PENNSYLVANIA STATEWIDE PROGRAM-TO-PROGRAM DRAFT ARTICULATION AGREEMENT IN EARTH SCIENCE

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 participating four-year college or university. This agreement specifically ensures that a student who successfully completes an Associate of Arts (AA) or Associate of Science (AS) degree in Earth Science or any AA or AS degree that incorporates the required competencies at a participating institution can transfer the full degree into a parallel bachelor degree program in Earth Science at a participating four-year institution.

In order for students to transfer the full associate degree into a parallel bachelor degree program at a participating four-year institution, all of the following criteria must be met:

- Successful completion of an associate degree that includes all of the required major competencies identified in this Agreement.
- Successful completion 30 credits of foundation courses from the Transfer Credit Framework.

See Appendix A: Program-To-Program Articulation Agreement for Earth Science.

It is therefore understood that students meeting these requirements will be considered by both the associate degree granting institution and the receiving four-year institution to possess the knowledge, skills and abilities necessary for entry as a junior into a parallel bachelor degree program in Earth Science.

The Earth Science program gives students an opportunity to develop a broad-based understanding of our Earth through the study of numerous disciplines. Requirements for Earth Science degrees are often similar to those for the degree in Earth and Space Science for secondary education majors. A solid grounding in a wide range of math and physical science specialties provides the necessary background for success in this interdisciplinary major. To that end, it is recommended that the associate degree in Earth Science include coursework in Astronomy, Geology, Meteorology, and Oceanography as well as Mathematics, Physics and Chemistry. It is the intent of the Physical Sciences Program Articulation Committee that the competencies for prerequisite subjects such as Physics and Chemistry match competencies listed in the appropriate major Program Articulation Agreements.

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]

REQUIRED Major-Specific Content Areas

Under this Agreement, a fully transferable associate degree in the field of Earth Science must include competencies in the following content areas:

1. **Geology**
2. **Meteorology**
3. **Oceanography**
4. **Astronomy**
5. **Calculus**
6. **Physics**
7. **Chemistry**

Institutions may determine how the competencies identified in these primary content areas are met. For example, one institution may choose to embed the geology competencies in one 4-credit course that includes both lecture and

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

laboratory sections, or a 3-credit lecture and 1-credit independent laboratory course. How an institution incorporates the competencies into the associate degree program does not affect the transferability of the associate degree under this Agreement, so long as all of the competencies are met.

1. Geology

An earth scientist needs an excellent understanding of the materials from which the Earth is made, the processes acting on and within the Earth, and Earth structures. The student should also have learned the history of the changing Earth through time, and how the rock record can be interpreted to provide evidence of these changes. The following competency areas will allow majors to identify and solve problems in the geosciences.

Competency Area 1: Formation Of The Solar System And Earth
Competency Area 2: Plate Tectonics And Earthquakes
Competency Area 3: Minerals
Competency Area 4: Igneous Rocks And Environments
Competency Area 5: Weathering, Soil, And Mass Wasting
Competency Area 6: Sedimentary Rocks And Environments
Competency Area 7: Metamorphic Rocks And Environments
Competency Area 8: Deformation And The Continents
Competency Area 9: Surface Water And Groundwater
Competency Area 10: Climate, Glaciers, Wind, And Coastal Processes
Competency Area 11: Geologic Time And Rock Correlation
Competency Area 12: Stratigraphy
Competency Area 13: Sedimentary Environments
Competency Area 14: Origin And Diversity Of Life
Competency Area 15: Evolution
Competency Area 16: The Precambrian
Competency Area 18: Late Paleozoic Life And Earth History
Competency Area 19: Mesozoic Life And Earth History
Competency Area 20: Cenozoic Life And Earth History
Competency Area 21: Primate And Human Evolution

Competency areas #1-11 are often taught as part of a Physical Geology course. Additional competencies in area #11 and competency areas #12-21 are often taught as part of a Historical Geology course. See Appendix C: Competencies for Preparation in Geology.

2. Meteorology

The Atmosphere interacts with and affects all earth systems, it is therefore required that Earth Science students demonstrate competency in Meteorology.

Students will demonstrate competency by:

- Listing the primary gaseous components of the atmosphere and explaining the importance of each.
- Explaining why the atmosphere has the observed vertical temperature, density, and pressure profiles that it has.
- Applying the first law of thermodynamics and the ideal gas law to the atmosphere.
- Describing the short and longwave radiation balance of the earth/atmosphere system, and explaining how that radiation balance influences climate and weather.
- Describing the details of the earth's orbit around the sun, and explaining how this earth/sun geometry influences the seasons.
- Listing and explaining the major factors that control the daily and seasonal temperatures.
- Describing how humidity is quantified and measured, and how to convert between the various measures of humidity.
- Describe how temperature and moisture determine the stability of the atmosphere, and explain how stability influences cloud and storm development.
- Applying the skew-t diagram to determining atmospheric static stability and cloud development.
- Listing the types and characteristics of the various clouds found in the atmosphere.
- Explaining how precipitation is formed, measured, and what determines the type of precipitation reaching the ground.

- Applying Newton's second law of motion to the atmosphere.
- Quantitatively describing geostrophic, hydrostatic, and gradient wind balance, and conceptually explaining departures from a balanced state.
- Explaining how pressure gradient force, Coriolis force, and friction determine the wind direction and speed.
- Describe how the vertical wind shear of the geostrophic wind relates to the horizontal temperature gradient.
- Listing the various scales of atmospheric motion, and providing examples of each.
- Explaining how the various scales of atmospheric motion interact.
- Describing how local wind systems develop and are maintained.
- Describing how the global circulation of the atmosphere is maintained.
- Listing the characteristics of the different types of air masses, and explaining how the air masses are formed.
- Defining a front, and explaining why fronts are regions of active weather.
- Listing the cloud sequences and other characteristics of warm, cold, occluded, and stationary fronts.
- Describing the horizontal and vertical structure of a developing extratropical cyclone, and explaining why this structure exists.
- Describing the development and structure of thunderstorms and tornadoes.
- Explaining the cause of lightning, and describe the different types of lightning.
- Interpreting and plotting station models for both surface and upper-air charts.
- Interpreting coded METAR reports.
- The use meteorological software and the worldwide web to locate, display, and analyze meteorological observations and model data.
- Applying the above-mentioned competencies in a collaborative laboratory environment.

3. Oceanography

More than two thirds of the Earth is covered by oceans. It is therefore required that Earth Science students study the environment that dominates the majority of the Earth's surface.

Students will demonstrate competency by:

- Describing the relationship between the oceans, land and atmosphere.
- Describing the concept of the earth system.
- Listing the relative sizes and distinguishing characteristics of the world's major ocean basins.
- Describing the formation of ocean basins and the general features of the ocean bottom.
- Describing the chemical properties of water; the hydrogen bond.
- Describing the concept of salinity and the principle of constant proportions.
- Describing the relationship between water's salinity, temperature and density.
- Describing the relationship between atmospheric circulation, climate belts and wind belts.
- Describing the ocean's major flow patterns and listing the names of the major ocean currents.
- Differentiating between surface ocean currents and deep ocean currents.
- Describing the dynamics of waves and tides.
- Explaining how ocean processes influence the shape of shorelines.
- Listing the major primary producers in the ocean ecosystem.
- Explaining how a simple and a more complex ocean ecosystem works.
- Discussing the role of the ocean in global climate change.
- Describing the locations of Earth's physiographic features, i.e., major mountain belts, mid-ocean rides, subduction zones, continental shelves, abyssal plains, etc.
- Identifying and describing basic features of the more common phytoplankton and zooplankton.

4. Astronomy

An Earth Scientist should understand Earth's place in the solar system and Universe, therefore it is required that students gain competence in Astronomy.

Students will demonstrate competency by:

- Evaluating three major historical developments in astronomy.

- Interpreting and describing contributions to astronomy from 4 different cultures.
- Differentiating, comparing, and contrasting 3 major telescope designs.
- Explaining the usage of astronomical instruments and their uses for 4 wavelengths of light other than visible.
- Identifying four types of lunar features and explaining the physical processes that created them.
- Analyzing five physical features of the Sun.
- Interpreting the process by which the Sun produces energy.
- Explaining the sunspot cycles and their relation on solar output.
- Analyzing four differences and similarities between the Terrestrial and Gas Giant planets.
- Stating four current features, properties, or characteristics of each planet.
- Comparing and contrasting the evolution of each planet.
- Differentiating the characteristics of Kuiper Belt and Oort Cloud objects.
- Arguing the evidence for meteorite impacts and their effect on Earth's biosphere

5. Calculus

The world around us is constantly changing. Calculus is the branch of mathematics that has been developed to study changes. Therefore, the following competencies provide geologists with the tools for understanding the changes that occur in the Earth, oceans, and atmosphere, and enable them to solve geologic problems:

Competency 1: Utilize the concept of limit.
Competency 2: Differentiate functions.
Competency 3: Use differential calculus to sketch curves and to solve applied problems.
Competency 4: Integrate functions by approximation and by use of antiderivatives.

See Appendix D: Competencies for Preparation in Calculus

6. Physics

Physics is concerned with the nature and properties of matter and energy. Earth Scientists must understand the underlying physical principles of gravity, kinetic energy, friction, strain, magnetism, refraction, force, and convection, for example, to fully grasp the materials, structure, and processes they study.

These competencies are often taught as part of a two-semester Physics sequence for majors. Earth Science students should master physics competencies at a science-major level.

Behavioral Objectives: Students will demonstrate competency by:

- Demonstrating how forces cause a change in motion.
- Describing Newton's three laws of motion and law of universal gravitation.
- Demonstrating understanding on impulse and momentum.
- Describing the conservation of momentum.
- Explaining how friction affects the changes of motion.
- Demonstrating how equilibrium is achieved.
- Locating the center of gravity of an object.
- Explaining the different conditions for equilibrium.
- Describing the laws governing planetary motion.
- Differentiating between mass and weight.
- Explaining the concepts of stress and strain, pressure and Archimedes principle.
- Explaining the relationship between force, work, power and energy.
- Describing the laws governing the conservation of energy.
- Describing the nature of waves as energy carriers and the wave properties of reflection, refraction, diffraction and interference.
- Explaining how sound waves are produced, transmitted and propagated.
- Describing the laws of thermodynamics.
- Applying the above-mentioned competencies in a collaborative laboratory environment.

Behavioral Objectives: Students will demonstrate competency by:

- Explaining how electric charges interact.

- Describing the concept of electric field.
- Differentiating between current, voltage and resistance.
- Describing ohm's law.
- Explain the nature of magnetism.
- Describing the contributions of Faraday and Oersted to electromagnetic theory.
- Describing the structure and function of simple integrated circuits.
- Appreciating the properties of electromagnetic waves and explaining how they are produced, transmitted and used.
- Applying the above-mentioned competencies in a collaborative laboratory environment.

7. Chemistry

Earth scientists use chemistry in their study of earth materials and processes ranging from soil development, to climate change, to the composition of the planets.

Earth Science students should master chemistry competencies at a science-major level.

Competencies for Preparation in *General Chemistry*

Competency 1: Introduction to Chemistry.
Competency 2: Measurement.
Competency 3: Atoms, Ions and Compounds.
Competency 4: Chemical Reactions.
Competency 5: Calculations with Formulas and Equations.
Competency 6: Gaseous State.
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.

See Appendix E: Competencies for Preparation in General Chemistry

Competencies for Preparation in *General Chemistry Laboratory*

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: Spectroscopy.
Competency 8: Kinetics.
Competency 9: pH.
Competency 10: Buffers.
Competency 11: Density and Other Physical Properties.

See Appendix F: Competencies for Preparation in General Chemistry Laboratory

RECOMMENDED General Content Areas

In addition to the required major competencies listed above, students transferring into a bachelor degree program in Earth Science would also benefit from acquiring competencies in both of the following content areas:

1. Elementary Statistics
2. Geographic Information Systems

Students will not be penalized for not completing competencies in one or both of these areas of study, though exposure to additional mathematical principles and geographic information systems would greatly benefit an Earth Science major transferring at the junior level.

See Appendix A: Program-to-Program Articulation Agreement for Earth Science.

30- Credit Transfer Framework

The Commonwealth's statewide college credit transfer system includes an advising tool called the "Transfer Credit Framework". The Framework allows students to seamlessly transfer up to 30 credits of foundation courses from one participating college or university to another and have those courses count toward graduation. See Appendix B or go to www.PAcollegetransfer.com.

Through the Transfer Credit Framework, the commonwealth's Transfer and Articulation Oversight Committee identified six categories of foundation-level coursework that is common among the participating institutions. Each category consists of multiple course options. However, some Framework courses are more relevant to the field of Earth Science than others. A list of highly recommended courses in each category is included in Appendix A: Program-to-Program Articulation Model for Earth Science. It is important to note that many worthwhile and useful courses, such as an introductory course in Geographic Information Systems (GIS), may not be part of that the Transfer Credit Framework, so we do **not** recommend that students take **only** Framework courses, but rather that they confer with a counselor both at the 2-yr and intended 4-yr transfer institution to determine the best possible courses.

Under this Agreement, students should select additional courses according to the criteria indicated for Framework Category 1, Category 2, Category 5 and Category 6.

In Framework Category 3, students may apply a maximum of 4 credits completed as part of the Required General Content Area of Calculus.

Likewise, a maximum of 8 credits in Chemistry, a Required General Coursework Area, may be used to satisfy the requirements of Framework Category 4. See Appendix A: Program-to-Program Articulation Agreement for Earth Science.

A sound understanding of Ethics is important to the professional work of Earth Scientists. A course in Ethics is recommended, but not required, to partially fulfill the requirements of Category 6 of the Transfer Credit Framework.

The Program Articulation Committee for Physical Sciences urges TAOC to consider adding more courses in Math (Calculus II) and the Physical Sciences (Physical and Historical Geology, Physics II, Calculus-based Physics I and II, Meteorology) to the Transfer Credit Framework, benefiting majors and non-majors alike. Students at two-year colleges may be less likely to take courses that are not part of the Framework, and consequently 1) may be less likely to find a good "fit" for their interests, since they may pass over an intriguing course in favor of one listed in the Framework, and 2) may consequently be at a disadvantage when they start work toward a four-year degree, if their interests lie in the physical sciences.

These courses are recommendations only. They are not (except as noted above) required as part of the major or the Articulation Agreement. Students will not be penalized for not completing recommended courses prior to transferring. The courses listed are merely suggestions that could enhance a student's academic frame of reference as an Earth Science major.

Students are advised to work closely with an advisor to select courses related to their associate degree program, transfer major and personal interests. Contact should be made with an advisor at the expected four-year institution to as soon as possible during Associate's degree coursework to ensure that the four-year institution's general education requirements are appropriately woven into the student's associate degree curriculum.

Appendix A: Program-to-Program Articulation Agreement for Earth Sciences

Major-Specific Content Areas – REQUIRED	Transfer Criteria
Geology	Mastery of the competencies noted in this agreement
Meteorology	Mastery of the competencies noted in this agreement
Oceanography	Mastery of the competencies noted in this agreement
Astronomy	Requirement could be satisfied by successfully completing Introductory Astronomy in Category 4 of the Transfer Credit Framework. See below.
Calculus	This requirement may be satisfied by successfully completing Calculus I in Category 3 of the Transfer Credit Framework. See below.
Physics	Mastery of the competencies noted in this agreement at the science major level.
Chemistry	This requirement may be satisfied by successfully completing General Chemistry I for majors in Category 4 of the Transfer Credit Framework. See below.
General Content Areas – RECOMMENDED	**Transfer Criteria**
Elementary Statistics	Student should consult an advisor before enrolling in the recommended coursework.
Geographic Information Systems	Student should consult an advisor before enrolling in the recommended coursework.

Transfer Credit Framework Category	Framework Requires Students to Take…^	Earth Science Majors are REQUIRED to Take…	Earth Science Majors are RECOMMENDED to Take…
Category 1	1 course (3-4 credits)		**One course** selected in consultation with an advisor
Category 2	1 course (3-4 credits)		**One course** selected in consultation with an advisor
Category 3^^	1-2 courses (3-8 credits)	**1. Calculus I***	**One additional math course** such as **Elementary Statistics***
Category 4^^	1-2 courses (3-8 credits)	**1. Chemistry I****	If the astronomy competencies listed herein are covered by the Transfer Credit Framework **Introductory Astronomy**** course, that course is recommended.
Category 5	1-2 courses (3-8 credits)		**2 courses** to be selected in consultation with an advisor.
Category 6	1-2 courses (3-8 credits)		**1. Ethics** **2. One course** selected in consultation with an advisor.

^Students are advised not to exceed the credit number indicated in each Framework Category. Credit requirements are presented as a range since actual credit number may vary by specific course and institution.
^^Adding courses in Math (Calculus II), and the Physical Sciences (Physical and Historical Geology, Physics II, Calculus-based Physics I and II, Meteorology) to the Transfer Credit Framework would benefit many students in the Physical Sciences.
* Earth Science majors may use up to 8 credits of coursework from the Required Major-Specific Content Area of Calculus and the Recommended General Content Area of Statistics to satisfy Category 3 requirements.
** Earth Science majors may use up to 4 credits of coursework from the Required Major-Specific Content Area of Chemistry to satisfy Category 4 requirements. If the Transfer Credit Framework Introductory Astronomy course covers the competencies listed in this agreement, then Earth Science majors may use up to 4 credits of coursework from the Required Major-Specific Content Area of Astronomy to satisfy additional Category 4 requirements.

Appendix B: Transfer Credit Framework[2]

Students who successfully complete courses from the approved categories below can have their credits transferred and counted towards graduation at any of the participating PA TRAC colleges and universities. Please be aware that certain majors may have specific requirements prescribed by external agencies. It is the student's responsibility to work with an advisor to select appropriate courses as they relate to the major.

Category 1 (3-4 credits total)	Category 2 (3-4 credits total)	Category 3 (min. 3-4 credits; max. 6-8 credits)	Category 4 Must include lab (min. 3-4 credits; max. 6-8 credits)	Category 5 (min. 3-4 credits; max. 6-8 credits)	Category 6 (min. 3-4 credits; max. 6-8 credits)
English Composition	Public Speaking	Foundations of Mathematics	General Chemistry I (majors & non-majors courses)	General Psychology	Introduction to Music
		College Algebra	General Chemistry II (majors & non-majors courses)	Introduction to Sociology	Introduction to Philosophy
		Elementary Statistics	General Biology I (majors & non-majors courses)	American National Government	Elementary Spanish I
		Precalculus	General Biology II (majors & non-majors courses)	Educational Psychology	Elementary Spanish II
		Calculus I	General Physics I (non-calculus)	History of Western Civilization II	Painting I
			General Physics II (non-calculus)	Principles of Macroeconomics	Elementary French I
			Anatomy & Physiology I*	Principles of Microeconomics	Elementary French II
			Anatomy & Physiology II*	U.S. History I	Drawing I
			Introduction to Astronomy	U.S. History II	Ethics
				History of Western Civilization I	Introduction to Art
				Contemporary Social Problems	German I
				Introduction to Anthropology	German II
				Child Growth & Development	Introduction to Literature (may also be known as Introduction to Poetry, Interpreting Literature, Reading Literature, Theses in Literature, Topics in Literature, Current Themes in Literature)
				Child Psychology	Survey of American Literature
					Literature of the Western World
					World Literature
					American Literature
					Survey of English Literature

[2] Framework chart amended on April 11, 2012 to include Child Growth & Development and Child Psychology under Category 5.

Appendix C: Competencies for Preparation in Geology

Competency area 1: Formation of the solar system and Earth
Behavioral Objectives: Students will demonstrate competency by:

- Describing current hypotheses for the formation of the solar system, Earth, and moon
- Explaining the internal structure and composition of the Earth

Competency area 2: Plate tectonics and earthquakes
Behavioral Objectives: Students will demonstrate competency by:

- Explaining the evidence for continental drift
- Explaining the evidence for plate tectonics
- Describing the energy sources and forces driving plate tectonics
- Describing the theory of plate tectonics
- Defining convergent, divergent, and transform plate boundaries and discussing geologic features associated with each.
- Describing the process by which energy is stored as strain and released as seismic waves to create an earthquake
- Describing and explaining the distribution of earthquake epicenters
- Listing the types of seismic waves and describing how they travel through/around the earth.
- Being able to locate the epicenter of an earthquake
- Discussing the methods and effectiveness of both short-term and long-term earthquake prediction

Competency area 3: Minerals
Behavioral Objectives: Students will demonstrate competency by:

- Defining mineral
- Discussing the basic building blocks of minerals, and the types of bonds that hold minerals together
- Identifying common rock-forming minerals based on characteristic physical properties
- Listing the major mineral families and providing examples of each

Competency area 4: Igneous rocks and environments
Behavioral Objectives: Students will demonstrate competency by:

- Identifying and classifying common intrusive and extrusive igneous rocks based on composition and texture
- Describing common intrusive and extrusive igneous environments, processes, and landforms
- Discussing magma evolution
- Explaining Bowen's reaction series

Competency area 5: Weathering, soil, and mass wasting
Behavioral Objectives: Students will demonstrate competency by:

- Explaining the difference between physical and chemical weathering
- Describing physical and chemical weathering processes
- Defining soil and explaining the formation of an idealized soil profile.
- Explaining the development of common broad soil classes
- Discussing the primary controls and triggers of mass wasting and subsidence
- Listing and describing the different types of mass wasting

Competency area 6: Sedimentary rocks and environments
Behavioral Objectives: Students will demonstrate competency by:

- Describing common sedimentary environments, processes, and structures
- Identifying and classifying common clastic and chemical sedimentary rocks based on composition and texture

Competency area 7: Metamorphic rocks and environments
Behavioral Objectives: Students will demonstrate competency by:

- Describing common metamorphic environments and processes
- Identifying and classifying common foliated and non-foliated metamorphic rocks based on composition and texture
- Explaining the processes by which one rock can be changed into another in the Rock Cycle.

Competency area 8: Deformation and the continents
Behavioral Objectives: Students will demonstrate competency by:

- Explaining the difference between stress and strain
- Discussing environments in which rocks experience strain
- Defining and being able to identify different types of faults and folds.
- Explaining how the attitude of rocks can be described with strike and dip.
- Identifying a wide variety of structures such as folds, faults, and unconformities on block diagrams.
- Explaining how mountain building events connect with the Wilson Cycle
- Defining isostasy
- Discussing the patterns of continental development through time

Competency area 9: Surface water and groundwater
Behavioral Objectives: Students will demonstrate competency by:

- Identifying the reservoirs in which water is stored, and describing both the processes that move water from one reservoir to another and the sources of energy driving water's movement through the hydrologic cycle.
- Discussing the most important factors influencing work (erosion, transport, deposition) done by streams
- Describing erosional and depositional stream-shaped landforms
- Identifying drainage patterns and relating patterns to geologic setting
- Explaining the occurrence and movement of groundwater
- Discussing issues of groundwater availability and contamination
- Explaining the development of karst

Competency area 10: Climate, glaciers, wind, and coastal processes
Behavioral Objectives: Students will demonstrate competency by:

- Differentiate between weather and climate
- Discussing the distribution of heat by air and water
- Explaining the main controls on climate, including possible causes of ice ages
- Explaining the greenhouse effect, and discus anthropogenic influence on climate
- Discussing use of temperature proxies
- Describing the location and movement of glaciers
- Identifying and explaining the origin of erosional and depositional glacial landforms
- Discussing the role of water and weathering in arid climates
- Identifying landforms common in arid climates
- Describing wave erosion and the landforms produced by wave erosion.
- Discussing shoreline erosional problems and solutions.

Competency area 11: Geologic time and rock correlation
Behavioral Objectives: Students will demonstrate competency by:

- Explaining the key principles of relative age dating
- Listing the three types of unconformities and Describing how each forms
- Determining the order of events in a cross section or landscape based on principles of relative age dating.
- Explaining the principles underlying radiometric dating.
- Explaining at least one line of evidence for the age of the Earth
- Knowing the names and age ranges of the major eons and eras of the geologic time scale
- Using the principle of faunal succession to determine relative age and correlate rock units.

Appendix D: Competencies for Preparation in Calculus

Competency 1: Utilize the concept of limit.
Behavioral Objectives: Students will demonstrate competency by:

1.1 determining limits using a table of values or graph.
1.2 evaluating limits of polynomial, rational, and trigonometric functions by direct substitution.
1.3 where substitution yields an indeterminate form, finding limits by cancellation and rationalization techniques or by the use of identities.
1.4 using L'Hopital's Rule to find limits of indeterminate forms.
1.5 evaluating limits using the Squeeze Theorem.
1.6 using limit theorems involving sums, differences, products, and quotients of functions.
1.7 indicating whether a function is continuous or discontinuous; if discontinuous, give all points of discontinuity.
1.8 determining limits at infinity.

Competency 2: Differentiate functions.
Behavioral Objectives: Students will demonstrate competency by:

2.1 defining and interpreting the derivative of a function.
2.2 computing derivatives of functions using the definition.
2.3 obtaining the derivatives of sums, products, quotients, and powers of polynomial, trigonometric, and transcendental functions using the general formulas for differentiation.
2.4 using the chain rule to differentiate the composition of functions.
2.5 finding differentials.
2.6 differentiating implicitly.
2.7 finding higher order derivatives.
2.8 evaluating derivatives.

Competency 3: Use differential calculus to sketch curves and to solve applied problems.
Behavioral Objectives: Students will demonstrate competency by:

3.1 finding the intervals on which a function is increasing or decreasing and the intervals on which a function is concave upward or concave downward.
3.2 determining relative minima, relative maxima, and points of inflection, if any, and sketch the graph of a function.
3.3 finding the equations of lines tangent and normal to a curve at a given point.
3.4 finding the point(s) on a curve where the tangent line has a given slope.
3.5 using differentials to approximate values of non-linear functions.
3.6 approximating a solution for an equation using Newton's Method.
3.7 given a position function, calculating the velocity and acceleration of a particle and analyzing its motion.
3.8 applying Rolle's Theorem and the Mean Value Theorem to a function.
3.9 solving applied related rate problems.
3.10 solving applied maximum-minimum problems.
3.11 applying the Extreme Value Theorem to a function.

Competency 4: Integrate functions by approximation and by use of antiderivatives.
Behavioral Objectives: Students will demonstrate competency by:

4.1 defining the indefinite and definite integral of a function.
4.2 finding antiderivatives by using the power rule and substitution.
4.3 integrating algebraic and trigonometric functions.
4.4 determining the constant of integration given sufficient conditions.
4.5 using the Fundamental Theorem of Calculus to evaluating definite integrals.
4.6 approximating an integral by the Trapezoidal Rule or Simpson's Rule.
4.7 using the 2nd Fundamental Theorem of Integral Calculus
4.8 expressing the limit of a Riemann sum as a definite integral.

Appendix E: Competencies for Preparation in General Chemistry

Competency 1: Introduction to Chemistry.
Behavioral Objectives: Students will demonstrate competency by:
- 1.1 Presenting the scientific method.
- 1.2 Classifying matter on the basis of physical and chemical properties.
- 1.3 Classifying matter on the basis of physical and chemical changes.

Competency 2: Measurement.
Behavioral Objectives: Students will demonstrate competency by:
- 2.1 Listing the common SI units of measurement, the values of selected prefixes, and the use of dimensional analysis to interconvert units of measurement.
- 2.2 Learning to use the rules for significant figures for calculation problems.

Competency 3: Atoms, Ions and Compounds.
Behavioral Objectives: Students will demonstrate competency by:
- 3.1 Describing 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 Describing the basic features of the periodic table.
- 3.3 Writing formulas of ionic or covalent compounds from their names and from their names write their formulas.

Competency 4: Chemical Reactions.
Behavioral Objectives: Students will demonstrate competency by:
- 4.1 Writing and balancing a chemical reaction.
- 4.2 Being able to 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 Equations.
Behavioral Objectives: Students will demonstrate competency by:
- 5.1 Using 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 Applying the mole concept to the determination of mass %, empirical and molecular formulas.
- 5.3 Applying the mole concept to reaction stoichiometry calculations including limiting reagent and percent yield.

Competency 6: Gaseous State.
Behavioral Objectives: Students will demonstrate competency by:
- 6.1 Using kinetic molecular theory to account for the properties of gases and the gas laws (Boyles, Charles, Avogadro, etc.).
- 6.2 Using gas laws to calculate the pressure, volume, temperature or number of moles from appropriate data.
- 6.3 Using the Ideal gas law to determine the density or molar mass of a gas and the stoichiometry of reactions involving gases.
- 6.4 Calculating the partial pressure or mole fractions from the appropriate data of gas mixtures.
- 6.5 Explaining how the properties of real gases differ from an Ideal Gas.

Competency 7: Thermochemistry.
Behavioral Objectives: Students will demonstrate competency by:
- 7.1 Explaining 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: Students will demonstrate competency by:
- 8.1 Explaining 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 Comparing and contrasting the Bohr and quantum theories of atomic structure and how they account for location of electrons in atoms and spectral lines.
- 8.3 Explaining the characteristics of atomic orbitals and the quantum numbers associated with them.

8.4 Writing the electronic configuration of atoms and ions.
8.5 Using 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: Students will demonstrate competency by:
9.1 Writing Lewis structures for neutral atoms, ions, ionic and covalent compounds.
9.2 Using Lewis structures and VSPER theory to predict electronic and molecular geometries.
9.3 Using the principle of electronegativity to describe the characteristics of polar covalent bonds.
9.4 Using the polar and covalent bonds and VSEPR to determine the overall polarity of a molecule.
9.5 Using valence bond theory and molecular geometry to determine the hybridization of atoms.
9.6 Comparing and contrasting 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: Students will demonstrate competency by:
10.1 Comparing the differences between the state of matter and the changes of state that occur.
10.2 Describing the major types of intermolecular forces and using them to explain the properties of solids and liquids such as boiling point, melting point, surface tension and viscosity.
10.3 Describing how intermolecular forces determine solubility of polar and nonpolar substances.

Competency 11: Solutions.
Behavioral Objectives: Students will demonstrate competency by:
11.1 Calculating the concentration of solutions in molarity, molality, normality, mole fraction, or percent by mass and be able to interconvert between them.
11.2 Listing the colligative properties of solutions (freezing point depression, boiling point elevation, vapor pressure lowering and osmotic pressure) and performing calculations involving them.

Appendix F: 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: Students will demonstrate competency by:
Performing an experiment that emphasizes dimensional analysis and use of significant figures.

Competency 3: Empirical Formula.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that involves the calculation of empirical formula.

Competency 4: Chemical Reactions.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that involves a synthesis and limiting reactant calculation.

Competency 5: Titration.
Behavioral Objectives: Students will demonstrate competency by:
Performing 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: Students will demonstrate competency by:
Performing an experiment involving calorimetry to measure specific heat or heat of reaction.

Competency 7: Spectroscopy.
Behavioral Objectives: Students will demonstrate competency by:
Performing 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: Students will demonstrate competency by:
Performing 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: Students will demonstrate competency by:
Performing an experiment that utilizes a pH meter and demonstrates changes in equilibria in a pH titration.

Competency 10: Buffers.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment involving buffers.

Competency 11: Density and Other Physical Properties.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that determines the density of substances or other physical properties.

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.[3]

[3] Adopted by TAOC and added to the agreement on April 11, 2012.

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.[4]

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.

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

[4] Approved by TAOC and added to agreement on August 18, 2011.

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.[5]

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.

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.

[5] 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.