

Current Pennsylvania Statewide Program-to-Program Articulation Agreements includes language that will be a barrier to student transfer from a Pennsylvania Community College to other TAOC partner institutions. Specifically, language in the Biology Agreement, and Chemistry Agreement (Approved by TAOC on June 16, 2011 Amended April 11, 2012) state that ***“All laboratories are required to be taught hands-on, with physical (not virtual) equipment in a laboratory setting.”***

In light of the current public health emergency with COVID-19, and the necessity of online or remote instruction, this requirement could be a barrier for community college students seeking to transfer under the provisions of Pennsylvania’s statewide articulation agreements.

Therefore, the Pennsylvania Commission for Community Colleges and the Office of the Chancellor of the State System of Higher Education recommend TAOC adopt the following waiver language:

“The requirement for laboratories to be taught hands-on, with physical (not virtual) equipment in a laboratory setting is waived beginning with the Spring 2020 semester through the end of the academic year concurrent with the end of the proclamation of disaster emergency related to COVID-19 issued by the Governor of Pennsylvania on March 6, 2020 and renewed on June 3, 2020.”

PENNSYLVANIA STATEWIDE PROGRAM-TO-PROGRAM ARTICULATION AGREEMENT IN CHEMISTRY

Overview:

In accordance with Act 50 of 2009, institutions participating in Pennsylvania's statewide college credit transfer system agree to the following policies governing the transfer of credits from a participating associate degree granting institution into a parallel degree program offered at any of the participating four-year colleges and universities. This agreement ensures that a student who successfully completes an Associate of Arts (A.A.) or Associate of Science (A.S.) degree at a participating institution can transfer the full degree into a parallel bachelor degree program in Chemistry at a participating four-year college.

Students will be admitted at the Junior-status level after successfully completing an Associate Degree that meets the following requirements:

- The associate degree includes, at minimum, 30 credits of major-specific coursework in Chemistry, Physics and Calculus as outlined under Major Requirements in this agreement.
- The maximum number of major-specific coursework in the associate degree does not *exceed* 50% of the major-specific coursework required by the parallel bachelor degree program offered by the four-year institution.
- In order for coursework to transfer, program-to-program, students must meet the existing minimum grade requirements of the institution of interest.

Standardized exams, such as the American Chemical Society (ACS) subject exams, cannot be used as a requirement for entrance into a parallel degree at a four-year institution. Standardized exams can be used as assessment tools if they are considered department policy and apply to both native and transferring students.

See Appendix A: Program-to-Program Articulation Model for Chemistry.

Students meeting these criteria will be considered by the participating four-year institutions to have received adequate knowledge, skills, and techniques necessary in the first two years and thus be eligible to transfer as an incoming junior into a parallel bachelor degree program in Chemistry.

References to courses in all agreements designate competencies and are not to be construed as making a reference to a specific course at a specific institution. Course titles in the agreements are presented for guidance in advising students as to which coursework they should take even though the course at the student's college may not have the specific title mentioned in the agreement.¹

¹ Adopted by TAOC and added to the agreement on April 11, 2012.

REQUIRED Major-Specific Content Areas:

Under this Agreement, a fully transferable associate degree in the field of Chemistry must include competencies from four primary content areas:

- 1. General Chemistry (minimum 6 credits of coursework)**
- 2. General Chemistry Laboratory (minimum 2 credits of lab work)**
- 3. Organic Chemistry (minimum 6 credits of coursework)**
- 4. Organic Chemistry Laboratory (minimum 2 credits of lab work)**

The field of chemistry has traditionally been based on sequential courses of General Chemistry with laboratories in the Freshman year followed by sequential courses of Organic Chemistry with laboratories in the Sophomore year. It is important to point out that not all institutions follow this sequence and therefore it is up to the institution to determine how the competencies are identified in the primary content areas. For example, one institution may only require one semester of General Chemistry followed by two semesters of Organic Chemistry. In addition, one institution may have a 3-credit course that covers certain competencies while another institution may have a 4-credit course. The purpose of this Agreement is to standardize the competencies regardless of course names or credit hours.

All Chemistry competencies are based on the ACS guidelines, written by the Committee on Professional Training (CPT) and outlined in the most recent publication of *Undergraduate Professional Education in Chemistry* (Spring 2008)¹. The ACS approves Chemistry programs based on these guidelines. The majority of Chemistry departments recognize the ACS as the governing body of chemical education in the United States.

DIFFERENCES in Major-Specific Curriculum Content:

In composing this document the committee recognized that several institutions, both at the community college level and the four-year program level, offer major courses during the Freshman or Sophomore year that do match other institutions. The American Chemical Society does not mandate a specific sequence for Chemistry courses, just that they should be offered. Examples include: Quantitative Analysis, Analytical Chemistry, Instrumental Analysis, Inorganic Chemistry, and Polymer Chemistry. Because these courses *are not standardized at a specific academic level across all institutions* that offer a degree in Chemistry, it is not possible to compile a list of competencies for these specific courses. For example, a student might take Inorganic Chemistry at the Freshman level at one institution but it is considered a Senior level course at another institution. This means that an Associate Degree student would have to complete any additional Chemistry coursework that is required by a particular four-year institution. An Associate Degree student would still get credit for the courses outlined in Chemistry Articulation Agreement, General Chemistry and Organic Chemistry, which are common to all programs.

1. General Chemistry

For institutions that begin students in the freshman year with General Chemistry, it is an introduction to the Chemistry field and primarily involves the application of mathematics in Chemistry. Additional skills include the development of in-depth analysis tools and problem solving skills, which are applied in upper level chemistry courses. As stated by the ACS in the *Undergraduate Professional Education in Chemistry*,¹ “The diversity of institutions and students requires a variety of approaches for teaching introductory chemistry.” Should an institution

provide a different sequence of General Chemistry, it is up to that institution to determine the best way to credit the student for the outlined competencies.

The following competencies have been identified as essential for preparation in General Chemistry. Please note that the competencies do not need to be introduced in the order listed.

- Competency 1: Introduction to Chemistry
- Competency 2: Measurement
- Competency 3: Atoms, Ions & Compounds
- Competency 4: Chemical Reactions
- Competency 5: Calculations with Formulas and Equations
- Competency 6: States of Matter: Gases
- Competency 7: Thermochemistry
- Competency 8: The Periodic Table and Atomic Structure
- Competency 9: Bonding
- Competency 10: States of Matter: Liquids and Solids
- Competency 11: Solutions
- Competency 12: Kinetics
- Competency 13: Chemical Equilibrium
- Competency 14: Acid-Base Equilibria
- Competency 15: Solubility and Complex Ion Equilibria
- Competency 16: Thermodynamics
- Competency 17: Electrochemistry

See Appendix B: Competencies for Preparation in General Chemistry.

2. General Chemistry Laboratory

Chemistry is a research-based science and therefore, all chemists must have a background in utilization of basic chemical laboratory techniques and equipment. In addition, safety practices, keeping of a laboratory notebook, and report writing should also be incorporated. Because individual experiments vary from institution to institution, an effort was made to compile a general list that is not experiment specific but rather concept specific. Also note that more than one of these competencies might be covered in a single laboratory period. ***All laboratories are required to be taught hands-on, with physical (not virtual) equipment in a laboratory setting.***

The following competencies have been identified as essential for a background in the General Chemistry Laboratory. Please note that the competencies do not need to be introduced in the order listed.

- Competency 1: Laboratory Safety and Laboratory Notebook
- Competency 2: Dimensional Analysis
- Competency 3: Empirical Formula
- Competency 4: Chemical Reactions
- Competency 5: Titration
- Competency 6: Calorimetry
- Competency 7: Visible Spectroscopy
- Competency 8: Kinetics
- Competency 9: pH
- Competency 10: Buffers

Competency 11: Density and Other Physical Properties

Competency 12: Gas Laws

Competency 13: Chemical Equilibrium

Competency 14: Electrochemistry

Competency 15: Colligative Properties

Competency 16: Solubility

See Appendix C: Competencies for Preparation in General Chemistry Laboratory.

3. Organic Chemistry

Organic Chemistry is the study and application of reactions involving carbon-based molecules. The ACS classifies the first semester of Organic Chemistry as a foundation course and the second semester as an in-depth course. As such, Organic chemistry should include the fundamentals of nomenclature, reactions, mechanisms, and related concepts. Please note that the competencies are not listed in any particular order but are instead grouped into categories.

The following competencies have been identified as essential for a background in Organic Chemistry. Please note that the competencies do not need to be introduced in the order listed.

Competency 1: Bonding

Competency 2: Structure and Function

Competency 3: Acid-Base Reactions

Competency 4: Stereochemistry

Competency 5: Nomenclature

Competency 6: Spectroscopy

Competency 7: Organic Reactions

Competency 8: Organic Synthesis

Competency 9: Macromolecules

See Appendix D: Competencies for Preparation in Organic Chemistry.

4. Organic Chemistry Laboratory

Organic Chemical reactions involve specialty glassware, equipment, and instrumentation that is different from many fields in Chemistry. Emphasis in the Organic Laboratory is on the synthesis and purification of compounds followed by the application of instrumentation in the analysis and identification of the products. Like all laboratories, safety practices, the keeping of a laboratory notebook, and report writing should also be incorporated. The competencies are based on the guidelines recommended by the American Chemical Society.¹ Also, note that a wide variety of experiments satisfy these competencies. ***All laboratories are required to be taught hands-on, with physical (not virtual) equipment in a laboratory setting.***

The following competencies have been identified as essential for a background in Organic Chemistry Laboratory. Please note that the competencies do not need to be introduced in the order listed.

Competency 1: Laboratory Safety and Laboratory Notebook

Competency 2: Purification Techniques

Competency 3: Spectroscopy

Competency 4: Functional Group Interconversion

Competency 5: Chromatography

Competency 6: Statistical Analysis
Competency 7: Computational

See Appendix E: Competencies for Preparation in Organic Chemistry Laboratory.

REQUIRED Coursework Outside the Discipline

Under this agreement, a fully transferable Associate Degree into a parallel Chemistry degree must include the following prerequisite courses outside the area of Chemistry:

- 1. Multivariable Calculus (minimum of 8 credits and the equivalent of Calculus 1 and 2 coursework).**
- 2. Calculus-based Physics and associated laboratories (minimum of 8 credits and the equivalent of Calculus-based Physics 1 and 2 coursework with labs).**

These courses are required for American Chemical Society certification and are prerequisites for upper division chemistry courses in the B.S. degree.¹ Transfer of these courses will follow the state-wide, program-to-program, Mathematics and Physics Articulation Agreements.

RECOMMENDED General Coursework

Associate degree students transferring into a parallel degree program in Chemistry would also benefit by completing additional coursework outside the major. The following courses are recommended but not required:

- 1. Computer Science – One course involving programming is recommended.**
- 2. Biology – One course with a lab, preferably in the sequence required by Biology majors.**

Transfer of these courses will follow the state-wide, program-to-program, Computer Science and Biology Articulation Agreements. Students will not be penalized for the absence of recommended coursework; however, it is important to note that certain “concentrations” offered in chemistry have additional requirements. For example, the Biochemistry concentration, which is offered by most departments, requires a student to take three courses in Biology in the first two years. These courses should include foundation biology coursework followed by some or all of the following: Genetics, Cell Biology, and/or Microbiology.

References

1. American Chemical Society (Spring 2008). *Undergraduate Professional Education in Chemistry*. Washington, DC: Committee on Professional Training.

Appendix A: Program-to-Program Articulation Model for Chemistry

<u>REQUIRED – Major Specific Content</u>	<u>Transfer Criteria</u>
General Chemistry (minimum 6 credits) General Chemistry Laboratory (minimum 2 credits) Organic Chemistry (minimum 6 credits) Organic Chemistry Laboratory (minimum 2 credits)	Must meet the requirements of the competencies outlined in this document (Statewide Program-to-Program Articulation Agreement in Chemistry).
<u>REQUIRED – Content Outside the Discipline</u>	<u>Transfer Criteria</u>
<u>Multivariable Calculus (minimum of 8 credits)</u> Must be the equivalent of Calculus 1 and 2.	See the Statewide Program-to-Program Articulation Agreement in Mathematics for coursework.
<u>Calculus-based Physics with labs (minimum of 8 credits)</u> Must be the equivalent of Calculus-based Physics 1 and 2 with associated laboratories.	See the Statewide Program-to-Program Articulation Agreement in Physics for coursework.
<u>RECOMMENDED – Content Outside the Discipline</u>	<u>Transfer Criteria</u>
Computer Science (minimum 3 credits)	See the Statewide Program-to-Program Articulation Agreement in Computer Science for coursework.
Biology with a lab (minimum 4 credits)	See the Statewide Program-to-Program Articulation Agreement in Biology for coursework.

Appendix B: Competencies for Preparation in General Chemistry

Competency 1: Introduction to Chemistry.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 1.1 Present the scientific method.
- 1.2 Classify matter on the basis of physical and chemical properties.
- 1.3 Classify matter on the basis of physical and chemical changes.

Competency 2: Measurement.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 2.1 List the common SI units of measurement, the values of selected prefixes, and the use of dimensional analysis to interconvert units of measurement.
- 2.2 Apply the rules for significant figures for calculation problems.

Competency 3: Atoms, Ions and Compounds.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 3.1 Describe the structure of the atom in terms of subatomic particles; write the isotopic symbol for any isotope of a given element or ion.
- 3.2 Describe the basic features of the periodic table.
- 3.3 Write formulas of ionic or covalent compounds from their names and from their names write their formulas.

Competency 4: Chemical Reactions.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 4.1 Write and balance a chemical reaction.
- 4.2 Classify reactions into various types such as combination, decomposition, single replacement, double replacement, oxidation-reduction, acid-base, precipitation and gas forming reactions.

Competency 5: Calculations with Formulas and Chemical Equations.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 5.1 Use mole concept to calculate the molar mass, the number of moles from the mass of a sample, the number of atoms or molecules and molarity of solutions.
- 5.2 Apply the mole concept to the determination of mass %, empirical and molecular formulas.
- 5.3 Apply the mole concept to reaction stoichiometry calculations including limiting reagent and percent yield.

Competency 6: Gaseous State.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 6.1 Use kinetic molecular theory to account for the properties of gases and the gas laws (Boyles, Charles, Avogadro, etc.).
- 6.2 Use gas laws to calculate the pressure, volume, temperature or number of moles from appropriate data.
- 6.3 Use the Ideal gas law to determine the density or molar mass of a gas and the stoichiometry of reactions involving gases.
- 6.4 Calculation of the partial pressure or mole fractions from the appropriate data of gas mixtures.

6.5 Explain how the properties of real gases differ from an Ideal Gas.

Competency 7: Thermochemistry.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 7.1 Explain the role of heat in chemical reactions (Thermodynamic Laws).
- 7.2 Perform calorimetric calculations and use enthalpy tables or Hess's Law to determine the heat of a reaction.

Competency 8: The Periodic Table and Atomic Structure.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 8.1 Explain the relationships between the properties of electromagnetic radiation with respect to wavelength, frequency, energy and spectral region and be able to calculate the energy, frequency or wavelength from appropriate data.
- 8.2 Compare and contrast the Bohr and quantum theories of atomic structure and how they account for location of electrons in atoms and spectral lines.
- 8.3 Explain the characteristics of atomic orbitals and the quantum numbers associated with them.
- 8.4 Write the electronic configuration of atoms and ions.
- 8.5 Use the periodic table to predict the physical and chemical properties of elements, including atomic radii, ionization energy and electron affinity.

Competency 9: Bonding.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 9.1 Write Lewis structures for neutral atoms, ions, ionic and covalent compounds.
- 9.2 Use Lewis structures and VSEPR theory to predict electronic and molecular geometries.
- 9.3 Use the principle of electronegativity to describe the characteristics of polar covalent bonds.
- 9.4 Use the polar and covalent bonds and VSEPR to determine the overall polarity of a molecule.
- 9.5 Use valence bond theory and molecular geometry to determine the hybridization of atoms.
- 9.6 Compare and contrast valence bond, molecular orbital and metallic bonding theories and how each accounts for molecular structures and properties.

Competency 10: States of Matter: Liquids and Solids.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 10.1 Compare the differences between the state of matter and the changes of state that occur.
- 10.2 Describe the major types of intermolecular forces and use them to explain the properties of solids and liquids such as boiling point, melting point, surface tension and viscosity.
- 10.3 Describe how intermolecular forces determine solubility of polar and nonpolar substances.

Competency 11: Solutions.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 11.1 Calculate the concentration of solutions in molarity, molality, normality, mole fraction, or percent by mass and be able to interconvert between them.
- 11.2 List the colligative properties of solutions (freezing point depression, boiling point elevation, vapor pressure lowering and osmotic pressure) and perform calculations involving them.

Competency 12: Kinetics.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 12.1 Determine rate laws and order of a reaction from experimental data using the initial rates or graphical methods.
- 12.2 Use collision theory to explain the concept of activation energy and the effect of temperature on reaction rates and use the Arrhenius equation to calculate the activation energy.
- 12.3 Learn to use elementary steps to link the mechanism of a reaction to the rate law.
- 12.4 Explain how a catalyst affects a reaction.

Competency 13: Chemical Equilibrium.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 13.1 State and apply LeChatelier's Principle to a reaction at equilibrium.
- 13.2 Calculate the value of an equilibrium constant from experimental data and use equilibrium constants to predict quantities of all species at equilibrium.

Competency 14: Acid-Base Equilibria.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 14.1 State and apply the Arrhenius, Bronsted-Lowry and Lewis acid-base theories to acid-base reactions.
- 14.2 Perform equilibrium calculations for pH, K_a and buffer systems.

Competency 15: Solubility and Complex Ion Equilibria.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 15.1 Explain the concept of solubility product constant, complex ion equilibrium, the common ion effect and write the K_{sp} and K_{eq} expressions.
- 15.2 Calculate the molar solubility of a species and determine if a precipitate will form.

Competency 16: Thermodynamics.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 16.1 Discuss the fundamental laws of thermodynamics, free energy and entropy.
- 16.2 Perform thermodynamics calculations to predict the spontaneity of a chemical reaction and its equilibrium constant.

Competency 17: Electrochemistry.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 17.1 Discuss and apply the principles of electrochemistry including writing and balancing redox reactions.
- 17.2 Calculate cell potentials.
- 17.3 Calculate free energy and equilibrium constants from cell potentials.

Appendix C: Competencies for Preparation in General Chemistry **Laboratory**

Competency 1: Laboratory Safety and Laboratory Notebook.

Behavioral Objectives: This competency applies to all laboratory competencies. Students should be instructed in: safe laboratory practices at the institutional level, safety protocols mandated by OSHA, proper use of equipment, proper practices in the acquisition of reagents for all experiments and proper disposal of waste. In addition, students should be instructed on how to keep a laboratory notebook for their experiments.

Competency 2: Dimensional Analysis.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform an experiment that emphasizes dimensional analysis and use of significant figures.

Competency 3: Empirical Formula.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform an experiment that involves the calculation of empirical formula.

Competency 4: Chemical Reactions.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform an experiment that involves a synthesis and limiting reactant calculation.

Competency 5: Titration.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform an experiment that involves titration analysis that utilizes the concept of oxidation-reduction reactions, acid-base reactions or complex ion reactions.

Competency 6: Calorimetry.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform an experiment involving calorimetry to measure specific heat or heat of reaction.

Competency 7: Spectroscopy.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform an experiment that utilizes a UV-Visible spectrometer in the construction of a calibration curve and analysis of an unknown.

Competency 8: Kinetics.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform an experiment that involves the application of kinetic calculations (first order, second order, or pseudo-first order, etc.) using the method of initial rates or a graphical approach.

Competency 9: pH.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform an experiment that utilizes a pH meter and demonstrates changes in equilibria in a pH titration.

Competency 10: Buffers.

Behavioral Objectives: In order to attain this competency, the student should be able to:
Perform an experiment involving buffers.

Competency 11: Density and Other Physical Properties.

Behavioral Objectives: In order to attain this competency, the student should be able to:
Perform an experiment that determines the density of substances or other physical properties.

Competency 12: Gas Laws.

Behavioral Objectives: In order to attain this competency, the student should be able to:
Perform an experiment that uses the Ideal Gas Law to determine the stoichiometry of a gas forming reaction or the molar mass of a gas or measures the physical properties of gases.

Competency 13: Chemical Equilibrium.

Behavioral Objectives: In order to attain this competency, the student should be able to:
Perform an experiment that illustrates LeChatalier's Principle or where an equilibrium constant is determined.

Competency 14: Electrochemistry.

Behavioral Objectives: In order to attain this competency, the student should be able to:
Perform an experiment that determines the potentials for voltaic cells or uses electrolytic cells to run chemical reactions.

Competency 15: Colligative Properties.

Behavioral Objectives: In order to attain this competency, the student should be able to:
Perform an experiment that determines the colligative property of a solution.

Competency 16: Solubility

Behavioral Objectives: In order to attain this competency, the student should be able to:
Perform an experiment that determines solubility rules or measures the solubility product constant of a compound.

Appendix D: Competencies for Preparation in Organic Chemistry

Competency 1: Bonding.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 1.1 Understand topics in chemical bonding and the relationship between chemical structures and their reactivity.
- 1.2 Understand the concept of resonance.
- 1.3 Understand the concept of hybridization.

Competency 2: Structure and Function.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 2.1 Identify functional groups.
- 2.2 Correlate chemical structure with reactivity and function.
- 2.3 Understand how the behavior and properties of molecules depend on electronic, orbital and steric interactions.
- 2.4 Understand the importance of environmental context (solution phase, pure gas, liquid or solid) on predicting the structure and reactivity of organic molecules.

Competency 3: Acid-Base Reactions.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 3.1 Make predictions of behavior attributable to Lewis acid-base principles, and Bronsted-Lowry acid-base principles.
- 3.2 Understand the concept of pKa.

Competency 4: Stereochemistry.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 4.1 Understand all stereochemical principles (cis, trans, R, S, exo, endo) and their identification/relationships.
- 4.2 Make predictions regarding stability and reactivity of stereochemical molecules from conformational analysis.
- 4.3 Understand the importance of stereochemistry in specific reactions.

Competency 5: Nomenclature.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 5.1 Name alkanes, alkenes, alkynes, aromatics, alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amides, halides and amines.
- 5.2 Incorporate stereochemistry in nomenclature.

Competency 6: Spectroscopy.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 6.1 Analyze and interpret structural data obtained from laboratory experiments, spectroscopic analysis, and computational methods.
- 6.2 Understand the theory and analysis of Infrared Spectroscopy (IR) and Nuclear Magnetic Resonance Spectroscopy (NMR).

Competency 7: Organic Reactions.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 7.1 Understand the concept of “reaction mechanism” in organic chemistry.
- 7.2 Predict reaction outcomes based on mechanistic principles, in the areas of addition, substitution, elimination and rearrangement chemistry.
- 7.3 Recognize and understand the significance of reactive intermediates such as carbocations, radicals, carbanions and carbenes.
- 7.4 Understand how reaction rate, kinetics, and energy diagrams apply to organic reactions.

Competency 8: Organic Synthesis.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 8.1 Understand the design of organic syntheses.
- 8.2 Understand the synthesis and reactions of the major classes of organic molecules: alkanes, alkenes, alkynes, aromatics, alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amides, halides and amines.
- 8.3 Plan organic syntheses through the application of retrosynthetic analysis principles.

Competency 9: Macromolecules.

Behavioral Objectives: In order to attain this competency, the student should be able to:

- 9.1 Recognize the organic functionality of macromolecules.
- 9.2 Understand the synthesis of, and the structure-based behavior of, macromolecular species such as proteins, lipids, (mono- and) polysaccharides, and synthetic polymers.

Appendix E: Competencies for Preparation in Organic Chemistry **Laboratory**

Competency 1: Laboratory Safety and Laboratory Notebook.

Behavioral Objectives: This competency applies to all laboratory competencies. Students should be instructed in: safe laboratory practices at the institutional level, safety protocols mandated by OSHA, proper use of equipment, proper practices in the acquisition of reagents for all experiments and proper disposal of waste. In addition, students should be instructed on how to keep a laboratory notebook for their experiments.

Competency 2: Purification Techniques.

Behavioral Objectives: In order to attain this competency, the student should be able to: Isolate and purify organic materials; methods should include simple and fractional distillation of liquids, recrystallization of solids, column chromatography, and extraction of solutes in immiscible solvents. Identification of purified products by melting point, boiling point, refractive index (or polarimetry), or by spectroscopic analysis should be included.

Competency 3: Spectroscopy.

Behavioral Objectives: In order to attain this competency, the student should be able to: Develop competence in the spectroscopic analysis of organic starting materials and synthetic products. Methods should include, at the very least, interpretation of IR and NMR spectra. It is recommended that GC/MS should also be included. Students should develop facility in deducing structures from spectra and be able to provide answers to questions involving data provided from 'unavailable' spectroscopic or computational sources.

Competency 4: Functional Group Interconversion.

Behavioral Objectives: In order to attain this competency, the student should be able to: Correctly plan and carry out a broad variety of organic reactions based on functional group interconversions.

Competency 5: Chromatography.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform an experiment that utilizes thin layer chromatography (TLC) and/or gas chromatography (GC). Examples include monitoring a reaction by observing both reactants and products and/or comparison of standards to unknowns.

Competency 6: Statistical Analysis.

Behavioral Objectives: In order to attain this competency, the student should be able to: Perform a laboratory that applies statistical methods to the analysis of experimental data, real or simulated (This competency is recommended by the ACS but not required as part of this agreement).

Competency 7: Computational.

Behavioral Objectives: In order to attain this competency, the student should be able to: Understand the value of, and the limitations associated with, computational methods (this competency is recommended by the ACS but not required but not required as part of this agreement).

ADDENDUM
GENERAL STATEWIDE PROGRAM-TO-PROGRAM
ARTICULATION in PENNSYLVANIA
(Revised April 11, 2012)

WHEREAS, the General Assembly of the Commonwealth of Pennsylvania enacted Act 114 of 2006, which added to the Public School Code of 1949, Article XX-C entitled “Transfers of Credits Between Institutions of Higher Education” (referred to in this Agreement as the “Statewide Transfer System”);

WHEREAS, Act 114 of 2006 requires all community colleges in Pennsylvania and Pennsylvania State System of Higher Education (PASSHE) universities to participate in the Statewide Transfer System;

WHEREAS, Act 114 of 2006 permits independent and state-related institutions of higher education in Pennsylvania, as each is defined in Article XX-C, to elect to participate in the Statewide Transfer System;

WHEREAS, the General Assembly of the Commonwealth of Pennsylvania enacted Act 50 of 2009, which requires institutions participating in the Statewide Transfer System to accept the transfer of Associate of Arts and Associate Science degrees into parallel baccalaureate programs and recognize all competencies attained within the associate degree program;

WHEREAS, Act 50 of 2009 defines an Associate of Arts (AA) or Associate of Science (AS) degree containing a minimum of 60 college-level credits and designed primarily for transfer to a baccalaureate institution;

WHEREAS, Act 50 of 2009 requires the Transfer Articulation Oversight Committee (TAOC), as established in section 2004-C of the Public School Code of 1949, to identify Associate of Arts and Associate of Science degree programs for transfer with full junior standing into parallel baccalaureate degrees annually; and,

WHEREAS, Act 50 of 2009 requires members of the Transfer Articulation Oversight Committee established in section 2004-C of the Public School Code of 1949, to identify modifications that may be required in existing associate or baccalaureate degrees to satisfy external accreditation or licensure requirement;

All Institutions participating in the Statewide Transfer System enter into this Articulation Agreement and mutually agree as follows:

1. The statewide program-to-program articulation agreement ensures that students who complete an AA or AS degree from a participating institution will have their coursework and credits transfer into a parallel baccalaureate program with full junior standing and without the need for course-by-course equivalency.
2. Students are subject to the admissions and transfer credit policies of the participating institutions. The admissions and transfer credit policies for all of the institutions participating in Pennsylvania’s college credit transfer system can be found at www.PAcollegetransfer.com.
3. The AA or AS degree must include a minimum of 60 college-level credits designed and acceptable for transfer, not including developmental or remedial courses or career, technical or applied courses.
4. The transfer of coursework with a grade less than a C (2.0 on a 4.0 scale) in the AA or AS will be consistent with the policies of native students at the participating college or university.
5. Students and institutional personnel will be able to find out which institutions offer articulated programs by accessing a searchable database located at www.PAcollegetransfer.com. PDE will maintain this database through program information provided to TAOC by the individual participating institutions.
6. References to courses in all agreements designate competencies and are not to be construed as making a reference to a specific course at a specific institution. Course titles in the agreements are presented for

guidance in advising students as to which coursework they should take even though the course at the student's college may not have the specific title mentioned in the agreement.²

7. Responsibilities of Associate Degree Institutions

- a. The AA or AS degree leading to a parallel bachelor degree will include the minimum number of credits and competencies of major-specific coursework as defined by the Agreement.
- b. Any remaining AA or AS degree requirements will be accepted from arts and sciences electives designed and acceptable for transfer, not including developmental, remedial, career, technical or applied courses.
- c. By awarding the AA or AS, the Associate Degree Institution is validating that the student has met the competency requirements outlined in the Agreement.

8. Responsibilities of Bachelor Degree Institutions

- a. The Bachelor Degree Institution will recognize all competencies attained within the AA or AS degree and accept a transfer student who has earned the associate degree with full junior standing into a parallel baccalaureate degree program.
- b. All decisions made with respect to the transfer process shall be based on the principle of equivalence of expectations and requirements for native and transfer students.
- c. A transfer student's admission into the parallel baccalaureate degree will be subject to the Bachelor Degree Institution's specific requirements for admission to that major and be consistent with such requirements for native students.

9. Agreement Revision and Assessment

- a. Once a statewide program-to-program articulation agreement has been approved by TAOC, no amendments to the agreement can be offered by any party within the initial six (6) months of the agreement. After that time, a TAOC member with a proposed amendment to an approved agreement should submit the change to PDE.

Amendments that are offered as clarifying or technical but do not alter the substantive portions or intent of the agreement must be forwarded to TAOC. TAOC representatives will have at least thirty (30) days to review, comment and approve or deny the proposed amendments.

Amendments that seek to alter the substantive nature or intent of the agreement in any part must be forwarded to the appropriate PAC for review and consideration. The PAC will then make a recommendation to the TAOC, and TAOC shall approve or deny the proposed amendments.³

- b. PDE and TAOC will exercise responsibility for monitoring the effectiveness of the Agreement and its implementation.
- c. PDE shall collect data annually from the participating institutions that will enable the Department and TAOC to assess the effectiveness of the implementation of the Agreement in fostering a seamless transfer process and the academic success of transfer students at the senior institutions.

10. Transfer Appeal Process

- a. In accordance with Pennsylvania's Statewide Transfer System, each Bachelor Degree Institution shall have a procedure through which a transfer student can appeal a decision that he/she believes is not consistent with this Agreement.

² Adopted by TAOC and added to the agreement on April 11, 2012.

³ Approved by TAOC and added to agreement on August 18, 2011.

- b. The Transfer Appeal Process shall be published, at minimum, in the institution's catalog and posted to the Commonwealth's official website of the Statewide Transfer System, www.PAcollegetransfer.com.

11. Institutional Resolution of Disputes

- a. In the event that an Associate Degree Institution considers the decision of a Bachelor Degree Institution to be inconsistent with this Agreement, the Associate Degree Institution shall consult directly with the Bachelor Degree Institution and attempt to resolve the matter.
- b. If the institutions are unable to resolve the issue, the Associate Degree Institution may submit their concern to PDE for consideration by the TAOC Dispute Resolution Committee. The Dispute Resolution Subcommittee will act according to the policies and procedures developed by TAOC as part of the Statewide Transfer System. The determination made by the Dispute Resolution Subcommittee will be binding upon the parties.

12. Implementation Date and Applicability

Having fulfilled the requirements outlined in the Program-to-Program Articulation Agreement, students transferring with an AA or AS degree from a participating institution will be considered by the receiving baccalaureate degree institution to have received adequate preparation in the field of study at the foundation level and therefore eligible to transfer as a junior into advanced major coursework.

Participating institutions will enact the Agreement in accordance to the timeline outlined by the TAOC, but no later Fall 2013.⁴

Continuation of the agreement remains in effect until such time as all cooperating institutions of the Statewide Transfer System formally approve any revisions.

GLOSSARY OF TERMS

Articulation: The aligning of curriculum between institutions of higher education to ensure the efficient and effective movement of students among those institutions.

Associate of Arts (AA) and Associate of Science (AS) Degree: A degree consisting of at least 60 college-level credits and designed for transfer into a baccalaureate degree program.

Foundation Coursework: Courses at a level of comprehension usually associated with freshman and sophomore students and typically offered during the first half of a baccalaureate degree program. Such coursework typically does not have course prerequisites.

Native Student: A student who entered a given college or university without first matriculating at another college.

Parallel Baccalaureate Degree: A bachelor degree program in a comparable field of study and with similar foundation-level major-specific competencies as an associate degree program.

Receiving Institution: The college or university where a transfer student plans to enroll and to apply previously earned credit toward a degree program.

Transfer Credit: The credit granted by a college or university for college-level courses or other academic work completed at another institution.

Transfer Student: A student who enters a participating college or university after earning college-level credit at another college or university.

⁴ Agreements approved by TAOC prior to August 31, 2011 must be implemented by the institutions by Fall 2012. Agreements approved by TAOC after August 31, 2011 but before May 1, 2012 must be implemented by the institutions by Fall 2013.

Transfer: The process by which a student moves from one postsecondary institution to another. Also refers to the mechanics of credit, course and curriculum exchange between institutions.

Advanced Coursework: Courses with advanced depth of content knowledge in the field of study and carry the expectation of more complex competencies identified in the expected student learning outcomes is referred to as advanced coursework. These courses often have prerequisites and are usually beyond the “Introduction to…” or “Foundation of…” level.