Chem 101

• Critique and give examples of how understanding and applying chemistry is a means to address global sustainability, including the important issues of: the air we breathe; the water we drink; protection of the ozone layer; global climate change; alternatives for energy sources and storage; and the threats of acid rain and ocean acidification.
• Demonstrate the ability to solve a range of chemistry problems by applying the skills of mathematical problem solving and understanding of the metric system, significant figures, unit conversion factors, symbols for chemical reactions, and chemical principles.
• Describe how energy changes in a chemical system are quantified as the substances in the system change state or temperature or undergo chemical reactions.
• Define the atomic structure and energy levels of an element and explain how they are represented.
• Explain how the information in the Periodic Table can be used to predict polarity of chemical bonds and the geometry and polarity of chemical substances.
• Explain how nuclear reactions change elemental structure and discuss how nuclear chemistry is important in medicine, energy production, and warfare.

CHEM 101L

• Describe the safety strategy learned in this course and how following that strategy facilitates safe behavior in everyday life.
• Describe how to properly take measurements, record data, perform calculations, analyze results, and summarize findings in simple experiments.
• Determine fundamental physical and chemical properties of chemical compounds.

CHEM 102

• Explain the functional groups, structure, and nomenclature of common organic and biochemical families of compounds.
• Demonstrate the direct relationship of structure of organic- and bio-chemicals with their physical and chemical properties.
• Summarize the basic biochemical processes of protein denaturation, enzymatic action, protein synthesis from DNA, and metabolism.
• Characterize the role organic and bio-chemistry has in our world and in our body chemistry.

CHEM 102L
• Students model the safety strategy learned in this course in everyday life.
• Students perform simple organic reactions
• Students contrast the structure and nomenclature of organic molecules with different functional groups
• Students summarize experimental findings and relate the impact of structure of the organic molecules on their physical and chemical properties

Chem 111
• Explain the definition of chemistry and employ scientific method
• Express common mathematical techniques in the solving of chemistry problems
• Understand the role of the atom in chemistry
• Distinguish, classify, and explain the properties of compounds
• Recognize and explain the fundamental nature of chemical reactivity
• Differentiate and describe the principles of the phases of matter

Chem 111L
• Develop an understanding of the scientific method in a chemistry laboratory setting
• Employ mathematical manipulations using acquired data
• Interpret scientific data

Chem 112
• Demonstrate competency with all of the learning objectives stated for Chem 111 and Math 111
• Apply common mathematical techniques to describe the kinetic and thermodynamic processes related to chemical equilibria

Chem 112L
• Develop an understanding of the scientific method in a chemistry laboratory setting
• Employ mathematical manipulations using acquired data
• Interpret scientific data

Chem 220
• To explain the principle of chemical equilibria and its applications and perform appropriate calculations.
• To carry out concentration, titrimetric, equilibrium, and statistical calculations.
• To explain and apply the theory behind quantitative methods and modern instrumentation.
• To construct and apply calibration curves used in chemical analysis.
• To assess the quality of laboratory data and identify any sources of error.
• To select the most appropriate method for a given chemical analysis.
• To explain the principles of equilibrium and its applications.
• To demonstrate problem-solving abilities in the area of chemical analysis.

Chem 220L
• Perform quantitative analytical methods including titrations, pH measurements, spectrophotometry, and chromatography.
• Demonstrate quantitative laboratory skills capable of obtaining precise and accurate results including:
  - ways to prevent the contamination of reagents, glassware, and instrumentation
  - how and when to dry a solid to constant weight
  - dispensing a known mass of a substance
  - methods of quantitative transfer
  - sample preparation
  - reading analog and digital devices
• Properly communicate results using appropriate calculations, statistical analyses, estimates of precision (significant figures), estimates of accuracy (confidence intervals), and units (percent by mass, molarity, percent by volume, and parts per million).
• Prepare high quality plots using Excel to visualize and analyze data.
• Demonstrate proper use of volumetric glassware, including the buret, pipet, and volumetric flask and when their use is warranted.
• Assess the credibility of data obtained in the laboratory.
• Keep a good laboratory notebook.
• Apply appropriate methods of safely handling chemicals and performing laboratory procedures, analyze health and safety information from safety data sheets (MSDS or SDS) and chemical labels, and identify chemical safety hazards.

CHEM 231
• Interpret and analyze structural formula and resonance characteristics of common functional groups
• Draw and interpret general features of curved arrow notations that illustrate mechanistic processes for common organic reactions
• Use IUPAC and common nomenclature for alkanes, alkenes, alkynes, alkyl halides and alcohols
• Draw and interpret three dimensional structures for all types of isomers of organic compounds
• Define and use fundamental concepts associated with acid-base, thermodynamic, kinetic and structural theories as they relate to processes associated with organic chemistry
• Evaluate knowledge and principles about organic reactions and reactivities to make reasonable predictions about likely outcomes when presented with related chemistry
• Deduce, design and evaluate retrosynthetic schemes including functional group transformations

CHEM 231L
• Find, apply and assess SDS to identify health and fire hazards of chemicals
• Make an accurate experimental record and succinctly summarize experimental findings
• Perform measurements and characterize organic compounds by use of MP, GC and IR analysis
• Apply the processes used in organic chemistry that might include combinations of simple distillation, fractional distillation, recrystallization, extraction, neutralization, chemical tests and thin layer chromatographic analysis
• Perform a simple chemical reaction, isolate the product, and then determine the percent yield and purity of the product

CHEM 232
• Use IUPAC and common nomenclature for ethers, aromatics, carbonyl containing compounds, and amines
• Draw and interpret mechanisms for complex reactions that might include some or all of the following: electrophilic and nucleophilic aromatic substitution, acyl nucleophilic substitution, Diels-Alder cycloaddition, nucleophilic addition to aldehyde or ketone, enol and enolate chemistries, nucleophilic aromatic substitution, and rearrangement reactions
• Integrate knowledge and principles of organic reactions and reactivities to make reasonable predictions about likely outcomes when presented with related chemistry
• Develop and evaluate multistep retrosynthetic schemes including methods to modify the carbon backbone of a molecule

CHEM 232L
• Identify and interpret the MS fragmentation ions of common organic compounds
• Interpret a 1D ¹H-NMR spectrum including higher level coupling
• Predict IR, MS, and NMR spectra for simple compounds
• Use combined spectral analysis to deduce and justify a structural formula of an organic compound
• Perform organic reactions to isolate and characterize reaction products and perform product purifications

**CHEM 311**

• Understand the quantum mechanical nature of atoms and molecules including bonding and molecular geometry
• Use symmetry and group theory to understand point groups as well as apply this knowledge to spectroscopy
• Know the principles of molecular orbital theory
• Be able to understand the principles of Lewis acids and bases
• Understand the structure of solid state materials including defects and bonding
• Know the fundamentals of coordination chemistry including bonding and reactivity
• Understand the basic ideas of organmetallic chemistry including electron counting, bonding, and the major types of reactions, particularly those used in catalysis
• Know the major roles of metal species in biological species as well as understand the role of metals in the environment

**Chem 312L**

• Conduct syntheses of a variety of inorganic compounds
• Construct a journal-type article to relate experimental results to a scientific audience

**Chem 351**

• Compare and contrast structure and function of biological molecules
• Recognize and evaluate principles of biological catalysis
• Appraise kinetic and thermodynamic data
• Employ chemical and thermodynamic principles to explain biological interactions

**Chem 352**

• To illustrate the chemical logic inherent in metabolism
• To compare and contrast the types of organic reactions that facilitate the breakdown and building of biological molecules
• To evaluate how errors in metabolism lead to human disease
• To recognize how metabolic pathways are regulated
Chem 354
- Explain the theory and concepts behind the techniques
- Demonstrate proficiency in the use of laboratory instrumentation
- Analyze and interpret results and formulate appropriate conclusions
- Communicate scientific information clearly and precisely

Chem 355
- apply a variety of standard biochemical lab techniques for the completion of a research problem in biochemistry
- compose a scientific manuscript based on results obtained in the course
- defend and present your results to scientific community at the School of Science and Math Poster Session in the spring
- interpret real data, examine its meaning, and formulate a modified research plan

Chem 356
- To develop an understanding of biological pathways and mechanisms that are faulty in selected diseases
- To illustrate how scientific knowledge is constructed by using examples from the medical and scientific literature
- To evaluate how biological and chemical tools can be applied to the study of disease
- To develop oral presentation skills appropriate for a professional scientist.

Chem 342
- Apply the basic concepts of calculus and physics to concepts in chemistry.
- Improve your proficiency reading and interpreting complex graphs and figures presenting experimental data.
- Become more comfortable reading advanced physical chemistry textbooks and finding the necessary information in the textbooks and handbooks needed to solve a particular problem.
- Learn selected history of science pertaining to quantum mechanics with emphasis on the early development of this theory, the new concepts therein and the modifications of human reasoning toward the subatomic world.
- Understand the postulates and structure of quantum mechanics.
- Understand how to think about quantum mechanical systems and how to apply this knowledge to atomic and molecular structure, systems of chemical interest, and molecular and atomic spectroscopy.
- Be able to set up and solve quantum mechanical problems, identify and understand any assumption(s) needed to solve a problem, and discuss the properties of the solutions.
Learn the fundamentals of group theory and understand the basic applications of group theory to molecular symmetry, structure and spectroscopy.

**Chem 341**

- Apply the basic concepts of calculus and physics to concepts in chemistry.
- Be proficient in reading and interpreting complex graphs and figures presenting experimental data.
- Be comfortable reading advanced physical chemistry textbooks and find the necessary information in the textbooks needed to solve a particular problem.
- Apply critical thinking skills to solve new chemistry problems that are different than ones you have already solved.
- Understand the physical basis of the gas laws used to describe real and ideal gas behavior.
- Discuss the Three Laws of Thermodynamics and their development.
- Be able to derive relationships between thermodynamic quantities.
- Understand thermodynamic state functions and their dependence on the state variables.
- Interpret phase diagrams and discuss phase equilibria in terms of the chemical potential.
- Explain the origin of the equilibrium constant and its relation to fugacity and activity. Apply the concepts of fugacity and activity to ideal and real solutions of electrolytes and non-electrolytes and to colligative properties.
- Apply the principles of electrochemistry to conductance, voltaic, and electrolytic systems.
- Provide a physical basis for Debye-Huckel theory. List the methods for arriving at a plausible mechanism and/or rate law based on kinetic information.
- Apply the steady-state hypothesis to obtain rate equations.
- Understand gas phase collisional and transport properties and their dependence on fundamental molecular and macroscopic properties.

**Chem 341L**

- Apply the basic concepts of calculus and physics to concepts in chemistry.
- Understand and be able to discuss the physical basis for the phenomena that you have observed in the laboratory.
- Be able to collect experimental data on the physical properties of chemical systems and then reduce and manipulate that data to the point where you can draw correct conclusions about the measurements you have made.
- Develop your proficiency in preparing and interpreting graphs, figures, and tables of experimental data.
- Write a coherent lab report that clearly summarizes the data collected or computation performed, the analysis undertaken, the results obtained, and the conclusions you have drawn.
• Improve your skills in the laboratory setting and develop your aptitude for carrying out advanced laboratory procedures and data analysis.

Chem 343
• recognize and understand various types of modeling that are used commonly by chemists
• evaluate some specific models using VVA
• gain experience in remote access (cloud) computing on a super computer
• gain experience with a typical molecular modeling user interface for constructing molecular models and for interpreting molecular modeling calculation results
• understand and choose the appropriate theoretical method(s) and basis set(s) for a given calculation based on desired accuracy and computational “expense”
• calculate and interpret single point, optimized, and transition structure energies for a molecule
• calculate and interpret simple molecular properties such as geometry and dipole moment
• calculate and interpret electron density, electron potential, and reactivity diagrams for molecules
• calculate and interpret theoretical values of IR, Raman, UV-Vis and NMR spectra and associated thermochemical properties
• perform and interpret molecular modeling calculations for molecules in solution
• model simple and complex first order kinetics reaction using GIDES
• formulate, design, perform the calculations, and interpret the results of a molecular modeling “experiment/exercise” suitable for use in an undergraduate chemistry class

CHEM 421
• To gain a fundamental understanding of the theoretical basis of measurements (electronics, signal processing, electrochemistry, spectroscopy, and chromatography), including the dependence of measurements on atomic, ionic, and molecular properties of the sample and analyte.
• To be able to select appropriate instrumental methods of analysis to solve real-world problems.
• To gain a practical knowledge of how to carry out meaningful interpretation of analytical data, based on both the theory underlying the measurement method and the limitations of the technique.

CHEM 421L
• Given instructions for using a particular instrument model and software, perform instrumental analytical methods including spectrometric and chromatographic methods.
• Demonstrate quantitative laboratory skills capable of obtaining precise and accurate results including:
  1. ways to prevent the contamination of reagents, glassware, and instrumentation
  2. dispensing a known mass of a substance
  3. methods of quantitative transfer and making dilutions
  4. reading analog and digital devices
• Demonstrate proper use of volumetric glassware, including the pipet and volumetric flask and when their use is warranted.
• Keep a good laboratory notebook
• Take data from the instrument and incorporate it into a written report that effectively communicates the analytical results
• Properly communicate results using appropriate calculations, statistical analyses, estimates of precision (significant figures), and units.
• Prepare high quality plots using Excel to visualize and analyze data.
• Apply appropriate methods of safely handling chemicals and performing laboratory procedures, analyze health and safety information from safety data sheets (MSDS or SDS) and chemical labels, and identify chemical safety hazards.

**Chem 422**
• To deepen understanding of the chemical processes that influence the environment (air, water, soil and climate).
• To apply fundamental chemical principles (specifically acid-base chemistry, thermodynamics, kinetics, redox reactions and light-matter interactions) to understand the sources, transport, transformation and ultimate fate of various chemical species in the environment.
• This course will be divided into three main units that reflect the most pressing issues in modern environmental chemistry. We will cover:
  o Atmospheric Chemistry and Air Pollution
  o Climate Change and Energy
  o Water Chemistry, Pollution and Treatment

**Chem 397/481/482**
• To design appropriate experiments after consulting scientific literature
• To evaluate experimental results and formulate a plan for moving the project forward
• To defend the results and interpretations of experiments in a written paper, poster presentation, or oral presentation

**Chem 490**
• To summarize current research trends in chemistry and biochemistry
• To articulate experimental strategies being used to address questions important to the discipline of chemistry
Chem 492

- To illustrate how scientific knowledge is constructed by exploring the chemical literature.
- To develop oral presentation skills.
- To apply written communication skills to chemical topics.
- To reflect about the contributions of chemists to society.
- To assess your learning at the end of the college career.