ENGINEERING CHEMISTRY

Courses

ENCH 211 Main Group Chemistry Units: 4.75
An introduction to chemistry of main group inorganic and organic compounds with the use of fundamental quantum mechanics, molecular orbital diagrams and Lewis structures to describe the structure and bonding. The stereochemistry and chirality of organic compounds, solid-state inorganic chemistry, and descriptive chemistry of compounds of the main group elements will be covered. The laboratory will introduce skills in inorganic and organic synthesis.
(Lec: 3, Lab: 1.5, Tut: 0.25)
Requirements: Prerequisites: APSC 131, APSC 132
Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 57
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Describe basic instrumentations and techniques used in the study of main group chemistry.
2. Predict molecular shapes using VSEPR theory, valence bond theory, and molecular orbital theory.
3. Describe molecular shapes in terms of point groups, stereochemistry, and types of isomers.
4. Prepare molecular orbital diagrams and interpret them to predict bonding order and molecular reactivity.
5. Explain the causes of differences in structure and reactivity of compounds of different main group elements.
6. Search for and understand a published research article describing the structure, bonding or reactivity of a main group molecule.
7. Perform laboratory experiments using main group molecules given a written procedure.

ENCH 212 Principles of Chemical Reactivity Units: 4.00
An introduction to the kinetics and mechanisms of reactions in gaseous and condensed phases, including acid-base and nucleophilic substitution reactions at carbon and other main group centers. Other topics will include molecular dynamics and reactions in solution. The laboratory illustrates measurement techniques and develops laboratory skills
(Lec: 3, Lab: 0.75, Tut: 0.25)
Requirements: Prerequisites: APSC 111, APSC 112, APSC 131, APSC 132 Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 48
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Identify reactive sites on reagents.
2. Determine rate laws for simple chemical processes.
3. Articulate the meaning of transition state theory and associated activation parameters.
4. Predict and rationalize solvent and electronic effects on chemical reactivity.
5. Use experimental data obtained in the laboratory to study reaction kinetics.
6. Critically analyze and communicate scientific results.

ENCH 213 Introduction to Chemical Analysis Units: 4.75
Introduction to analytical chemical methods and science. Topics include statistical analysis of data, titrations and equilibrium theory, spectrophotometry and instrumental elemental analysis.
(Lec: 3, Lab: 1.5, Tut: 0.25)
Requirements: Prerequisites: APSC 131, APSC 132
Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 42
Complementary Studies 0
Engineering Science 15
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Perform statistical analysis to assess the quality of analytical data and the validity of analytical methods.
2. Determine sample concentrations of unknown species based on comparison to calibration standards.
3. Use different calibration strategies; accurately prepare calibration standards at desired concentration levels.
4. Apply fundamental concepts of chemical equilibria to evaluate the composition of complex solutions and heterogeneous samples.
5. Formulate, prepare and use buffer solutions for various applications.
6. Demonstrate the proper use of basic lab equipment for preparation of calibration standards, liquid and solid samples.
7. Use methods of analytical titrations for the determination of various chemical species.
8. Perform analytical procedures based on methods of UV-visible spectrophotometry, fluorescence spectroscopy and atomic spectrometry.

ENCH 222 Methods of Structure Determination Units: 3.75
A survey of practical spectroscopic and spectrometric methods for the determination of the structures of organic and inorganic compounds. Methods will include nuclear magnetic resonance, electronic, infrared/ Raman spectroscopy, and mass spectrometry. Tutorials will involve solving compound structures using spectroscopic data, and include an introduction to computational methods in spectroscopy.
(Lec: 3, Lab: 0, Tut: 0.75)
Requirements: Prerequisites: APSC 131, APSC 132
Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 45
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Understand the basic elemental composition of organic compounds.
2. Define basic spectroscopic properties of organic compounds.
3. Discuss trends in spectroscopic properties in organic functional groups.
4. Analyze IR, NMR (1H, 13C and 2D), Mass and UV-vis spectra of organic compounds.
5. Combine all spectroscopic data given to determine the molecular structure of an unknown organic compound.
6. Apply Spinworks to process experimental NMR data.

ENCH 245 Applied Organic Chemistry I Units: 4.75
A survey of organic functional group reactivity from a mechanistic perspective, including substitution, addition, elimination, rearrangement and redox reactions; extensive use of examples from industrial process chemistry. The laboratory provides experience in organic synthesis, including the preparation, purification and characterization of organic compounds.
(Lec: 3, Lab: 1.5, Tut: 0.25)
Requirements: Prerequisites: ENCH 211, ENCH 212 Corequisites: Exclusions: CHEM 223
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 41
Complementary Studies 0
Engineering Science 16
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Identify reactive sites and predict reactivity of nucleophiles, electrophiles, acids, bases, and leaving groups.
2. Write complete mechanisms for some of the most common types of reactions.
3. Explain reaction mechanisms of industrial importance.
4. Apply the mechanistic details of useful reactions encountered in chemical laboratories/industry to future applications and designs.
5. Conduct laboratory experiments focused on reactions and the synthesis of organic molecules.

ENCH 311 Mechanistic Organic Chemistry Units: 3.50
Fundamental mechanistic concepts of organic reactions, structure activity relationships, solvent effects and catalysis. Mechanistic aspects of substitution, addition, elimination and pericyclic reactions.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: ENCH 245 Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 42
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 312 Transition Metal Chemistry Units: 3.50
Introduction to the chemistry, bonding and structures of coordination compounds of the transition metals; transition metals in the solid state and in biological systems; industrial and environmental aspects of transition metal chemistry.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: ENCH 211 (CHEM 211)
Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 42
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Name transition metal complexes and draw structures based on the formulae, including determining the oxidation state of the metal, given a set of common coordinated ligands.
2. Describe the space group symmetry of crystalline compounds and diffraction techniques used in the study of transition metal compounds.
3. Interpret electronic spectra of transition metal complexes in terms of the relationships between energy and intensities of the transitions present in the spectrum and the nature of the metal and the coordinated ligands.
4. Predict the electronic and spin configurations, magnetic properties and reactivity of transition metal ions and their complexes based on the type of metal, its oxidation state and the nature of the coordinated ligands.
5. Explain the causes of differences in structure and reactivity of compounds of different transition elements.
6. Describe the electronic structures of solid transition metal compounds and how they impact the properties of functional material.
7. Describe the basic roles of transition metal ions and their complexes in biological systems.

ENCH 313 Quantum Mechanics Units: 3.50
Elementary principles and applications of wave mechanics with special reference to molecular orbitals and chemical bonding.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 210, MTHE 225
Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 21
Complementary Studies 0
Engineering Science 21
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Explain the historical motivation and fundamental ideas underlying quantum mechanics.
2. Calculate average values of observables using quantum mechanics.
3. Solve the Schrodinger equation for the particle-in-a-box, harmonic oscillator, and rigid rotor problems, relating to spectroscopy.
4. Describe the Born-Oppenheimer approximation, and the origin and features of potential energy surfaces.
5. Use perturbation theory and variational methods to calculate approximate energies.
6. Solve the Schrodinger equation for the hydrogen atom, explain the origins of the H atom orbitals.
7. Explain the fundamentals of electronic structure theory and apply electronic structure methods to compute energy levels.
8. Explain how quantum chemistry relates to a number of chemical concepts and properties.

ENCH 321 Instrumental Chemical Analysis Units: 3.00
Overview of instrumental methods of chemical analysis. Topics include gas and liquid chromatography, mass spectrometric detection, new separations methods, electrochemical analysis, inductively coupled plasma-based elemental analysis.
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: CHEE 270 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 322 The Chemical Bond: Computation and Spectroscopy Units: 3.50
The application of quantum mechanics to the structures and internal motions of molecules. The foundations of electronic, vibrational, rotational and NMR spectroscopy will be discussed together with their applications.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: ENCH 313 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 42
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 323 Biological Chemistry Units: 3.00
Introduction to the chemical basis of biological systems and biomolecules; protein structure and synthesis, enzyme catalysis, nucleic acids (DNA, RNA), carbohydrates, membranes, cell signalling, biosynthetic and metabolic pathways.
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: CHEE 342 or CHEE 324 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 326 Environmental and Green Chemistry Units: 3.00
The first part examines chemical contaminants in the atmosphere, water, soils and sediments, including sources, behaviour, transport, and distribution among these environments. The second part introduces Green chemistry, examining industrial sources of contaminants and the modification of industrial processes in order to minimize environmental impact.
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: ENCH 211, ENCH 212, ENCH 245 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 24
Complementary Studies 0
Engineering Science 12
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Describe the main chemicals that are important to environmental issues, including their fate and behaviour related to phenomena including ozone depletion, greenhouse gas effects, and toxicity in air and water.
2. Use partition calculations and fugacity-based models to describe the distribution of chemicals between different environmental compartments and relate this to molecular structure and properties.
3. Describe the main approaches for treating contaminated water before drinking or releasing to the environment.
4. Explain the principles of Green Chemistry including the main measures and metrics, including E-factors, environmental impacts, and energy consumption.
5. Design chemical processes using alternative feedstocks and reagents with green synthetic methods and strategies, including solventless conditions or use of preferred organic solvents, water, supercritical fluids, expanded liquids, ionic liquids, and liquid polymers.
6. Prepare a report proposing a green chemical process within a small group and present the this to a peer class including chemists, engineering chemists and chemical engineers.

ENCH 397 Experimental Chemistry Units: 7.00
Laboratory course introducing modern experimental methods in chemistry, including synthesis, analytical instrumentation and computational methods. The integration of several methods will be emphasized in the synthesis and characterization of molecules.
DELETED 2024-2025
(Lec: 3, Lab: 0.5, Tut: 0)
Requirements: Prerequisites: At least 6 units at the 200-level in ENCH/CHEM or permission of the Department. Corequisites: At least 3 units at the 300-level in ENCH/CHEM or permission of the Department. Exclusions:
Offering Term: FW
CEAB Units:
Mathematics 0
Natural Sciences 84
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. N/A

ENCH 398 Experimental Chemistry I Units: 3.50
Laboratory course. In consultation with the course coordinator, and subject to availability, students may select experiments as are relevant to their degree program including synthesis, analytical instrumentation and computational methods. The integration of several methods will be emphasized in the design and characterization of molecules.
DELETED 2024-2025
(Lec: 0, Lab: 3, Tut: 0.5)
Requirements: Prerequisites: (ENCH 211 or ENCH 212), ENCH 222, ENCH 245 Corequisites: At least 3 units at the 300-level in ENCH/CHEM or permission of the Department. Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 42
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Develop critical skills necessary for the analysis of experimental data in comparison to established theoretical chemical concepts.
2. Formulate scientific reports based on the critical evaluation of available theoretical and experimental data.
3. Perform complex lab procedures with little or no supervision to implement various chemical reactions in synthesis and catalysis.
4. Perform complex chemical separation and purification steps for subsequent compound characterization studies.
5. Perform compound and material characterization studies using common spectroscopic techniques.
6. Perform qualitative and quantitative chemical analysis using instrumental detection techniques based on gas and liquid chromatography.
7. Use specialized software to apply basic computational methods to evaluate fundamental chemical and physical properties of compounds.
8. Perform literature studies using online resources to identify and access published information pertaining to Chemistry and related fields.

ENCH 399 Experimental Chemistry II Units: 3.50
Laboratory course. In consultation with the course coordinator, and subject to availability, students may select experiments as are relevant to their degree program including synthesis, analytical instrumentation and computational methods. The integration of several methods will be emphasized in the design and characterization of molecules.
(Lec: 0, Lab: 3, Tut: 0.5)
Requirements: Prerequisites: (ENCH 211 or ENCH 212), ENCH 222, ENCH 245. Corequisites: At least 3 units at the 300-level in ENCH/CHEM Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 42
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Develop critical skills necessary for the analysis of experimental data in comparison to established theoretical chemical concepts.
2. Formulate scientific reports based on the critical evaluation of available theoretical and experimental data.
3. Perform complex lab procedures with little or no supervision to implement various chemical reactions in synthesis and catalysis.
4. Perform complex chemical separation and purification steps for subsequent compound characterization studies.
5. Perform compound and material characterization studies using common spectroscopic techniques.
6. Perform qualitative and quantitative chemical analysis using instrumental detection techniques based on gas and liquid chromatography.
7. Use specialized software to apply basic computational methods to evaluate fundamental chemical and physical properties of compounds.
8. Perform literature studies using online resources to identify and access published information pertaining to Chemistry and related fields.
9. Adhere to appropriate workplace safety protocols in all laboratory environments.

ENCH 411 Advanced Analytical Chemistry Units: 3.00
A discussion of recent advances in analytical chemistry and its applications to the environmental, materials and biomedical fields. At least four topics will be covered from sample preparation, separation methods, multidimensional chromatography, elemental spectroscopy, mass spectroscopy, and surface analysis methods. Additional topics will be selected from the current literature.
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: ENCH 213 Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 412 Statistical Mechanics Units: 3.00
The fundamentals of statistical mechanics with applications to thermodynamic properties of gases, liquids and solids and to chemical equilibrium in dilute gases.
NOT OFFERED 2024-2025
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: ENCH 313 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 413 Computational Chemistry Units: 3.00
The application of quantum mechanics to chemical structures, energetics, internal motions of molecules, and chemical reactions. An introduction to the use of modern electronic structure software in chemistry.
NOT OFFERED 2024-2025
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: ENCH 313 Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 414 Catalysis Units: 3.00
An advanced treatment of the concepts and applications of catalysis, including the kinetics of catalysis and topics selected from the areas of homogeneous, heterogeneous, and biocatalysis.
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: ENCH 245, ENCH 312 Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 415 Electrochemistry and Electrocatalysis Units: 3.00
The course covers concepts of equilibrium electrochemistry and examines the structure of the electrode-solution interface. It discusses the basics of electron transfer and derives electrochemical kinetics equations. It shows examples of several electrochemical reactions and overviews experimental methods used to study electrochemical phenomena.
DELETED 2024-2025
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: CHEE 210 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science

ENCH 417 Research Project Units: 9.00
In this course, projects will be assigned requiring design and synthesis in the solution of problems in engineering chemistry, using principles and concepts discussed in previous courses. Originality and innovation are encouraged. Students are required to significantly contribute to the design of original experiments, and independently analyze, interpret and communicate the results, both orally and in writing.
(Lec: 0, Lab: 9, Tut: 0)
Requirements: Prerequisites: ENCH 397 or ENCH 398 or ENCH 399 Corequisites: Exclusions:
CEAB Units:
Mathematics 0
Natural Sciences 53
Complementary Studies 27
Engineering Science 28
Engineering Design 0
Course Equivalencies: ENCH 417; ENCH 417B
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. Conduct independent research.
2. Present results in poster format.
3. Present results in formal thesis.
4. Make oral presentation.

ENCH 421 Advanced Methods in Physical Chemistry Units: 3.00
Modern spectroscopic methods for the structural and electronic characterization of molecules will be discussed, including: NMR, X-ray and synchrontron-based spectroscopies, laser spectroscopy, surface spectroscopic methods, and scanning probe methods.
NOT OFFERED 2024-2025
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: ENCH 313 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 422 Synthetic Organic Chemistry Units: 3.50
Modern synthetic methods in organic chemistry. Principles of strategy in
planning organic syntheses based on simple classifications of reagents and reactions, and on the control of stereochemistry.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 324 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 42
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 423 Topics in Inorganic and Organometallic Chemistry Units: 3.00
An examination of aspects of modern inorganic and organometallic chemistry. Topics will include metal-ligand bonding in organometallic complexes, applications of organometallics in organic synthesis, metal-metal bonding in dinuclear and polynuclear metal complexes, and may include reaction mechanisms of transition metal complexes, bioinorganic chemistry and symmetry.
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: ENCH 312 Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

ENCH 424 Polymer Chemistry Units: 3.00
Specific properties of polymers (glass transition, crystallinity, polydispersity, etc) and their dependence on macromolecular structure and isomerism. Polymer synthesis overview: step and chain polymerization (free-radical, ionic and insertion mechanisms) and reactions on polymers. Examples of polymers and their uses.
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: CHEM 223 or ENCH 245 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science

ENCH 425 Self Assembly and Materials Units: 3.00
Four topics covering a range of self-assembled molecular systems will be discussed: monolayers and bilayers, block co-polymers, nanoparticles, and liquid crystals. Material properties, synthetic methods and application of these systems in current and emerging technologies, including nanotechnologies, will be covered.
(Lec: 3, Lab: 0, Tut: 0)
Requirements: Prerequisites: CHEE 210, ENCH 245 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 36
Complementary Studies 0
Engineering Science 0
Engineering Design 0
Offering Faculty: Faculty of Arts and Science
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.