin Categories: Biology: Electives
- Bulletin Categories: Chemistry: Electives
- Bulletin Categories: Physics: Biophysics Electives
- Crosslisted with: Biology Major: Required
- Crosslisted with: Biology
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Physics Major: Required
- Crosslisted with: Physics

**CHEM-UH 3090 Research Seminar in Chemistry (2 Credits)***Typically offered Fall*

The research seminar provides students with an overview of the diverse, multidisciplinary research areas that have captured the interest and fascination of chemists and others in related fields at NYU Abu Dhabi. Through exposure to faculty research, students identify potential areas of interest for their own capstone research, and over the course of the semester develop and put into writing an in-depth research proposal that will form the core of their capstone project. The final capstone project proposal is due at the end of the seminar so that students can begin the Capstone Project in Chemistry in the fall semester of their senior year. Students who have chosen chemistry as their secondary major do not need to complete the research seminar course; students must instead take two courses in their chosen elective that are not research courses.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No

- Bulletin Categories: Chemistry Major: Required
- Bulletin Categories: Chemistry

**CHEM-UH 3101 Physical Chemistry for the Life Sciences (2 Credits)***Typically offered Fall*

This is a 2-credit course on physical chemistry specializes in life sciences. The Physical chemistry is a broad application area in the study of biosciences. This course is designed to give an understanding of the principles of physical chemistry that play a crucial role in the field of biomaterials, bioinstrumentation, mechanobiology as well as biophysics. Students will learn physical chemistry concepts, their interpretations and their applications in the area of bioscience. This course will particularly cover the three fundamental areas of physical chemistry relevant to life sciences: (i) equilibrium thermodynamics, (ii) chemical kinetics and biomolecular transport, and (iii) principles of spectroscopic and structural determination techniques, respectively.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Prerequisites:** Foundations of Science 3-4.

- Bulletin Categories: Chemistry: Electives
- Bulletin Categories: Engineering: Bioengineering Required
- Bulletin Categories: Required Science Courses
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Engineering Common Courses (ECC)
- Crosslisted with: Engineering

**CHEM-UH 3130 Computational Biology & Biophysics (4 Credits)***Typically offered Fall*

The aim of this course is to walk students through the main ideas in computational techniques used in structural biology and biophysics. Emphasis will be given to the algorithms and ideas pertaining to modeling structure, dynamics, and interactions of proteins and nucleic acids using computer simulations. Current approaches in structure prediction, biomolecular dynamics, and Monte Carlo simulations will be covered. To assist students in developing a practical understanding of the methods, hands-on exercises and projects will be provided. Special topics including computer-aided drug design and the use of machine learning approaches in studying biology and biophysics will be discussed.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No

- Bulletin Categories: Biology: Biophysics Required
- Bulletin Categories: Chemistry: Biophysics Required
- Bulletin Categories: Physics: Biophysics Required
- Crosslisted with: Biology Major: Required
- Crosslisted with: Biology
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Physics Major: Required
- Crosslisted with: Physics

**CHEM-UH 3201 Interdisciplinary Magnetic Resonance (4 Credits)***Typically offered Spring*

This Interdisciplinary course on Magnetic Resonance Spectroscopy provides an introduction to Nuclear Magnetic Resonance (NMR), Electron Paramagnetic Resonance (EPR) in the solution and solid state, and Magnetic Resonance Imaging. The course provides a theoretical foundation and experimental skills to develop an aptitude for various magnetic resonance techniques in different disciplines such as structural biology, biomedical imaging, catalysis, materials characterization, spin engineering, and also the emerging quantum information science. The course also covers the application of nuclear magnetic resonance in industries, including petrochemistry and pharmaceuticals. Students will have the opportunity to work on a 3-week short project on a topic of their choice, e.g., multidimensional spectral analysis for proteins, pharmaceuticals, soft matter, catalysis, instrumentation, spin engineering, numerical simulation, magnetic resonance in health.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Prerequisites:** Foundations of Science 3-4.

- Bulletin Categories: Biology: Biophysics Electives
- Bulletin Categories: Chemistry: Electives
- Bulletin Categories: Engineering Crosslisted Courses
- Bulletin Categories: Engineering: Bioengineering ENGR Electives
- Bulletin Categories: Physics: Biophysics Electives
- Bulletin Categories: Psychology: Brain Cognitive Sci Spec: Electives
- Crosslisted with: Biology Major: Required
- Crosslisted with: Biology
- Crosslisted with: Chemistry Major: Required
- Crosslisted with: Chemistry
- Crosslisted with: Engineering Common Courses (ECC)
- Crosslisted with: Engineering
- Crosslisted with: Physics Major: Required
- Crosslisted with: Physics
- Crosslisted with: Psychology Major: Required
- Crosslisted with: Psychology

**CHEM-UH 3260 Special Topics in Chemistry (4 Credits)***Typically offered occasionally*

This course provides in-depth treatment of an area of current interest in chemistry. Lectures present background material and address current problems in the area related to the topic. Students read and discuss review articles and current literature on the topic. Course content is determined on a semester-by-semester basis and focus on interdisciplinary topics.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** Yes

- Bulletin Categories: Chemistry: Electives

**CHEM-UH 4001 Capstone Project in Chemistry 1 (4 Credits)***Typically offered Fall and Spring*

The senior capstone experience in chemistry is designed to engage students in a long-term, mentored learning experience that culminates in a piece of original research and/or scientific theory. The research project focuses on the art of scientific problem solving through theoretical analysis and/or experimental and technical design. The capstone project provides an opportunity for students to use their knowledge and skills to identify and solve a problem or answer a question in the field of chemistry. The students design and execute a project under the guidance of a faculty mentor.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Prerequisites:** CHEM-UH 3090.

- Bulletin Categories: Chemistry: Capstone

**CHEM-UH 4002 Capstone Project in Chemistry 2 (4 Credits)***Typically offered Fall and Spring*

This is a continuation of Capstone Project in Chemistry 1. During this semester, the project culminates in a presentation and a written document of significant length that describes the work in detail.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**Prerequisites:** CHEM-UH 4001.

- Bulletin Categories: Chemistry: Capstone

**CHEM-UH 4210 Biophysical Chemistry (4 Credits)***Typically offered occasionally*

Applications of physical and chemical principles to topics of biochemical and biological interest with an emphasis on the basic principles underlying biophysical techniques that are used to study important macromolecules such as proteins and nucleic acids. Topics in this course include molecular spectroscopic techniques such as light absorption, fluorescence, and circular dichroism, as well as nuclear magnetic resonance and vibrational spectroscopy. Applications of these methods to important biophysical, biochemical, and biological problems of current interest such as protein folding, imaging, and protein-DNA and protein-protein interactions are discussed.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No

- Bulletin Categories: Chemistry: Electives

**CHEM-UH 4211 Bioorganic Chemistry (4 Credits)***Typically offered occasionally*

Covering a broad range of topics at the interface between organic chemistry and biology, this course focuses on current advances in bioorganic chemistry and chemical biology.

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No

- Bulletin Categories: Chemistry: Electives

**CHEM-UH 4212 Advanced Organic Chemistry (4 Credits)**

*Typically offered Spring*

This course builds upon the concepts and skills learned in Organic Chemistry 1 and 2, applying them to the study of advanced concepts in structure, reactions and their mechanisms, and the multi-step synthesis of complex molecules. The course applies principles of stereochemistry, thermodynamics, kinetics, and molecular orbital theory to functional group transformations, pericyclic and photochemical reactions, and carbon-carbon bond formations. The reactions are placed into context by a comprehensive discussion of the multi-step synthesis of important complex organic molecules, such as drug molecules and natural products, with an emphasis on retrosynthetic analysis.

**Grading:** Ugrd Abu Dhabi Graded

**Repeatable for additional credit:** No

**Prerequisites:** CHEM-UH 3010 and Foundations of Science 1-4.

- Bulletin Categories: Chemistry: Electives