



## Department of Chemistry

Chemistry forms the link between the fundamental principles governing the nature of the universe and the science of life. Chemistry education at SNU provides focus on a variety of inter-disciplinary areas, spanning different scientific disciplines as well as non-traditional areas in the arts and humanities, *e.g.* a Major in Chemistry can be combined with a Minor in Bioinformatics at SNU. Or you can pursue a Major in Chemistry with a specialization in either Chemical Physics or Chemical Biology.

Our research programs reach across the campus and beyond, linking together departments, schools, inter-disciplinary centers and internship opportunities in the chemical industry and national labs. University-wide elective courses in the curriculum allow students unprecedented freedom to explore subjects outside their chosen major, in some depth. This flexible and broad curriculum prepares students not just for a career in chemistry upon graduation, but for a leadership role in the world as well.

### The Undergraduate Chemistry Experience

The chemistry curriculum at SNU provides both a broad background in chemical principles and in-depth study of chemistry or chemistry-related areas that build on this background. The chemistry curriculum is divided into three categories: introductory general chemistry, foundation courses providing breadth across sub-disciplines, and rigorous in-depth courses that build upon these foundations and develop critical thinking and problem-solving skills. Since chemistry is an experimental science, substantial laboratory work is an integral part of almost all our courses. The introductory general chemistry course provides a common grounding in basic chemical concepts for students with diverse backgrounds, develops basic mathematical and laboratory skills, and prepares students for the foundation courses. Foundation courses in analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, and physical chemistry provide breadth and lay the groundwork for more in-depth course work.

**Laboratory Experience:** The chemistry laboratory experience at SNU includes synthesis of molecules; measurement of chemical properties, structures, and phenomena; hands-on experience with modern analytical instrumentation; and computational data analysis and modeling. All laboratory programs are conducted in a safe environment that includes adherence to national and state regulations regarding hazardous waste management and laboratory safety including, facilities for chemical waste disposal, safety information and reference materials, and personal protective equipment available to all students and faculty. The chemistry laboratories at SNU are equipped with functioning fume hoods, safety showers, eyewashes, first aid kits, and fire extinguishers must be readily available. Students are trained in modern chemical safety, to understand responsible disposal techniques, understand and comply with safety regulations, understand and use material safety data sheets (MSDS), recognize and minimize potential chemical and physical hazards in the laboratory, and know how to handle laboratory emergencies effectively.

**Problem-Solving Skills:** As part of the SNU experience, students will be expected to develop the ability to define problems, develop testable hypotheses, design and execute experiments, analyze data using statistical methods, and draw appropriate conclusions. The chemistry curriculum provides ample opportunities for developing both written and oral communication skills, as well as team skills. Our instructional programs incorporate team experiences in classroom and laboratory components of the chemistry curriculum.

## **Careers in Chemistry**

Chemistry forms the scientific basis for a wide variety of career options, ranging from traditional areas such as pharmaceuticals, chemical analysis and synthesis, quality control and quality assurance, to interdisciplinary fields such as molecular biology, materials science and biophysics, and non-traditional areas such as medicine, patent or environmental law, forensic science, technical writing, art conservation, environmental studies, *etc.*

## **Undergraduate Research in Chemistry**

Research activities are not confined to post-graduate level, but are integrated into the under-graduate program at SNU through our REAL (Research Experiential & Applied Learning) courses. Undergraduate research allows students to integrate and reinforce chemistry knowledge from their formal course work, develop their scientific and professional skills, and create new scientific knowledge. Original research culminating in a comprehensive written report provides an effective means for integrating undergraduate learning experiences, and allows students to participate directly in the process of science. Opportunities for research in chemistry at SNU are available in the following broad areas:

- Bioinorganic Chemistry
- Organic and Polymer Chemistry
- Structural Chemistry
- Quantum Chemistry and Cheminformatics
- Medicinal Chemistry
- Nanomaterials
- Organometallic and Environmental Chemistry
- Chemical Biology

## **Major in Chemistry**

The basic undergraduate degree program offered by the Department of Chemistry is the four-year Bachelor of Science (BS) in Chemistry. By taking extra courses, in consultation with the Undergraduate Advisor of the Department, a student can also be eligible for award of any of the following degrees:

- BS Chemistry Honours
- BS Chemistry Honours with a Chemistry Specialization
- BS Chemistry with a Minor

Every chemistry undergraduate student of the University is required to take a number of credits from courses broken up into the following categories:

- a) CCC (Common Core Curriculum courses offered by the university)
- b) UWE (University Wide Electives; courses so designated and offered by departments other than Chemistry)
- c) Introductory Chemistry courses (CHY100 – 199)
- d) Foundation Chemistry courses (CHY200 – 299)
- e) In-Depth Chemistry courses (CHY300 – 499)

The credit requirements are:

- a) **BS Chemistry: 84** credits = 76 credits in compulsory courses (10 Introductory + 23 Foundation + 16 In-Depth + 27 Required Physics/Maths/Life Sci/CS) + 8 credits chosen from the Chemistry electives.
- b) **BS Chemistry Honours: 90** credits = 79 credits in compulsory courses (10 Introductory + 23 Foundation + 16 In-Depth + 27 Required Physics/Maths/Life Sci/CS + 3 Senior Project) + 11 credits chosen from the Chemistry electives.
- c) **BS Chemistry Honours with specialization in Chemical Physics: 97** credits (10 Introductory + 23 Foundation + 24 In-Depth + 37 Required Physics/Maths/Life Sci/CS courses + 3 Senior Project).
- d) **BS Chemistry Honours with specialization in Chemical Biology: 96** credits (10 Introductory + 23 Foundation + 28 In-Depth + 32 Required Physics/Maths/Life Sci/CS courses + 3 Senior Project).
- e) **BS Chemistry Honours with specialization in Materials: 90** credits = 86 credits in compulsory courses (10 Introductory + 23 Foundation + 23 In-Depth + 27 Required Physics/Maths/Life Sci/CS + 3 Senior Project) + 4 credits chosen from the Chemistry electives.
- f) **BS Chemistry Honours with specialization in Informatics: 95** credits in compulsory courses (10 Introductory + 23 Foundation + 20 In-Depth + 39 Required Physics/Maths/Life Sci/CS + 3 Senior Project).

## Minor in Chemistry

Undergraduate students of the university who are not majoring in Chemistry have the option to take a Minor in Chemistry.

### Academic Requirements for Chemistry Minor:

**29** credits = 21 credits in compulsory courses (10 Introductory + 11 Foundation) + 8 credits chosen from the Chemistry electives.

## Chemistry Course Catalog

The chemistry program at SNU provides both a broad background in chemical principles and in-depth study of chemistry or chemistry-related areas that build on this background. The chemistry curriculum is divided into three parts: (1) the introductory chemistry experience, (2) foundation course work that provides breadth, and (3) rigorous in-depth course work that builds on the foundation. Because chemistry is an experimental science, substantial laboratory work is an integral part of this experience.

**Introductory or General Chemistry:** The introductory or general chemistry experience plays a vital role in educating all students. The introductory courses provide a common background for students with a wide range of high school experiences, and allow a period for consolidation of chemical concepts, as well as mathematical and laboratory skills. For students pursuing a chemistry major, the introductory chemistry courses provide preparation for the foundation course work, ensuring that students know basic chemical concepts such as stoichiometry, states of matter, atomic structure, molecular structure and bonding, thermodynamics, equilibria, and kinetics. Students also need to be competent in basic laboratory skills such as safe practices, keeping a notebook, use of electronic balances and volumetric glassware, preparation of solutions, chemical measurements using pH.

CHY101:       **Applied Chemistry** (5 credits: 3 Lectures+ 1 Tutorial + 3-hour Lab) Monsoon

This course will focus on applying principles of chemistry to engineering problems. The principles taught in the course will enable the conceptualization of engineering models. Topics include the problems associated with using untreated water in industries; selecting appropriate methods of treating water for industrial and domestic purposes; understanding the properties of polymers; applications of engineering plastics and relation to properties; constructing electrochemical cells; determining the chloride and iron content in electrolytes; corrosion related problems which occurs due to improper design / selection of materials / incompatible environment; selecting an appropriate method of corrosion prevention; manufacture of coke, cracking, and production of water gas and producer gas; methods of coal analysis.

*Prerequisite:* None.

CHY111:       **Chemical Principles** (5 credits: 4 Lectures/Tutorial + 3-hour Lab) Monsoon

This course will focus on introductory chemical principles, including periodicity, chemical bonding, molecular structure, organic functional groups, equilibrium and the relationship between structure and properties. Students will explore stoichiometric relationships in solution and gas systems which are the basis for quantifying the results of chemical reactions. Understanding chemical reactivity leads directly into discussion of equilibrium and thermodynamics, two of the most important ideas in chemistry. Equilibrium, especially acid/base applications, explores the extent of reactions while thermodynamics helps us understand if a reaction will happen. The aim of the laboratory will be to develop your experimental skills, especially your ability to perform meaningful experiments, analyze data, and interpret observations. This is a required course for Chemistry majors, but also satisfies UWE requirements for non-majors.

*Prerequisite:* None.

CHY112:        **Structure and Bonding** (5 credits: 3 Lectures+ 1 Tutorial + 3-hour Lab) Spring

This course will introduce atomic theory, classical and quantum bonding concepts, and chemical kinetics. Students will be introduced to new lab techniques and ways to measure progress of reactions. Kinetics (rates of reaction) provides information about how reactions work and, along with thermodynamics, provides the basis for evaluating the viability of a reaction. This concept will be explored particularly with respect to substitution reactions. The class will have reading assignments and lecture/discussion meetings at which we will critically examine the major concepts, discuss articles, and review some of the current developments in the field. Taking Chemical Principles and Structure and Bonding provides a good background for students interested in environmental applications. This is a required course for Chemistry majors, but also satisfies UWE requirements for non-majors.

*Prerequisite:* Chemical Principles.

CHY140: **Chemistry of Color and Art** (4 credits: 3 Lectures+ 3-hour Lab) Spring [REAL]

This inter-disciplinary course will introduce students to the basic principles of optics, and the chemical principles behind the colors of gemstones and pigments. Absorption and scattering of light, emission of light from gases and generation of light from electricity, chemical reactions and thermal radiation will be discussed. Students will have the opportunity to discover for themselves the fundamentals of chemical and digital photography, color vision and art. Field trips to natural locations, art galleries and museums will be included to provide opportunities for creating individual works of art.

*Prerequisite:* None.

**Foundation Courses:** Foundation courses provides breadth and lays the groundwork for the in-depth course work in each of the five major areas of chemistry: analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, and physical chemistry. The chemistry laboratory experience at SNU includes synthesis of molecules; measurement of chemical properties, structures, and phenomena; hands-on experience with modern instrumentation; and computational data analysis and modeling. Students get hands-on experience with a variety of analytical instruments, including spectrometers, and are expected to understand the operation and theory of modern instruments and use them to solve chemical problems as part of their laboratory experience.

CHY211:        **Chemical Equilibrium** [+ Lab] (4 credits) Monsoon

The primary focus of this course will be a capstone project developed by each student. The student will develop a question, research background, develop an experimental plan, carry it out and present the results to the class. In class we will explore real chemical questions involving equilibrium and acid base chemistry, by reading and discussing research papers. We will also consider topics of interest such as electrochemistry, surface phenomena, solution chemistry and chemistry of heavy metals.

*Prerequisites:* Chemical Principles, Structure & Bonding, Organic Reactions & Mechanisms.

CHY213: **Chemical Analysis lab** (3 credits) Monsoon

Instrumental Methods of Chemical Analysis are the core experimental components of modern chemistry. Students of this course will gain proficiency in the most commonly used methods of analysis.

*Prerequisites:* Chemical Principles, Structure & Bonding.

CHY221: **Organic Reactions and Mechanisms** [+ Lab] (4 credits) Monsoon

Reactions and Mechanisms focuses on how reactions happen: what are the steps, how do we discover them, and how we use this to look at some practical systems: the synthesis of a drug, the kinetics of substitution. Emphasis will be using the general principles such as nucleophiles and electrophiles, to guide an understanding of specific reactions. Lab will focus on several clusters of experiments designed for students to extend what they know to answer questions of their own.

*Prerequisites:* Chemical Principles, Structure & Bonding.

CHY242: **Coordination Chemistry** [+ Lab] (4 credits) Spring

The principles of group theory will be introduced in this course to present a comprehensive understanding of the chemistry of transition metal complexes and organometallic compounds. Students will synthesize interesting compounds and perform reactions to promote the understanding of common reactions. Intensive use of analytical and spectroscopic techniques to interpret extent of reaction and purity of product will be involved.

*Prerequisites:* Chemical Principles, Structure & Bonding.

CHY244: **The Nature of Materials** [+ Lab] (3 credits) Spring [REAL]

Students will apply the principles of chemistry to substantive research projects that they will design, execute, and present. Lecture material will focus on the principles behind modern materials such as polymers, semi-conductors, and novel nanostructures.

*Prerequisites:* Chemical Principles, Structure & Bonding, Organic Reactions & Mechanisms.

CHY252: **Biochemistry** (4 credits: 3 Lectures+ 3-hour Lab) Spring [REAL]

Students in this course will apply principles from general and organic chemistry, as well as general biology, to understand the molecular processes that characterize life. The goal of this class will be to give students a solid background with which they can appreciate the chemistry of life. Beginning with fundamental principles, the course will then delve into a detailed look at metabolism - the specific means by which organisms use chemical energy to drive cell functions and how they convert simple molecules to complex biological molecules. Students will have the opportunity for independent work, and will apply the principles of biochemistry to a research project that they will design, execute, and present. Taking Chemical Principles, Structure & Bonding and Biochemistry provides the basic foundation for students interested in a minor in Bioinformatics.

*Pre/Co-requisites:* Chemical Principles, Structure & Bonding, Essentials of Biology.

**In-Depth Courses:** In-depth courses provide not only advanced instruction, but also development of critical thinking and problem-solving skills. Students are expected to be able to define problems clearly, develop testable hypotheses, design and execute experiments, analyze data using appropriate statistical methods, and draw appropriate conclusions, applying an understanding of all chemistry sub-disciplines. Students are also expected to be able to use the peer-reviewed scientific literature effectively and evaluate technical articles critically, learning how to retrieve specific information from the chemical literature, with the use of online, interactive database-searching tools.

CHY311:           **Chemical Binding** [+ Lab] (4 credits) Monsoon

Quantum mechanics provides the microscopic basis for a fundamental understanding of chemistry, molecular structure, bonding, and reactivity. This course and the associated computer lab provide a comprehensive treatment of valence bond and molecular orbital theories, post Hartree-Fock wave function and density functional methods. Students will learn to compute molecular structures, spectra, and thermochemical parameters for molecules in the gas-phase and for condensed-phase systems.

*Prerequisites:* Chemical Principles, Structure & Bonding, Calculus, Linear Algebra, physics, CS.

*Co-requisite:* Molecular Spectroscopy.

CHY313:           **Molecular Spectroscopy** [+ Lab] (4 credits) Monsoon

This course introduces the theory of molecular spectroscopy. Students will gain experience in several advanced spectroscopic techniques, and learn to interpret, electronic, vibration-rotation and nuclear magnetic resonance spectra in detail.

*Prerequisites:* Chemical Analysis lab.

*Co-requisite:* Chemical Binding.

CHY321:           **Molecular chirality and Isomerism**

Structural and Stereoisomerism chemistry, conformational analysis & optical activity. Enantiomer, Diastereomer and mesomers. R and S configuration and their importance in biological system.

CHY332:           **Informatics & Drug Discovery** [+ Lab] (4 credits)

This course and the associated computer lab deal with Bioinformatics and Cheminformatics, applied to the search for new drugs with specific physiological effects (*in silico* Drug Discovery). Students will learn the general principles of structure-activity relationship modeling, docking & scoring, homology modeling, statistical learning methods and advanced data analysis. They will gain familiarity with software for structure-based and ligand-based drug discovery. Some coding and scripting will be required. At the end of the course, students will be expected to present a completed piece of software of significant utility and/or an analysis of experimental data from the published literature. Students will be encouraged to seek avenues for publication of their most significant results.

*Prerequisites:* Organic Reactions and Mechanisms, Chemical Binding, Biochemistry, Statistics, Computer Science, Macromolecules.

CHY342: **Chemistry of Solids and Surfaces** [+ Lab] (4 credits) Spring

This course deals with solid state chemistry and surface chemistry. The use of techniques such as X-ray crystallography, surface plasmon resonance and microscopy to elucidate the structures of crystals and surfaces, and the details of bonding, will also be discussed.

*Prerequisites:* Chemical Principles, Structure & Bonding, Nature of Materials.

CHY344: **Topics in Nanotechnology** (3 credits) Spring

All aspects of modern life, including medicine, energy, computing, electronics and defense, are being radically transformed by nanotechnology. These technologies all involve the manipulation of structures at the atomic level - what used to be the stuff of fantasy is now reality. The economic impact of these developments is enormous. But, as with all new technologies, ethical and legal challenges will arise in their implementation and further development. This course will examine the science of nanotechnology and place it in the larger social context of how this technology may be, and already is, applied. Underlying physical science principles will be covered in lecture sessions and students will read articles from current news sources and the scientific literature. There will be short papers on topics of student interests, as well as a more comprehensive project in which students will examine the science and applications of a well-defined aspect of nanotechnology of their choosing.

*Prerequisites:* Chemical Principles, Structure & Bonding, Nature of Materials.

CHY351: **Macromolecules** (3 credits) Monsoon

The chemistry of Polymers and Biomolecules - proteins, DNA, RNA - forms the subject matter for this advanced course, which will also serve as an introduction to Molecular Biology. The molecular nature of genes, their encoding, translation, transcription and regulation, and primary, secondary, tertiary and quaternary structure of proteins will be covered. This course serves as a prerequisite for Informatics & Drug Discovery, Medicinal Chemistry and Polymers, and also as an elective for engineering students.

*Prerequisites:* Nature of Materials, Biochemistry.

CHY 352: **Polymers** (3 credits) Spring [REAL]

The chemistry of polymers, their synthesis and characterization will form the subject matter of this advanced course, which will follow a case-study approach. Students will be expected to apply their knowledge to a real-world problem of their choice.

*Prerequisites:* Chemical Principles, Nature of Materials, Macromolecules.

CHY411: **Dynamics of Chemical Reactions** [+ Lab] (4 credits) Monsoon [REAL]

The principles of chemical kinetics, as well as equilibrium and non-equilibrium statistical mechanics will be covered in this advanced course. The associated computer lab will introduce the student to classical and *ab initio* quantum molecular dynamics and Monte Carlo simulations of liquids and proteins. The techniques learned in this course will be applied to substantive research projects that the students will design, execute, and present. Students will be encouraged to seek avenues for publication of their most significant results

*Prerequisites:* Chemical Equilibrium, Chemical Binding, Macromolecules.

CHY413:        **Topics in the Philosophy of Chemistry** (3 credits) Spring [REAL]

Chemical concepts such as atoms, molecular structure, electron density, equilibrium, reaction path, etc. will be discussed from a historical and philosophical context. There will be numerous short papers on topics of student interest, as well as a more comprehensive project in which students will examine the historical and/or philosophical aspects of a chemical concept of their choosing.

*Prerequisites:* Chemical Principles, Structure and Bonding.

CHY415:        **Theoretical Chemistry Seminar** (3 credits) Spring [REAL]

This advanced course will cover special topics in quantum chemistry and statistical mechanics. Students will examine in-depth selected articles from the current scientific literature, and develop a viable research proposal in the chosen area.

*Prerequisites:* Chemical Binding.

CHY421:        **Organic Synthesis** [+ Lab] (4 credits) Spring [REAL]

Students will gain expertise in the techniques of organic synthesis. A major project will be the development of a research proposal based on the student's own question. Background from the literature will motivate the proposal and initial experiments will be proposed.

*Prerequisites:* Chemical Principles, Structure & Bonding, Organic Reactions & Mechanisms.

CHY442:        **Chemistry and Ceramics** (3 credits) Spring

What is clay? Why do glazes make such wonderful colors? Why does the water content of clay play such an important role in making pots? What do charges and ions and silicon have to do with ceramics? Making pottery is an art as old as civilization itself. The ancients who perhaps accidentally heated clay and discovered that heat gave the material different properties were among the first chemists. After thousands of years the basic procedure is still the same with some influences by modern technology. In this course we will learn basic ideas of chemistry and the more advanced ideas of transition metal chemistry to investigate the process of throwing and glazing pottery. Students will read papers and handouts, write a term paper exploring a chemistry problem in depth, and experiment with the ceramic form.

*Prerequisites:* Chemical Principles, Structure and Bonding.

CHY451:        **Introduction to Bioorganic Chemistry-**

Basic structure of nucleic acids, proteins, lipids and carbohydrates; biological functions and biosynthesis of precursors.

CHY453: **Forensic Chemistry**

Chemistry for Forensic Scientists, Skills for Forensic Scientists Crime Scene Science, Aspects of Forensic Science, Application of Forensic Science Forensic Science Dissertation, Advances in Forensic Chemistry, Forensic Toxicology.

**Course Requirements for BS Chemistry**

Course Number	Course Title	L:T:P	Chem. Hons. Major	Chem. Minor	Chem. Major	Chemistry Hons. Major with specialization				Prerequisites
						Chemical Physics	Chemical Biology	Materials	Informatics	
CHY111	Chemical Principles	3:1:1	•	•	•	•	•	•	•	None
CHY112	Structure and Bonding	3:1:1	•	•	•	•	•	•	•	CHY111
CHY211	Chemical Equilibrium	3:1:1	•	•	•	•	•	•	•	CHY111, CHY112
CHY213	Chemical Analysis lab	1:0:1	•	•	•	•	•	•	•	CHY111, CHY112
CHY221	Organic Reactions & Mechanisms	3:0:1	•	•	•	•	•	•	•	CHY111, CHY112
CHY242	Coordination Chemistry	3:0:1	•		•	•	•	•	•	CHY111, CHY112
CHY244	The Nature of Materials	3:0:1	•		•	•	•	•	•	CHY111, CHY112, CHY221
CHY252	Biochemistry	3:0:1	•		•	•	•	•	•	CHY111, CHY112, CHY221
CHY311	Chemical Binding	3:0:1	•		•	•	•	•	•	CHY111, CHY112, PHYS, MATH
CHY313	Molecular Spectroscopy	3:0:1	•		•	•	•	•	•	CHY213, CHY311
CHY332	Informatics & Drug Discovery	3:0:1	•		•	•	•	•	•	CHY221, CHY252, CHY311, CS, STAT
CHY351	Macromolecules	3:0:1	•		•	•	•	•	•	CHY244, CHY252
CHY411	Chemistry of Solids and Surfaces	3:0:1				•				CHY244, CHY311
CHY412	Dynamics of Chemical Reactions	3:0:1				•				CHY211, CHY311, CHY351
CHY414	Theoretical Chemistry Seminar	3:0:0								CHY311
CHY421	Organic Synthesis	3:0:1					•			CHY221
CHY422	Medicinal Chemistry	3:0:1					•		•	CHY252, CHY332, CHY351, CHY421
CHY452	Polymers	3:0:1					•	•		CHY244, CHY351
CHY444	Topics in Nanotechnology	3:0:0						•		CHY244
PHY	Physics I	3:1:1	•		•	•	•	•	•	
PHY	Physics II	3:1:1	•		•	•	•	•	•	
PHY	Physics III	3:1:1				•				
PHY	Physics IV	3:1:1				•				

MAT	Maths I	3:1:0	•		•	•	•	•	•	
MAT	Maths II	3:1:0	•		•	•	•	•	•	
MAT	Statistics	3:0:0							•	
LIF	Essentials of Biology	3:1:1	•		•	•	•	•	•	
LIF	Molecular Biology	3:1:1					•		•	
CS	Programming I	2:0:2	•		•	•	•	•	•	
CS	Programming II	2:0:2							•	
CHY499	Senior Project	0:0:3	•			•	•	•	•	
	Credits from Electives		11	8	8	-	-	4	-	
	<b>Total Credits</b>		<b>90</b>	<b>29</b>	<b>84</b>	<b>97</b>	<b>96</b>	<b>90</b>	<b>95</b>	

(Dots • refer to required **compulsory** courses for the specified program.)