2019-2010

Undergraduate Catalog Program Template for Transfer Single Articulation Pathways (TSAP) Programs

Program: Chemistry

Degree: B.S.C.

I. Introduction

a. [Department of Chemistry]

b. Student Learning Outcomes

   i. Upon completion of the B.S. Chemistry degree students will:

      1. Transferrable Skills

         a. Written Communication Skills

            i. Develop, assert, and support a focused thesis with appropriate reason and adequate evidence.

            ii. Produce texts that use appropriate formats, genres, conventions, and documentation styles while controlling tone, syntax, grammar, and spelling.

            iii. Demonstrate an understanding of writing as a social process that includes multiple drafts, collaboration, and reflection.

            iv. Read critically, summarize, apply, analyze, and synthesize information and concepts in written and visual texts as the basis for developing original ideas and claims.

            v. 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.

            vi. 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.)

         b. Oral Communication Skills

            i. Use appropriate organization or logical sequencing to deliver an oral message.

            ii. Adapt an oral message for diverse audiences, contexts, and communication channels.

            iii. Identify and demonstrate appropriate oral and nonverbal communication practices.

            iv. Advance an oral argument using logical reasoning.

            v. Provide credible and relevant evidence to support an oral argument.

            vi. Demonstrate the ethical responsibilities of sending and receiving oral messages.

vii. Summarize or paraphrase an oral message to demonstrate comprehension.

c. Team Work

i. Demonstrate an ability to work effectively in a team setting, including with others from different perspectives, gender, and cultures.

ii. Be able to identify and acknowledge other collaborators' contributions to the team effort.

2. Mathematics Competencies

i. Functions

1. Recognize, calculate with, and model with polynomial, rational, algebraic, exponential, logarithmic, and trigonometric functions.
2. Recognize, calculate with, and model with inverse functions.
3. Recognize, calculate with, and interpret limits of functions including limits at infinity.
4. Recognize, establish, and apply continuity of functions.

ii. 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.

iii. 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.

iv. 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.

v. 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.

vi. 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.

vii. Demonstrate mastery in techniques of integration. Specifically:
    1. Definite and indefinite integration of polynomial, rational, algebraic, exponential, logarithmic, and trigonometric functions as well as improper integrals.
    2. How to use different techniques such as integration by parts, function substitution and partial fractions including important special cases such as trigonometric substitutions.
    3. 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.

viii. Demonstrate proficiency in modeling problems in a variety of contexts, both applied and abstract. This includes calculating arc length, 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.

ix. Demonstrate proficiency in understanding and analyzing sequences and series. Including:
    1. Understanding the meaning of sequences and infinite series, and the meaning of convergence and possible ways in which they can diverge.
    2. 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.

x. 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.

3. Physics Competencies
    a. Mechanical Sciences
        i. 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.

ii. 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.
iii. Demonstrate the ability to sketch shear-force and bending moment diagrams and perform "simple" stress calculations (pure axial, shear, torsional, and bending).
iv. 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.
v. Demonstrate the ability to apply conservation principles (work, energy, linear-momentum, and angular impulse-momentum).
vi. Demonstrate an introductory knowledge of 2nd order linear systems

b. Electromagnetic Sciences
   i. Electricity: Solve problems involving Electric Fields and Electric Forces.
   ii. 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.
   iii. 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.
   iv. Magnetism: Solve problems dealing with the forces exerted on charges moving in magnetic fields.
   v. Solve problems and apply theories of sources of magnetic fields, including the Biot-Savart Law and Amperes Law.
   vi. Solve problems dealing with induction, including Faraday's Law, Lenz's Law, self-induction, mutual-induction, and circuits containing inductance.
   vii. Solve problems dealing with alternating current circuits containing resistors, inductors, and capacitors.
   viii. Solve problems dealing with electromagnetic wave theory.
   ix. Optics: Solve geometrical optics problems dealing with refraction, reflection, lenses, and mirrors.
   x. Solve wave optics problems dealing with interference and polarization.
   xi. 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.
   xii. 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.
   xiii. Apply the principles of superposition, linearity, source transformations, and Thevenin/Norton equivalent circuits to analyze circuits and/or determine responses.

xiv. Predict (qualitatively) and calculate the step responses of first order (RL and RC) and second order (RLC) circuits.
xv. Calculate the steady state AC responses of basic circuits using the phasor method.
xvi. Calculate effective and average values of periodic signals, and calculate the instantaneous and average power delivered to a circuit element.
xvii. Calculate the complex power associated with a circuit element, and design a circuit to improve the power factor in an AC circuit.
xviii. Determine the conditions for maximum power transfer to any circuit element.
xix. Analyze resistive and RC op amp circuits.
xx. Design simple amplifiers using op amps.

4. Chemistry Competencies
   a. Chemical Toolbox
      i. Use theory to predict, graph, and interpret experiment observations.
      ii. 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.
      iii. Apply relevant fundamental mathematical relationships in order to carry out accurate calculations related to the specific topics covered.
      iv. Apply rules of significant figures and rounding, converting among units, and using dimensional analysis to solve numerical problems.
      v. Use problem-solving skills to reduce complex problems into simpler components, identifying principle objectives.
      vi. Integrate knowledge of two or more traditional subfields of chemistry to solve complex chemical problems.
      vii. Demonstrate computer literacy to use multiple programming, computational, online and database tools. Utilize computational tools to organize, process, store, and retrieve data.
      viii. Understand the major systems of nomenclature used in chemistry for inorganic and organic compounds, including stereochemistry (R/S and E/Z).
   b. Matter
      i. Recognize the atomic symbols of the elements and use the periodic table to extract valuable information about atoms and ions especially concerning bonding.
      ii. Classify matter: pure substances (elements and compounds) or mixtures (homogeneous or heterogeneous).
      iii. Understand the differences between physical and chemical changes, physical properties and chemical properties.
      iv. Describe matter in terms of its physical properties (both intensive and extensive) and chemical properties.

v. 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.
vi. Use mathematical relationships (including Boyle's Law, Charles' Law, Avogadro's Law, ideal gas law, and van der Waals equation) to describe gases.
vii. Describe gases with respect to density, vapor pressure, partial pressures, diffusion, effusion, molecular speed distributions.
viii. Define changes of state physically and pictorially (heating curves and phase diagrams). Apply the Clausius-Clapeyron equation.
ix. Describe liquids with respect to surface tension, viscosity, capillary action, and vapor pressure.
x. 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.
xi. Demonstrate a comprehensive knowledge of the structure of the nucleus (including nucleons), atoms, isotopes, ions, and molecules.
xii. Apply a fundamental knowledge of atomic orbitals (s, p, d, and f) to electronic configurations and the explanation of electronic spectroscopy.
xiii. Apply the Pauli exclusion principle, Hund's rule, Aufbau principle to write the electronic configurations for the elements, identifying diamagnetic and paramagnetic species. Explain how electronic configurations relate to electronegativities and bonding properties of these elements. Distinguish between core and valence electrons.
xiv. Employ periodic trends (including successive ionization energies, electron affinities, atomic radii, ionic radii, shielding and effective nuclear charge) to atoms and ions.
xv. 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.
xvi. 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.
xvii. Describe the shapes of s, p, and d orbitals and apply the rules of quantum numbers to electrons residing in these orbitals.

c. Chemical Bonding

i. 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.

ii. Apply valence bond theory (hybridization, $\sigma + \pi$ bonds), and molecular orbital bonding models to describe bonding at the molecular level.

iii. Develop a fundamental understanding of the behavior and properties of phases of matter (gases, liquids, and solids).

iv. Define and identify ionic and covalent bonding, energetics of bonding, lattice energy through the Born-Haber cycle.

v. Describe bonds using single, double, and triple bond notation, coordinate covalent bond, valence bond descriptions (hybrid orbitals), and σ and π bond descriptions.

vi. Relate bonding properties (such as delocalized electrons, formal charge, bond length, bond order, bond enthalpy) and its consequences to molecular structure and reactivity.

vii. Define bonding in metals and metal compounds, metallic bonding, band theory, magnetic properties, conductivity, semiconductors, insulators, and defects.

viii. Describe diatomic molecules using molecular orbital theory, identifying bonding, antibonding orbitals, and bond order.

d. Molecular Structure & Function

i. Distinguish between structure/reactivity and structure/property relationships.

ii. Relate bond polarity and molecular dipole moment to identify polar and non-polar molecules.

iii. Predict general trends in the boiling points and solubilities of compounds, based on their size, polarity, and ability to form hydrogen bonds.

iv. Identify constitutional isomers, stereoisomers, and diastereomers, including cis-trans (geometric) isomers.

v. Distinguish between angle strain, torsional strain, steric strain, and understand their significance to reactivity.

vi. Identify resonance-stabilized structures and compare the relative importance of their resonance forms. Calculate formal charges for different bonding modes.

vii. Relate the dependence of structure and reactivity on context, particularly solvent effects and other non-covalent interactions.

viii. 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.

ix. Relate the interplay between electronic, steric, and orbital interactions in the behavior and properties of molecules.

x. 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.

e. Reactions
    i. 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)
    ii. 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).
    iii. 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.
    iv. 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.
    v. 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.
    vi. Understand and employ the methodologies of organic synthesis, including retrosynthetic analysis of target molecules.

f. Energy & Thermodynamics
    i. Define a system (versus surroundings) in terms of kinetic and potential energy, internal energy, work and heat.
    ii. 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.
    iii. 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).
    iv. 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.)
    v. Calculate and relate E_{cell}, equilibrium constant, ΔG at various conditions.

   vi. Calculate the binding energy in a nuclear reaction.

g. Kinetics
   i. Calculate reaction rates, determining reaction orders and rate constants.
   ii. Calculate concentrations given the rate law, time, and initial reactant concentrations; relating a reaction half-life to a rate constant.
   iii. Use the Arrhenius equation to determine a reaction's activation energy or rate constant at a different temperature.
   iv. Determine the molecularity and rate law for an elementary reaction.
   v. Write the overall chemical reaction and rate law for a given mechanism.
   vi. Understand the effect of a catalyst. Employing methods of activation, including Brønsted or Lewis acid/base, free radical chemistry, and organometallic catalysis.

h. Equilibrium
   i. Calculate and interpret values of equilibrium constants. Writing equilibrium constant expressions and using them to calculate equilibrium constant values.
   ii. Calculate free-energy changes from equilibrium constants, and calculate the position of reaction equilibrium from the free-energy changes.
   iii. Predict reaction direction based on comparing Q and K.
   iv. Describe and employ the reversibility of reactions. Apply Le Châtélier's principle for changes in equilibrium concentrations, temperature and pressure.
   v. Apply foundational equilibrium concepts to aqueous equilibria, including acids, bases, salts, buffers, titrations, solubility and complex ion equilibria.

i. Experimentation
   i. 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.
   ii. Apply major concepts, theoretical principles and experimental findings in general and organic chemistry lectures to the solution of laboratory problems.
   iii. Demonstrate creative and independent thinking in a laboratory setting.
   iv. Demonstrate knowledge of chemical, instrumental and workplace safety. Know and follow the proper safety procedures and regulations for safe handling and use of chemicals.

v. Employ appropriate, safe, and ethical research methodologies to collect, analyze and interpret data critically (error analysis) toward the solution of a problem.
vi. Critically evaluate methodologies, data and conclusions of one's own and other's technical work.
vii. Use technology for computations, data acquisition, and data base searching.
viii. 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).
ix. Be able to maintain an organized and well-documented laboratory notebook.
x. Interact effectively in a group to solve scientific problems and work productively with a diverse group of peers.
xi. 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.
xii. Write scientific reports, with graphical presentation of data (technical writing skills) using appropriate scientific formalisms.
xiii. Communicate and store scientific information and experimental data correctly by keeping a well-documented laboratory notebook or other written records.
xiv. Demonstrate the responsible treatment of data, proper citation of others' work, and the standards related to plagiarism and the publication of scientific results.
xv. Find and evaluate the validity and usefulness of chemistry information in the scientific literature.
xvi. Demonstrate proper conceptual and mathematical knowledge upon which chemical instrumentation is based.
xvii. Collect empirical data through the safe and effective physical manipulation of materials, equipment, and instrumentation in a face-to-face instructional setting.

j. Visualization
   i. Understand the relationship between symbolic and particulate representations.
   ii. Predict molecular geometry, shape and ideal bond angles at the molecular level using VSEPR theory.
   iii. Employ the concept of the mole to relate the macroscopic and microscopic views of chemical reactions.
   iv. Use mathematical equations to provide a tool to visualize chemical and physical processes.
   v. 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.

vi. Draw and identify the types of stereoisomers for a molecule, identifying the relationship between stereoisomers, identifying each carbon with the R/S nomenclature.

vii. Draw a reaction-energy diagram for a mechanism, and point out the corresponding transition states, activation energies, intermediates, and rate-limiting steps.

viii. Visualize the movements of the microscopic world using a qualitative description of the gas laws based on the kinetic molecular theory.

ix. 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.

x. 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.

xi. Develop a basic understanding of the microscopic point of view, especially for thermodynamic quantities such as entropy.

c. American Chemical Society Accreditation

d. TSAP information

II. Program Delivery

a. This program is available on-campus

III. Declaring This Major

a. Declare this major within the Department of Chemistry

IV. General Requirements

a. Degree Requirements

b. General Education Requirements* *(some programs require specific courses that also meet general education requirements)*

c. Overlapping Course Content

d. College Graduation Requirements

e. Academic Regulations

V. Program Requirements

a. General Education Requirements: The Indiana Statewide General Education Core is satisfied as part of the TSAP program. The Purdue Fort Wayne General Education Capstone Course (Category C8) is included in your major requirements. A grade of C- or higher is required in each course used to satisfy the Purdue Fort Wayne General Education Requirements.

b. Listing of Major courses and supporting courses required at PFW

   i. CHM 19400, Freshman Chemistry Orientation, 1 credit

ii. CHM 24100, Intro Inorganic Chemistry, 4 credits
iii. CHM 28000, Chemical Literature, 1 credit
iv. CHM 32100, Analytical Chemistry I, 4 credits
v. CHM 34200, Inorganic Chemistry, 3 credits
vi. CHM 34300, Inorganic Chemistry Lab, 1 credit
vii. CHM 37600, Physical Chemistry Lab, 2 credits
viii. CHM 38300, Physical Chemistry, 4, credits
ix. CHM 38400, Physical Chemistry, 2 credits
x. CHM 42400, Analytical Chemistry II, 4 credits
xi. CHM 49600, Advance in Chemistry I, 0 credits
xii. CHM 49700, Advances in Chemistry II, 1 credit
xiii. CHM 53300, Introductory Biochemistry, 3 credits
xiv. CHM Elective (CHM 3xx, 4xx, or 5xx), 3 credits
xv. MA 26100 Multivariate Calculus, 4 credits
xvi. MA 35100, Elementary Linear Algebra, 3 credits
xvii. MA 36300, Differential Equations, 3 credits
xviii. PHYS 34200, Modern Physics, 3 credits
xix. PHYS 34300, Modern Physics Lab, 1 credit
xx. 8 Credits Language Sequence
xxi. GCAP Category C8 – Capstone Experience, 3 credits
xxii. Free elective, 2 credits

c. Cumulative GPA requirement for graduation and Major GPA requirement for graduation. A GPA of 2.00 or higher for all major department courses taken in all CHM courses numbered 300xx and above.
d. Student Responsibilities: You are responsible for satisfying the graduation requirements specified for your selected program. Thus, it is essential that you develop a thorough understanding of the required courses, academic policies, and procedures governing your academic career. All requests for exceptions to specific requirements must be made in writing and may be granted only by written approval from the appropriate chair or dean.
e. Total credits for degree: 120 credits