Pathway: Chemistry

Preamble: See document on page (insert page number here).

Competencies and Learning Outcomes:	**Ivy Tech Class**
1. **Transferrable Skills**	
1.1. **Written Communication Skills**	
1.1.a. Demonstrate an ability to write effective written reports (both short and long) that are layered (title, executive summary, main report, appendices, references) so the reader can easily go as deep or as shallow as required for their need, recognizing that the report needs to be designed for multiple audiences (peers, supervisors, management, company president, etc.)	ENGL 111 ENGL 112
1.1.b. Produce texts that use appropriate formats, genres, conventions, and documentation styles while controlling tone, syntax, grammar, and spelling.	ENGL 111 ENGL 112
1.1.c. Demonstrate an understanding of writing as a social process that includes multiple drafts, collaboration, and reflection.	ENGL 111 ENGL 112
1.1.d. Read critically summarize, apply, analyze, and synthesize information and concepts in written and visual texts as the basis for developing original ideas and claims.	ENGL 111 ENGL 112
1.1.e. Demonstrate an understanding of writing assignments as a series of tasks including identifying, analyzing, using, and evaluating useful and reliable outside resources including electronic sources such as visual, electronic, library databases, internet sources, other official databases, federal government databases, reputable blogs, and wikis.	ENGL 111 ENGL 112
1.1.f. Develop, assert, and support a focused thesis with appropriate reason and adequate evidence.	ENGL 111 ENGL 112
1.2. **Oral Communication Skills**	

1.2.a. Use appropriate organization or logical sequencing to deliver an oral message.	COMM 101
1.2.b. Adapt an oral message for diverse audiences, contexts, and communication channels.	COMM 101
1.2.c. Identify and demonstrate appropriate oral and nonverbal communication practices.	COMM 101
1.2.d. Advance an oral argument using logical reasoning.	COMM 101
1.2.e. Provide credible and relevant evidence to support an oral argument.	COMM 101
1.2.f. Demonstrate the ethical responsibilities of sending and receiving oral messages.	COMM 101
1.2.g. Summarize or paraphrase an oral message to demonstrate comprehension.	COMM 101
1.3. **Teamwork**	
1.3.a. Demonstrate an ability to work effectively in a team setting, including with other from different perspectives, gender, and cultures.	CHEM 211 CHEM 212
1.3.b. Be able to identify and acknowledge other collaborators' contributions to the team effort.	CHEM 211 CHEM 212
2. **Mathematics Competencies**	
2.1. **Calculus**	
2.1.a. Demonstrate fluency in language of functions. Specifically, they will demonstrate proficiency in:	MATH 211
2.1.a.i. Recognizing, calculating with, and modeling with polynomical, rational, algebraic, exponential, logarithmic, and trigonometric functions	MATH 211
2.1.a.ii. Recognizing, calculating with, and modeling with inverse functions	MATH 211
2.1.a.iii. Recognizing, calculating with, and interpreting limits of functions including limits at infinity	MATH 211

	2.1.a.iv. Recognizing, establishing, and applying continuity of functions	MATH 211
2.1.b.	Demonstrate proficiency in calculating, estimating, expressing, and interpreting average, relative, and instantaneous rates of change of one quantity with respect to another, using the language of differential calculus. This includes situations when the relationship between the quantities takes the form of a table, a graph, a textual description, and a symbolic formula.	MATH 211
2.1.c.	Demonstrate proficiency in modeling optimization problems in a variety of contexts, both applied and abstract. This includes creating independent and dependent variables, translating constraint information into an interval of values for the independent variable, solving the resulting optimization problem using techniques from differential calculus, and drawing qualitative conclusions from the numerical solutions.	MATH 211
2.1.d.	Demonstrate proficiency in calculating, estimating, expressing, and interpreting the accumulated change of one variable, given its rate of change with respect to another variable, using the language of integral calculus. This includes situations when the relationship takes the form of a table, a graph, a textual description, and a symbolic formula.	MATH 211 MATH 212
2.1.e.	Demonstrate proficiency in the expression of mathematical reasoning by stating, applying in appropriate problems, and interpreting the major milestone theorems of one-variable calculus, specifically: the Intermediate Value Theorem, the Mean Value Theorem, and the Fundamental Theorem of Calculus.	MATH 211
2.1.f.	Demonstrate understanding of the meaning of the integral and how it is related to derivatives and functions presented in various forms such as algebraic, graphical, and numerical descriptions. This includes the proficiency in relating, calculating and interpreting Riemann sums and similar quantities as approximations to integrals.	MATH 211

2.1.g. Demonstrate mastery in techniques of integration. Specifically:	
2.1.g.i. Definite and indefinite integration of polynomial, rational, algebraic, exponential, logarithmic, and trigonometric functions as well as improper integrals.	MATH 211
2.1.g.ii. How to use different techniques such as integration by parts, function substitution and partial fractions including important special cases such as trigonometric substitutions.	MATH 212
2.1.g.iii. Recognizing when to use different techniques and how to combine different techniques with other skills such as the use of trigonometric identities and recursive iteration in order to evaluate integrals.	MATH 212
2.1.h. Demonstrate proficiency in modeling problems in a variety of contexts, both applied and abstract. This includes calculating arclength, surface area and volume of geometric objects by reducing the problem to one of integration, and solving problems stated in "real world" context including optimization.	MATH 212
2.1.i. Demonstrate proficiency in understanding and analyzing sequences and series. Including:	
2.1.i.i. Understanding the meaning of sequences and infinite series, and the meaning of convergence and possible ways in which they can diverge.	MATH 212
2.1.i.ii. Understanding how certain tests for convergence are derived, and proficiency in using various test criteria to determine the convergence or divergence for sequences and series.	MATH 212

2.1.j. Demonstrate proficiency in calculating, estimating, expressing, and manipulating power series. This includes calculating and understanding the meaning of Taylor polynomials and Taylor-Maclaurin series for smooth functions at different points, finding and understanding the meaning of the radius of convergence of general power series, using power series to estimate the values of functions and their derivatives and integrals, understanding how to manipulate, add, multiply, and compose a power series and identify certain power series as closed form functions.	MATH 212
3. **Physics Competencies**	
3.1. **Mechanical Sciences**	
3.1.a. Mechanics: Demonstrate the ability to apply a unified approach to the basic principles of linear momentum, energy, angular momentum, and thermodynamics to microscopic and/or macroscopic systems including hands-on laboratory applications and computer simulations	PHYS 220
3.1.b. Statics: Demonstrate the ability to apply Newton's Laws of Motion to systems in static equilibrium including general systems, trusses, frames and machines, and systems with friction.	PHYS 220
3.1.c. Demonstrate the ability to sketch shear-force and bending moment diagrams and perform "simple" stress calculations (pure axial, shear, torsional, and bending).	PHYS 220
3.1.d. Dynamics: Demonstrate an ability to apply Newton's Laws of Motions to systems of particles, rigid body planar motion and systems experiencing 3-D motion with moving reference frames.	PHYS 220
3.1.e. Demonstrate the ability to apply conservation principles (work, energy, linear-momentum, and angular impulse-momentum).	PHYS 220
3.1.f. Demonstrate an introductory knowledge of 2nd order linear systems.	PHYS 220
3.2. **Electromagnetic Sciences**	

3.2.a. Electricity: Solve problems involving Electric Fields and Electric Forces.	PHYS 221
3.2.b. Apply Gauss's Law to derive the Electric Field resulting from spherical, cylindrical, planar, and linear charge distributions involving both dielectric materials and conducting materials.	PHYS 221
3.2.c. Solve problems dealing with resistors in direct current circuits. This includes series circuits, parallel circuits, and circuits to which Kirchoff's Laws are applied. Calculations include current, equivalent resistance, voltage power, and energy.	PHYS 221
3.2.d. Magnetism: Solve problems dealing with the forces exerted on charges moving in magnetic fields.	PHYS 221
3.2.e. Solve problems and apply theories of sources of magnetic fields, including the Biot-Savart Law and Amperes Law.	PHYS 221
3.2.f. Solve problems dealing with induction, including Faraday's Law, Lenz's Law, self-induction, mutual-induction, and circuits containing inductance.	PHYS 221
3.2.g. Solve problems dealing with alternating current circuits containing resistors, inductors, and capacitors.	PHYS 221
3.2.h. Solve problems dealing with electromagnetic wave theory.	PHYS 221
3.2.i. Optics: Solve geometrical optics problems dealing with refraction, reflection, lenses, and mirrors.	PHYS 221
3.2.j. Solve wave optics problems dealing with interference and polarization.	PHYS 221
3.2.k. Circuit Analysis: Define and explain the meaning/function of charge, current, voltage, power, energy, R, L, C, and O amp, the fundamental principles of Ohm's Law, KVL and KLC.	PHYS 221
3.2.l. Determine the equilibrium equations for a given network, and solve them using appropriate software as needed for the steady state (DC and AC/phasor) solution.	PHYS 221

3.2.m. Apply the principles of superposition, linearity, source transformations, and Thevenin/Norton equivalent circuits to analyze circuits and/or determine responses.	PHYS 221
3.2.n. Predict (qualitatively) and calculate the step responses of first order (RL and RC) and second order (RLC) circuits.	PHYS 221
3.2.o. Calculate the steady state AC responses of basic circuits using the phasor method.	PHYS 221
3.2.p. Calculate effective and average values of periodic signals, and calculate the instantaneous and average power delivered to a circuit element.	PHYS 221
3.2.q. Calculate the complex power associated with a circuit element, and design a circuit to improve the power factor in an AC circuit.	PHYS 221
3.2.r. Determine the conditions for maximum power transfer to any circuit element.	PHYS 221
3.2.s. Analyze resistive and RC op amp circuits.	PHYS 221
3.2.t. Design simple amplifiers using op amps.	PHYS 221
4. **Chemistry Competencies**	
4.1. **Chemical Toolbox**	
4.1.a. Use theory to predict, graph, and interpret experiment observations.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.1.b. Use math and critical reasoning to organize and manipulate data for meaningful interpretations of data and results, use statistics to judge limitations of error, and discern causes of error. Distinguish between precision and accuracy.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.1.c. Apply relevant fundamental mathematical relationships in order to carry out accurate calculations related to the specific topics covered.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.1.d. Apply rules of significant figures and rounding, converting among units, and using dimensional analysis to solve numerical problems.	CHEM 105; CHEM 106 CHEM 211; CHEM 212

	4.1.e. Use problem-solving skills to reduce complex problems into simpler components, identifying principle objectives.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
	4.1.f. Integrate knowledge of two or more traditional subfields of chemistry to solve complex chemical problems.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
	4.1.g. Demonstrate computer literacy to use multiple programming, computational, online and database tools. Utilize computational tools to organize, process, store, and retrieve data.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
	4.1.h. Understand the major systems of nomenclature used in chemistry for inorganic and organic compounds, including stereochemistry (R/S and E/Z).	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.2.	**Matter**	
	4.2.a. Recognize the atomic symbols of the elements and use the periodic table to extract valuable information about atoms and ions especially concerning bonding.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
	4.2.b. Classify matter: pure substances (elements and compounds) or mixtures (homogeneous or heterogeneous).	CHEM 105; CHEM 106 CHEM 211; CHEM 212
	4.2.c. Understand the differences between physical and chemical changes, physical properties and chemical properties.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
	4.2.d. Describe matter in terms of its physical properties (both intensive and extensive) and chemical properties.	CHEM 105
	4.2.e. Compare and contrast the three forms of matter: solid, liquids and gas. Compare a gas, a liquid, and a solid using a kinetic-molecular theory description.	CHEM 105 CHEM 106
	4.2.f. Use mathematical relationships (including Boyle's Law, Charles's Law, Avogadro's Law, ideal gas law, and van der Waals equation) to describe gases.	CHEM 105
	4.2.g. Describe gases with respect to density, vapor pressure, partial pressures, diffusion, effusion, molecular speed distributions.	CHEM 105
	4.2.h. Define changes of state physically and pictorially (heating curves and phase diagrams). Apply the Clausius-Clapeyron equation.	CHEM 105

4.2.i. Describe liquids with respect to surface tension, viscosity, capillary action, and vapor pressure.	CHEM 105
4.2.j. Identify types of solids: molecular solids, metallic solids, ionic solids, and covalent network solids. Identify coordination number, common unit cells (simple cubic, body-centered cubic, and face-centered cubic unit cell) , and properties that relate to its structure.	CHEM 105 CHEM 106
4.3 Atomic Structure	
4.3.a Demonstrate a comprehensive knowledge of the structure of the nucleus (including nucleons), atoms, isotopes, ions, and molecules.	CHEM 105
4.3.b Apply a fundamental knowledge of atomic orbitals (s, p, d, and f) to electronic configurations and the explanation of electronic spectroscopy.	CHEM 105
4.3.c Apply the Pauli exclusion principle, Hund's rule, Aufbau principle to write the electron~~ic~~ configurations for the elements, identifying diamagnetic and paramagnetic species. Explain how electron~~ic~~ configurations relate to electronegativities and bonding properties of these elements. Distinguish between core and valence electrons.	CHEM 105
4.3.d Employ periodic trends (including successive ionization energies, electron affinities, atomic radii, ionic radii, shielding and effective nuclear charge) to atoms and ions.	CHEM 105
4.3.e Understand the basic mathematical relationships underpinning quantum mechanics, such as the wave function, de Broglie wavelength, and the Heisenberg uncertainty principle, and other physical properties of a particle.	CHEM 105
4.3.f Understand the interaction of light with matter. Relate energy of a photon to wavelength, frequency, and to emission and absorption spectroscopy. Understand the relative regions of the electromagnetic radiation.	CHEM 105
4.3.g Describe the shapes of s, p, and d orbitals and apply the rules of quantum numbers to electrons residing in these orbitals.	CHEM 105
4.4 Chemical Bonding	

	4.4.a	Predict, compare and contrast the different types of intramolecular (covalent, ionic, and metallic) and intermolecular bonding (London forces (induced dipole), dipole-dipole, hydrogen-bonding, and ion-dipole) demonstrated in substances? Predict the consequences of these types of bonds on physical properties.	CHEM 105 CHEM 211
	4.4.b	Apply valence bond theory (hybridization, σ + π bonds), and molecular orbital bonding models to describe bonding at the molecular level.	CHEM 105 CHEM 211
	4.4.c	Develop a fundamental understanding of the behavior and properties of phases of matter (gases, liquids, and solids).	CHEM 105
	4.4.d	Define and identify ionic and covalent bonding, energetics of bonding, lattice energy through the Born-Haber cycle.	CHEM 105
	4.4.e	Describe bonds using single, double, and triple bond notation, coordinate covalent bond, valence bond descriptions (hybrid orbitals), and sigma and pi bond descriptions.	CHEM 105 CHEM 211
	4.4.f	Relate bonding properties (such as delocalized electrons, formal charge, bond length, bond order, bond enthalpy) and its consequences to molecular structure and reactivity.	CHEM 105 CHEM 211
	4.4.g	Define bonding in metals and metal compounds, metallic bonding, band theory, magnetic properties, conductivity, semiconductors, insulators, and defects.	CHEM 105
	4.4.h	Describe diatomic molecules using molecular orbital theory, identifying bonding, antibonding orbitals, and bond order.	CHEM 105 CHEM 211
4.5	**Molecular Structure & Function**		
	4.5.a	Distinguish between structure/reactivity and structure/property relationships.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
	4.5.b	Relate bond polarity and molecular dipole moment to identify polar and non-polar molecules.	CHEM 105

	4.5.c	Predict general trends in the boiling points and solubilities of compounds, based on their size, polarity, and ability to form hydrogen bonds.	CHEM 105
	4.5.d	Identify constitutional isomers, stereoisomers, and diastereomers, including cis-trans (geometric) isomers.	CHEM 211
	4.5.e	Distinguish between angle strain, torsional strain, steric strain, and understand their significance to reactivity.	CHEM 105 CHEM 211; CHEM 212
	4.5.f	Identify resonance-stabilized structures and compare the relative importance of their resonance forms. Calculate formal charges for different bonding modes.	CHEM 105 CHEM 211
	4.5.g	Relate the dependence of structure and reactivity on context, particularly solvent effects and other non-covalent interactions.	CHEM 105
	4.5.h	Demonstrate a detailed knowledge of structure-function relationships for organic molecules by functional groups, including alkanes, alkyl halides, alkenes, alkynes, arenes, alcohols, ethers, amines, aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives.	CHEM 211 CHEM 212
	4.5.i	Relate the interplay between electronic, steric, and orbital interactions in the behavior and properties of molecules.	CHEM 105 CHEM 211
	4.5.j	Draw and describe reactive intermediate structures of carbocations, carbanions, free radicals, and carbenes and the structural features that stabilize them. Explain which are electrophilic and which are nucleophilic.	CHEM 211
4.6	**Reactions**		
	4.6.a	Write accurate, balanced equations for chemical (including redox) and nuclear reactions, including deducing stable products in a nuclear reaction based on the stability of radionuclides. Predict the type of radioactive emission for a nuclear reaction. Distinguish the different classes of nuclear reactions (fission, fusion, artificial vs. Natural radioactivity)	CHEM 105 CHEM 106

	4.6.b	Employ the detailed quantitative relationships (moles, molar mass, and molarity) governing chemical reactions, including the ability to perform a variety of stoichiometry calculations (such as limiting reagent, dilutions, theoretical yield, percent yield).	CHEM 105
	4.6.c	Demonstrate a basic understanding of reaction chemistry, including oxidation-reduction (both inorganic and organic, half reactions and net ionic equations), acid-base, neutralization, precipitation, substitution (both inorganic and organic), elimination, rearrangements, and addition.	CHEM 105 CHEM 211; CHEM 212
	4.6.d	Identify nucleophiles (Lewis bases) and electrophiles (Lewis acids), and write equations for Lewis acid-base reactions using curved arrows to show the flow of electrons.	CHEM 106 CHEM 211
	4.6.e	Demonstrate a comprehensive understanding of reactions and propose logical mechanisms for the major functional groups of organic molecules, including alkanes, alkyl halides, alkenes, alkynes, arenes, alcohols, ethers, amines, aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives.	CHEM 211 CHEM 212
	4.6.f	Understand and employ the methodologies of organic synthesis, including retrosynthetic analysis of target molecules.	CHEM 211 CHEM 212
4.7	**Energy & Thermodynamics**		
	4.7.a	Define a system (versus surroundings) in terms of kinetic and potential energy, internal energy, work and heat.	CHEM 105 CHEM 106
	4.7.b	Define chemical and physical processes as exothermic or endothermic processes, calculating ΔH^o and ΔS^o for a reaction based on stoichiometry. Calculate ΔG^o from both ΔH^o and ΔS^o, and from ΔG values of formation.	CHEM 105 CHEM 106
	4.7.c	Manipulate common thermochemical calculations and relationships (including calorimetry; heats of reaction; Hess's Law and standard enthalpies or entropies of formation; calculating for reactions and phase changes).	CHEM 105 CHEM 106

	4.7.d	Manipulate common calculations and relationships to solutions (such as Henry's Law; calculating solution concentration and converting between the various forms of concentration expression; applying Raoult's Law; calculating colligative properties.)	CHEM 105 CHEM 106
	4.7.e	Calculate and relate E_{cell}, equilibrium constant, ΔG at various conditions.	CHEM 106
	4.7.f	Calculate the binding energy in a nuclear reaction.	CHEM 106
4.8	**Kinetics**		
	4.8.a	Calculate reaction rates, determining reaction orders and rate constants.	CHEM 106
	4.8.b	Calculate concentrations given the rate law, time, and initial reactant concentrations; relating a reaction half-life to a rate constant.	CHEM 106
	4.8.c	Use the Arrhenius equation to determine a reaction's activation energy or rate constant at a different temperature.	CHEM 106
	4.8.d	Determine the molecularity and rate law for an elementary reaction.	CHEM 106
	4.8.e	Write the overall chemical reaction and rate law for a given mechanism.	CHEM 106
	4.8.f	Understand the effect of a catalyst. Employing methods of activation, including Brønsted or Lewis acid/base, free radical chemistry, and organometallic catalysis.	CHEM 106
4.9	**Equilibrium**		
	4.9.a	Calculate and interpret values of equilibrium constants. Writing equilibrium constant expressions and using them to calculate equilibrium constant values.	CHEM 106
	4.9.b	Calculate free-energy changes from equilibrium constants, and calculate the position of reaction equilibrium from the free-energy changes.	CHEM 106
	4.9.c	Predict reaction direction based on comparing Q and K.	CHEM 106

4.9.d	Describe and employ the reversibility of reactions. Apply Le Châtélier's principle for changes in equilibrium concentrations, temperature and pressure.	CHEM 106
4.9.e	Apply foundational equilibrium concepts to aqueous equilibria, including acids, bases, salts, buffers, titrations, solubility and complex ion equilibria.	CHEM 106
4.10	**Experimentation**	
4.10.a	Demonstrate a basic ability to define problems clearly, develop testable hypotheses, design and execute experiments, analyze data using appropriate statistical methods, understand the fundamental uncertainties in experimental measurements, and draw appropriate conclusions.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.b	Apply major concepts, theoretical principles and experimental findings in general and organic chemistry lectures to the solution of laboratory problems.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.c	Demonstrate creative and independent thinking in a laboratory setting.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.d	Demonstrate knowledge of chemical, instrumental and workplace safety. Know and follow the proper safety procedures and regulations for safe handling and use of chemicals.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.e	Employ appropriate, safe, and ethical research methodologies to collect, analyze and interpret data critically (error analysis) toward the solution of a problem.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.f	Critically evaluate methodologies, data and conclusions of one's own and other's technical work.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.g	Use technology for computations, data acquisition, and data base searching.	CHEM 105; CHEM 106 CHEM 211; CHEM 212

4.10.h Use appropriate instrumentation for chemical analysis and characterization. Students must have hands-on experience with a variety of instruments, including spectrometers (such as UV/Vis, FTIR, NMR), and with chemical separation techniques (such as TLC, CC, and GC).	CHEM 211
4.10.i Students will be able to maintain an organized and well-documented laboratory notebook.	CHEM 211
4.10.j Interact effectively in a group to solve scientific problems and work productively with a diverse group of peers.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.k Present information in a clear and organized manner, write well-organized and concise reports in a scientifically appropriate style, and use relevant technology in their communications.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.l Write scientific reports, with graphical presentation of data (technical writing skills) using appropriate scientific formalisms.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.m Communicate and store scientific information and experimental data correctly by keeping a well-documented laboratory notebook or other written records.	CHEM 211
4.10.n Demonstrate the responsible treatment of data, proper citation of others' work, and the standards related to plagiarism and the publication of scientific results.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.10.o Find and evaluate the validity and usefulness of chemistry information in the scientific literature.	CHEM 106
4.10.p Demonstrate proper conceptual and mathematical knowledge upon which chemical instrumentation is based.	CHEM 106
4.10.q Collect empirical data through the safe and effective physical manipulation of materials, equipment, and instrumentation in a face-to-face instructional setting.	CHEM 105; CHEM 106 CHEM 211; CHEM 212
4.11 Visualization	

4.11.a Understand the relationship between symbolic and particulate representations.	CHEM 105
4.11.b Predict molecular geometry, shape and ideal bond angles at the molecular level using VSEPR theory.	CHEM 105
4.11.c Employ the concept of the mole to relate the macroscopic and microscopic views of chemical reactions.	CHEM 105
4.11.d Use mathematical equations to provide a tool to visualize chemical and physical processes.	CHEM 105
4.11.e Draw and interpret Lewis, condensed, and line-angle structural formulas. Convert these drawings to accurate Newman projections, Fisher projections, Haworth projections, chair conformations as appropriate, envisioning these representations as space filling diagrams.	CHEM 105
4.11.f Draw and identify the types of stereoisomers for a molecule, identifying the relationship between stereoisomers, identifying each carbon with the R/S nomenclature.	CHEM 211
4.11.g Draw a reaction-energy diagram for a mechanism, and point out the corresponding transition states, activation energies, intermediates, and rate-limiting steps.	CHEM 211
4.11.h Visualize the movements of the microscopic world using a qualitative description of the gas laws based on the kinetic molecular theory.	CHEM 105
4.11.i Cultivate the understanding that the way to molecular knowledge is through experimentation; correlating structure with reactivity and function through wet chemical methods, spectroscopy (notably NMR, FTIR, and MS), and use of computational simulations.	CHEM 211
4.11.j Employ spectrometric techniques for the determination of organic structure at the molecular level. Identify the reliable characteristic peaks in provided spectroscopic data, and propose which functional groups are likely to be present in the molecule based on this knowledge.	CHEM 211

4.11.k Develop a basic understanding of the microscopic point of view, especially for thermodynamic quantities such as entropy.	CHEM 106

Assessments:

CHEM 105 – Assessed through examinations, experimentation in laboratory, laboratory reports, presentations, discussion, and written assignments.

CHEM 106 – Assessed through examinations, experimentation in laboratory, laboratory reports, presentations, discussion, and written assignments.

CHEM 211 – Assessed through experimentation, presentations, laboratory reports, discussion, written assignments, mechanism-based problems, literature reviews, and examinations.

CHEM 212 – Assessed through experimentation, presentations, laboratory reports, discussion, written assignments, mechanism-based problems, literature reviews, and examinations.

PHYS 220 – Assessed through evaluation of laboratory work (evaluation of experimental technique, quality of the interpretation of data and its presentation in the lab report, and the functionality of the student computer code in simulation based experiments), homework assignments, four open-book preliminary quizzes, and two closed book comprehensive examinations.

PHYS 221 – Assessed through evaluation of laboratory work (evaluation of experimental technique, quality of the interpretation of data and its presentation in the lab report, and the functionality of the student computer code in simulation based experiments), homework assignments, four open-book preliminary quizzes, and two closed book comprehensive examinations.

ENGL 111 – Assessed through discussions, written assignments, peer responses (discussions), quizzes, and outline assignments.

ENGL 112 – Assessed through discussion, peer revision/review, and multiple writing projects including, rhetorical analysis, visual argument analysis, annotated bibliography, and literary analysis.

COMM 101 –Assessed through speeches, speech peer reviews, discussions, written assignments/writing exercises, exams, and quizzes.