COMMUNITY COLLEGE OF PHILADELPHIA

Proposed Program Revision

Name of Program	Science (SCIP)
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PART I: ABSTRACT

The revision of the Science program (AS degree) is being undertaken in response to the Science program audit of 2012, to complement the newly developed Biology program (AS degree.

The 2012 audit of the Science program indicated that the program met its primary goal of successful transfer of its graduates to a four-year institution. Although not identified as a problem, the fact that the program is housed in one department (Chemistry) but the courses, faculty and facilities are the responsibility of three departments (Biology, Chemistry and Physics) has made assessing the program difficult as no one area has ultimate control over the program.

Until Fall 2014, students interested in transfer to a four-year institution for a Bachelor's degree in any of the sciences (Biology, Chemistry and Physics) or related pre-professional degrees (Medicine, Pharmacy, etc.) were best served by choosing the Science degree at the College. With the creation of the Biology program (effective Fall 2014), students interested in a four-year Biology degree, Biology-related degree or various pre-professional degrees have the ability to pursue either program as a means to their goal. The current Science program and Biology program catalog descriptions show that the programs have significant areas of overlap.

Science Program (Current)**:**
The Associate in Science (A.S.) degree program is for students who wish to pursue baccalaureate studies in biological or physical sciences or who plan to continue with professional studies, such as pre-pharmacy, premedical or pre-dental programs. This curriculum parallels the first two years of study offered in the science programs of other colleges and universities.

Biology Program
The Associate of Science (A.S.) in Biology degree program is for students who wish to pursue baccalaureate studies in the biological sciences or plan to fulfill prerequisite courses for pre-pharmacy school or for programs such as pre-veterinary, pre-medical, and pre-dental. To enable seamless transfer, this curriculum is designed to parallel the

first two years of study offered in biology programs at other colleges and universities.

It is envisioned that due to the new Biology Program, the pool of students currently in Science (381 students who are continuing and in good standing as indicated by My Degree Path, May 2014) will decrease significantly and that those remaining will intend to pursue a Chemistry degree, a Physics degree, or various pre-professional degree programs upon transfer. (Note: Students seeking to move into pre-professional degree programs will be served equally well by an AS degree in Chemistry or in Biology at the College.)

This being the case, rather than the more open-ended courses of the Science programs (Ex. "Natural Science with Lab" and "Natural Science with Lab or MATH 172"), students will be better served by a more structured curriculum with specific courses that would align with the Pennsylvania Statewide Program-to-Program Articulation Agreement in Chemistry as provided in the Pennsylvania Department of Education Transfer and Articulation Oversight Committee (TAOC) guidelines for two-year programs. (See **Appendix A**) This would assure the specific preparation needed for transfer into Chemistry (and Physics) Bachelor degree programs.

PART II: OVERVIEW OF EXISTING PROGRAMS

Overview of the Existing Science Program:

The current Science program is open-ended in terms of the science courses that need to be taken for graduation. Thus it is possible for students to take varied Science courses to fulfill graduation requirements, not necessarily providing them with a coherent set of Science courses that would be required by their transfer program at another College or University. In addition, the Science program currently serves the same population of students as the recently approved Biology program but without the prescribed set of science courses needed to progress successfully along this path.

Program Revisions

The Science program at the College began in 1976. Since its inception, there have been two Science program revisions.

The program was revised in Spring 2003 to change the MATH 172: Calculus II requirement to MATH 172 or Natural Science with Lab requirement. The revision was made in keeping with Temple University's course pre-requisites for their Pharmacy program. Since that time, Temple has re-added Calculus II as a pre-requisite for that program. The revision being proposed now would once again align our Chemistry program with their pre-requisites for Pharmacy.

The second program revision took place in Fall 2009 in order to meet the College's general education requirements for graduation; CIS 103 was added to the program.

Program Audit
An audit of the Science program was completed in August of 2012. As mentioned in the Abstract of this document, the program audit indicated that the program is successful in meeting its primary goal of successful transfer of its graduates to a four-year institution. Nevertheless, the audit also stated that "As the program has a flexible core of science courses from which to choose, the coherence of the program is dependent on the career field (biology, chemistry, or physics) the student wishes to pursue upon transfer. The courses themselves may have pre-requisites that must be met before a student becomes eligible for the more advanced courses within that specific discipline. Advising students properly ensures that they can meet their goals within a two-year time span."

This point is echoed by two bullet points from that same audit under the recommendation to develop a Recruitment/Retention Plan:

- (Having a) Course management schedule to assist students in selecting the correct sequence of courses in a timely manner
- (Conducting a) Review of current and future mechanisms to increase the effectiveness of advising efforts related to the Science Program.

Thus the flexibility of the Science course selections is both a challenge and a weakness of the program. With such an open-ended designation, "self-advised" students have often chosen a level of courses that are not aligned to those needed for transfer into a science-based program. Please see **Appendix B** for the full Findings and Recommendations of the audit.

Emergent Issue
The catalog description of the current Science program is almost identical to that of the newly approved degree in Biology. The common areas have been bolded below

> **Biology Program**
>
> The Associate of Science (A.S.) in Biology degree program is **for students who wish to pursue baccalaureate studies in the biological sciences or plan to fulfill prerequisite courses for pre-pharmacy school or for programs such as pre-veterinary, pre-medical, and pre-dental.** To enable seamless transfer, this curriculum is designed to parallel the first two years of study offered in biology programs at other colleges and universities.
>
> PROGRAM ENTRY REQUIREMENTS
> **This is a select program**. Students who enter the program must have completed one year of high school biology and chemistry within the last ten years and received a grade of C or better. In the absence of these requirements, student must take BIOL 106 and/or CHEM 110, although these courses cannot count toward the degree. Additional science and mathematics courses are desirable. In order to enter the program, students must be at the ENGL 101 and MATH 162 placement levels.

PROGRAM OF STUDY AND GRADUATION REQUIREMENTS
To qualify for the A.S. degree in Biology, students must successfully complete a minimum of 65 credit hours as prescribed and attain a grade point average of 2.0 ("C" average). **Students must pass all biology courses with a grade of "C" or better.**

PART III: DESCRIPTION OF THE PROPOSED REVISION

This proposed revision to the Science program will result in a revision of the existing Science program-and the renaming of this revised program as Chemistry. The reason behind the proposed revision is to provide students with a clear pathway into a Bachelor's degree in Chemistry at a transfer institution.

Although there are no apparent negative experiences of students in the current Science program, maintaining the current structure of the Science program in conjunction with the new Biology program has added an element of ambiguity for students who intend to transfer into a pre-professional program after graduation. Both the current Science program and the new Biology program clearly state that these programs are intended for students pursuing this career path. Initially, the Science program was created to address the needs of all students planning to pursue a Bachelor's degree in any of the three scientific fields of Biology, Chemistry or Physics. The implementation of an independent Biology program (Fall 2014) at the institution requires that the goals of the various Science programs be better differentiated. Creating a separate defined curriculum focused on Chemistry (versus Biology) as a stepping stone on this career path will serve those students who are chemistry-oriented in their career choice and directly align them with the current standardized program-to-program articulation agreements in Chemistry, as outlined by the Pennsylvania Department of Education's Transfer and Articulation Oversight Committee (TAOC). TAOC's April 11, 2012 document states that "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." (The TAOC document for Chemistry is found in **Appendix C**.)

It is anticipated that the 380 or so students[1] currently in the Science program will, upon adoption of this revision, choose between the Biology program and the Chemistry program as the best route towards their goal. What percentage of these students will choose Biology versus Chemistry is unknown, although most likely Biology will attract a greater number of students. For example, at Temple University in Fall 2013, 1512 of their students (5.4% of enrollment) were biology majors while only 342 (1.22%) were chemistry majors: a ratio of roughly 3:1. [Note: Physics majors were 52 students (0.19%)]

Course Implications

In creating an Associate Degree program in Chemistry, courses have been adapted from the

[1] Data from My Degree Path, for continuing students in good standing, May 2014

current Science program. All the courses needed for this degree are already among the College's offerings. Other than the course revision to CHEM 214 that becomes effective Fall 2016, no other revisions to current courses at the College are necessitated by this program revision, and no new courses need to be written at this time nor are any envisioned. Additionally, the courses required to fulfill the College's general education requirements for graduation are specified within the program. In essence, students will have less choice on their path to graduation, which is in alignment with recommended best practices in providing students a *guided pathway* to graduation.

As a two-year Chemistry program, the Chemistry program is not entitled to accreditation by the American Chemical Society. (See **Appendix C**) Nevertheless, the program does follow their recommendations for required coursework for the first two years of a Chemistry program (**Appendix D**), and their recommendations also constitute the foundation for TAOC's Chemistry guidelines.

There are, however, specific changes to courses to be added and/or eliminated to create an A.S. in Chemistry degree program, and they are as follows:

Additions: Compliance with TAOC Guidelines for General Course Work for Chemistry Degree

CIS 106: Introduction to Programming, BIOL 123: Principles of Biology I, BIOL 281: Biochemistry I and BTT 101: Biomedical Technician Training will be designated as choices for the "directed elective" in the proposed curriculum. This complies with the TAOC recommendations for general course work in a chemistry degree (TAOC guidelines, **Appendix A**).

Changes: Required Courses in Chemistry and Mathematics

Rather than allowing students to select a "Natural Science Elective with Lab," as previously required in the Science Curriculum, students will be required to take the following Chemistry courses:

a) CHEM 121: College Chemistry I
b) CHEM 122: College Chemistry II
c) CHEM 221: Organic Chemistry
d) CHEM 222: Organic Chemistry II
e) CHEM 214: Chemical Analysis

MATH 172 will be required rather than allowing students to choose between taking MATH 172 or a Natural Science Elective with a Lab.

Current and Revised Program Learning Outcomes

Students who successfully complete the A.S. degree in Chemistry will have the ability to transition into the workforce as chemical technicians if they so choose. In particular, the CHEM 214: Chemical Analysis provides the hands-on instrumental experience that would be needed. However, a survey of job openings for technicians shows that a BS, not an AS, is the usual qualification being sought.

Science Program Learning Outcomes (Current)

Upon completion of this program graduates will be able to:

- Successfully transfer into a science-based program at a four-year institution.
- Demonstrate an understanding of scientific principles and concepts and be able to apply this knowledge to the solution of problems and performance of experiments in one or more of the natural science disciplines.
- Competently perform laboratory tasks related to their scientific discipline.
- Communicate information in a manner appropriate to their scientific discipline using verbal, written and graphical means.

Chemistry Program Learning Outcomes (Proposed)

Upon completion of this program graduates will be able to:

- Demonstrate preparedness to successfully transfer into a chemistry program at a four-year institution
- Demonstrate a foundational knowledge of general inorganic and organic chemistry principles and concepts by applying this knowledge to the solution of problems and performance of experiments.
- While adhering to all safety rules, competently perform routine laboratory tasks in the chemistry laboratory using the instrumentation for measurement and analysis that is commonly available
- Effectively collect, interpret, evaluate and communicate scientific data in multiple formats using computer technology as needed.

Curriculum Map and Assessment Plan

The proposed curriculum map for the A.S. in Chemistry is shown below. The core chemistry courses of the program are matched to the program's learning outcomes, which in turn are linked to the Program's Assessment Plan (See **Appendix E**)

Assigned to each is the level of competence showing the outcome as being a preliminary introduction (**I**) or being further practiced and reinforced (**R**). **A** indicates that assessment of this PLO will occur within this course.

Curriculum Map for A.S. in Chemistry

Required Courses	**Program Learning Outcomes**			
	Demonstrate preparedness to successfully transfer into a chemistry program at a four-year institution	Demonstrate a foundational knowledge of general inorganic and organic chemistry principles and concepts by applying this knowledge to the solution of problems and performance of experiments.	While adhering to all safety rules, competently perform routine laboratory tasks in the chemistry laboratory using the instrumentation for measurement and analysis that is commonly available	Effectively collect, interpret, evaluate and communicate scientific data in multiple formats using computer technology as needed.
CHEM 121		**I**	**I**	**I**
CHEM 122	**I**	**R (A)**	**R (A)**	**R (A)**
CHEM 221		**I**	**I**	**I**
CHEM 222	**I (A)**	**R (A)**	**R (A)**	**R (A)**
CHEM 214	**I**	**R (A)**	**R (A)**	**R (A)**

Technology Impact

The College's and the Department's technology resources are adequate to support this revision. The Chemistry department has recently (2013-2014) undergone major renovations to all five of its laboratories. During this period, two laboratories (W4-22 and W4-44) were equipped with SmartBoard technology. Additionally, classroom W4-01 was equipped with SmartBoard technology, and several additional classrooms are to have this technology installed in the near future. This newly adopted technology will be used to enhance hands-on experiences in the laboratory and student engagement in the classroom.

Additional computer-interfaced instrumentation was also purchased for the laboratories to expose all students to their increasing use within the academic, research and industrial environments. While the sophisticated instruments used in CHEM 214: Chemical Analysis are definitely showing signs of age, they are still functional. Proactive maintenance continues to assure their ability to meet their primary purpose: hands-on training for the students. Nevertheless, a well-thought-out plan for replacement of these capital items should be adopted by the College.

PART IV: INSTITUTIONAL EFFECTS OF THE REVISION

The credits needed to graduate from the Science program (60) will remain the same (60 credits).

The revision will have no institutional impact. The Science program currently has no outside accreditation. As a two-year Chemistry program, the Chemistry program is not entitled to accreditation by the American Chemical Society. (See **Appendix C**). Nevertheless, the program does follow their recommendations for required coursework (**Appendix D**), and their recommendations also constitute the foundation for TAOC's Chemistry guidelines.

As the course offerings of the department will remain the same, there will be no effect upon budget, personnel (faculty and aides), support structure, technology needs, equipment needs or space utilization for the department. Indeed, the newly renovated General, Organic and Instrumental laboratories (all ADA compliant) should fulfill the department's space utilization needs for the foreseeable future.

The program will be available to all students who qualify for this select program and will remain accessible for students with disabilities.

PART V: CATALOG DESCRIPTIONS

Science (current)

Description: The Associate in Science (A.S.) degree program is for students who wish to pursue baccalaureate studies in biological or physical sciences or who plan to continue with professional studies, such as prepharmacy, premedical or predental programs. This curriculum parallels the first two years of study offered in the science programs of other colleges and universities.

Student Learning Outcomes:
Upon completion of this program graduates will be able to:

- Successfully transfer into a science-based program at a four-year institution.
- Demonstrate an understanding of scientific principles and concepts and be able to apply this knowledge to the solution of problems and performance of experiments in one or more of the natural science disciplines.
- Competently perform laboratory tasks related to their scientific discipline.
- Communicate information in a manner appropriate to their scientific discipline using verbal, written and graphical means.

Program Entry Requirements: Students who enter the program should have completed one year of high school biology, chemistry and physics. In addition, students should have completed one year of geometry and two years of algebra. Additional science and mathematics courses are desirable. Students without proper high school preparation can take appropriate basic college courses. Students who seek entrance into this select program must demonstrate competence at the ENGL 101 and MATH 161 level.

Program of Study and Graduation Requirements: To qualify for the Associate in Science (A.S.) degree, students must successfully complete a minimum of 60 credit hours as prescribed and attain a grade point average of 2.0 ("C" average). All program core courses must be passed with a grade of "C" or better.

To ensure appropriate course selections, students must consult academic advisors in the departments concerned.

Students wishing to transfer the A.S. degree to a particular college or university should, with the help of an advisor, review that institution's requirements and/or existing articulation agreements with the College so that program courses may be chosen appropriately.

Science Course Sequence (Current)

Course Number and Name	Prerequisites and Corequisites	Credits	Gen Ed Req.
First Semester			
ENGL 101 – English Composition I		3	ENGL 101
MATH 171 - Calculus I or MATH 165/166 - Differential Calculus I and II	MATH 162 or dept. head approval or placement	4	Mathematics
Natural Science with Lab Elective[1]		4	Natural Science
CIS 103 – Applied Computer Technology		3	Tech Comp
Second Semester			
ENGL 102 – The Research Paper	ENGL 101 with a grade of "C" or better	3	ENGL 102, Info Lit
MATH 172 - Calculus II or Natural Science with Lab Elective[1]	MATH 171 or MATH 166 dept. head approval	4	Natural Science with Lab Elective
Humanities Elective		3	Humanities
Natural Science with Lab Elective[1]		4	

Natural Science with Lab Elective[1]		4	
Third Semester			
Natural Science with Lab Elective[1]		4	
Social Science Elective		3	
Humanities Elective		3	
General Elective		3	
Natural Science with Lab[1] or General Elective		3/4	
Fourth Semester			
Natural Science with Lab[1] or General Elective		3/4	
Social Science Elective		3	
General Elective		3	
General Elective		3	
Minimum Credits Needed to Graduate: 60			

General Education Requirements: All General Education requirements are met through required courses (as indicated above) except for the **Writing Intensive** requirement, the **Interpretive Studies** requirement and the **American/Global Diversity** requirement. Therefore, in order to graduate, students in this program must choose one course that is designated **Writing Intensive**, one course that is designated **Interpretive Studies** and one course that is designated **American/Global Diversity**. The same course may be used to fulfill more than one of these requirements. View the courses that fulfill all degree requirements and receive a more detailed explanation of the College's general education requirements to help in your selection.

[1] Students interested in pursuing science-related Bachelors' degrees, should consult with an academic advisor to assure proper course selection. In general, appropriate lab science courses for this degree would be BIOL 109 and above, CHEM 121 and above and PHYS 111 and above.

For More Information Contact: The Division of Math, Science and Health Careers, Room W2-7, 1700 Spring Garden Street, Philadelphia, PA 19130, Telephone (215) 751-8430; or the College Information Center (215) 751-8010.

Chemistry (proposed)

The Associate of Science (A.S.) in Chemistry degree program is for students who wish to pursue baccalaureate studies in the chemical or physical sciences or who plan to continue with professional studies, such as pre-pharmacy, pre-medical or pre-dental programs. This curriculum parallels the first two years of study offered in the chemistry programs of other colleges and universities.

Student Learning Outcomes:
Upon completion of this program, graduates will be able to:

- Demonstrate preparedness to successfully transfer into a chemistry program at a four-year institution
- Demonstrate a foundational knowledge of general inorganic and organic chemistry principles and concepts by applying this knowledge to the solution of problems and performance of experiments.
- While adhering to all safety rules, competently perform routine laboratory tasks in the chemistry laboratory using the instrumentation for measurement and analysis which is commonly available
- Effectively collect, interpret, evaluate and communicate scientific data in multiple formats using computer technology as needed.

Program Entry Requirements: This is a select program. In order to enter the program, students must have placement at ENGL 101, MATH 162 (or MATH 161 completed with a C or better) and CHEM 121 (Department approval or CHEM 110 completed with a C or better) levels.

Program of Study and Graduation Requirements: To qualify for the A.S. degree in Chemistry, students must successfully complete a minimum of 60 credit hours as prescribed and attain a grade point average of 2.0 ("C" average). Students must pass all Science and Mathematics courses with a grade of "C" or better.

Chemistry Course Sequence (Proposed)

Course Number and Name	Prerequisites and Co-requisites	Credits	Gen Ed Req.
First Semester			
ENGL 101- English Composition I		3	ENGL 101
MATH 171 - Calculus I	MATH 162 with a grade of "C" or better or dept. head approval or placement	4	Mathematics
CHEM 121- College Chemistry I	CHEM 110 with a grade of "C" or better or dept. head approval	4	Natural Science
CIS 103- Applied Computer Technology		3	Technological Competency
Second Semester			
ENGL 102 - The Research Paper	ENGL 101 with a grade of "C" or better	3	ENGL 102, Info Lit
MATH 172 - Calculus II	MATH 166 with a grade	4	

	of “C” or better or MATH 171with a grade of “C” or better		
CHEM 122- College Chemistry II	CHEM 121 with a grade of “C” or better	4	
PHYS 140 - Mechanics, Heat and Sound	MATH 171	5	
Third Semester			
CHEM 221- Organic Chemistry I[1]	CHEM 122 with a grade of “C” or better	5	
CHEM 214 - Chemical Analysis [1]	CHEM 122 with a grade of “C” or better MATH 162 with a grade of “C” or better	5	
PHYS 241 - Electricity, Magnetism and Light	PHYS 140 and MATH 172 or dept. head approval	5	
Fourth Semester			
CHEM 222 - Organic Chemistry II[1]	CHEM 221 with a grade of “C” or better or dept. head approval	5	
Directed Elective [2]		4	
Social Science Elective		3	Social Science
Humanities Elective		3	Humanities
Minimum Credits to Graduate: 60 [3]			

General Education Requirements: All General Education requirements are met through required courses (as indicated above) except for the **American/Global Diversity** requirement, the **Interpretive Studies** requirement and the **Writing Intensive** requirement. Therefore, in order to graduate, students in this program must choose one course that is designated **American/Global Diversity**, one course that is designated **Writing Intensive** and one course that is designated **Interpretive Studies**. The same course may be used to fulfill all three requirements. View the courses that fulfill all degree requirements and receive a more detailed explanation of the College's general education requirements to help in your selection.

1 Students planning to pursue baccalaureate studies in Physics should substitute CHEM 221, CHEM 222, and CHEM 214 (15 credits) with MATH 270, MATH 271, MATH 272 and PHYS 242 (16 credits)

2 CIS 106: Introduction to Computer Programming (4)
or BIOL 123: Principles of Biology I (4)
or BIOL 281: Biochemistry I (4)
or BTT 101: Biomedical Technician Training (3) [Students who choose this elective will need 1 additional credit to graduate]

3 Students who are required to take CHEM 110 prior to CHEM 121 will need 64 credits to graduate.

Appendix A: Pennsylvania Statewide Program-to-Program Articulation Agreement in Chemistry (TAOC)

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.

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

REQUIRED – Major Specific Content	Transfer Criteria
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).
REQUIRED – Content Outside the Discipline	**Transfer Criteria**
Multivariable Calculus (minimum of 8 credits) Must be the equivalent of Calculus 1 and 2.	See the Statewide Program-to-Program Articulation Agreement in Mathematics for coursework.
Calculus-based Physics with labs (minimum of 8 credits) 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.
RECOMMENDED – Content Outside the Discipline	**Transfer Criteria**
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 VSPER 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 LeChatlelier'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 Arrenhius, Bronsted-Lowry and Lewis acid-base theories to acid-base reactions.
14.2 Perform equilibrium calculations for pH, Ka 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 Ksp and Keq 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

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. 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. The AA or AS degree will meet the minimum requirements of the Commonwealth's Transfer Credit Framework ("Framework"), as defined by the Statewide Transfer System.

c. 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.

d. By awarding the AA or AS, the Associate Degree Institution is validating that the student has met the competency requirements outlined in the Agreement.

7. <u>Responsibilities of Bachelor Degree Institutions</u>
   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.

8. <u>Agreement Revision and Assessment</u>
   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.[1]

   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.

9. <u>Transfer Appeal Process</u>
   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.

10. <u>Institutional Resolution of Disputes</u>
    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.

11. 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.[2]

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

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

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.

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[2] 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.

Appendix B: Excerpts from 2012 Audit of Science program

Community College of Philadelphia

Academic Program Audit: Associate in Science in Science
Division of Math, Science and Health Careers

Contributors: David Cattell
Mary Anne Celenza
Linda Hansell
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August 16, 2012

Abstract from Part II ….*emphasis added*

II. Program & Curriculum

Anticipated Revisions and Challenges

Continued good advising is needed ***to assure that students are taking the proper level and sequence of science courses to fulfill the freshman and sophomore level expectations*** of their anticipated transfer program and institution. Completion of the A.S. degree enhances transfer opportunities and should be strongly encouraged.

Abstract from Audit Section VIII….*emphasis added*

VIII. Findings and Recommendations

The goals of the Science program support the mission of the College by providing "a coherent foundation for College transfer, employment and life-long learning," through a program that has built in course selection flexibility, specifically for transfer to a four-year institution. Dual admission agreements with Cabrini College, Cheyney University, Temple University, La Salle University, Rosemont College, Chestnut Hill College and Drexel University illustrate the clear trajectory students can follow in order to complete their coursework and transfer.

With national emphasis on the study of Science, Technology, Engineering and Mathematics (STEM), the ***Science degree is significant in its objective to meet the***

transfer needs of students. On the whole, students in the program do well in science courses as shown by the overall success rates of students in the three most common courses taken by students in all three disciplines and by the higher course completion rates, GPA, academic standing and success at departure as compared to the College as a whole. Most of the students who graduate from the Science program believe their preparation for transfer was either excellent or good and at least two-thirds to 100% per year transfer to another institution shortly after graduating from the College. Results of student and graduate surveys document that overall, students are very satisfied with the level of instruction received in the Science program. They particularly cite a "well informed" and "supportive faculty"

While all current science laboratories seek to update equipment as needed, capital funding has been limited over the years. Thus some key laboratory equipment has become dated and needs to be replaced. This was also noted by some of the students responding to the audit surveys. The College has increased the availability of technology in the classroom but the availability of technology in the laboratory to increase student learning has not been as readily addressed. Thus the ability to bring the most current information to students can be hampered. Given that students have choices among different science-oriented degrees at the College, the message about which degree may be more or "the most" appropriate for the student may not always be clear. This is especially true in aligning career goals with program outcomes. It is especially important for students to have pertinent information early in their academic career. This may be a factor in the current retention rates for the program and the decreases in enrollment.

Recommendations

1. Increase enrollment in the program by developing a Recruitment/Retention Plan (Spring 2013) which will contain the following information:
    a. Review of the curriculum to determine if new directions or alternative teaching strategies (i.e. hybrid courses) are warranted.
    b. Course management schedule to assist students in selecting the correct sequence of courses in a timely manner
    c. Plan to better utilize the Center for Science and Engineering Education as a vehicle to support recruitment of students
    d. Analysis of retention issues and potential solutions so as to develop strategies to increase retention and provide stronger connections between students and the Science program.
    e. Review of current and future mechanisms to increase the effectiveness of advising efforts related to the Science Program.

2. Review equipment and facilities' needs (Fall 2012) in order to fully participate in the following initiatives:
    a. New Facilities Master Plan discussions
    b. Renovation and creation of new laboratories
    c. Need for additional technology in the current and new laboratories.

Appendix C: ACS Standards, Guidelines and ACS Approval Program

http://www.acs.org/content/acs/en/education/policies.html

ACS Approval Program for Bachelor's Degree Programs

- ACS Approval Program for Bachelor's Degree Programs
  ACS promotes excellence in chemistry education for undergraduate students through approval of baccalaureate chemistry programs.

Guidelines, Standards and Recommendations

- ACS Guidelines for Chemistry in Two-Year College Programs
  A comprehensive model for two-year colleges granting associate degrees.
- ACS Guidelines and Recommendations for the Teaching of High School Chemistry
  Guidelines for facilities, safety, and professional growth.
- High School Chemistry in the National Science Education Standards
  Addresses science education standards specified by the National Research Council and provides models for meaningful classroom learning.
- Safety Guidelines
  Use ACS guidelines to incorporate safe practices into your teaching curriculum.
- Tomorrow: A Report of the Task Force for the Study of Chemistry Education in the United States

Appendix D: ACS Guidelines for Chemistry in Two-Year College Programs

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ACS Guidelines for Chemistry in Two-Year College Programs

1. Goals of the Guidelines

Chemistry is central to intellectual and technological advances in many areas of science. The traditional boundaries among chemistry subdisciplines are blurring, and chemistry is increasingly intersecting with other sciences. Unchanged, however, is the atomic and molecular perspective that lies at the heart of chemistry. Chemistry programs have the responsibility to communicate this outlook to their students and to teach the skills their students need to apply it.

Within the context of the diversity of institutions and students that make up American higher education, ACS has developed a set of guidelines to promote high-quality chemistry education for students in two-year college programs. The goal of these guidelines is to help faculty provide students with the best possible education in the fundamental areas of modern chemistry while relating it to other disciplines and to society.

ACS recognizes that diversity of institutions and students is a strength in higher education. Thus, the ACS guidelines for chemistry in two-year colleges have always provided a comprehensive model designed for a range of institutions.[1] Although a program may not fulfill all of the guidelines, it will benefit from pursuing those appropriate for its mission, student body, and curriculum. Implementing the guidelines can ensure that the chemistry course offerings and programs of an institution:

- are consistent with the mission of the institution,
- meet the needs of the diverse backgrounds and abilities of entering students,
- enhance the strengths of the institution and the community,
- articulate with programs to which students transfer,
- are comparable to programs of recognized quality, and
- augment continuing education and other local community chemistry education needs.

1 Those institutions that offer two-year programs in chemistry-based technology should also refer to the ACS Chemical Technology Program Approval Service.

Educators must prepare students to make informed decisions about a wide variety of scientific issues. These guidelines apply not only to students pursuing careers in scientific fields, but also to those in other areas.

These guidelines provide a framework for reviewing two-year college chemistry programs, for identifying areas of strength and opportunities for change, and for leveraging support from institutions, partners, and external agencies. In preparing and disseminating these guidelines, ACS seeks to enhance understanding of the many different two-year college environments, engaging chemistry faculty and programs across higher education in efforts to address needs, develop resources, and foster excellence.

2. Institutional Environment

To be effective, chemistry education requires an institutional commitment to student learning and success. Existing within the context of the institutional mission, chemistry in a two-year college program must support the needs, career goals, and interests of the institution's students.

In order to support a viable and sustainable chemistry program, the institutional environment must provide and develop the following attributes.

2.1 Institutional Accreditation. The institution must be accredited by the regional accrediting body. Such accreditation ensures broad institutional support in areas such as mathematics, related sciences, and the humanities. When undergoing institutional reviews, these guidelines should be consulted as part of self-studies and shared with the accrediting bodies.

2.2 Faculty Policies. The institution must support faculty efforts to develop high-quality instructional programs. The institution's policies regarding salaries, teaching loads, promotions, tenure and/or continuing contracts, leave policies (sabbatical or other), and hiring practices must be developed with faculty input, encourage improved faculty morale, and serve to attract and retain high-quality chemistry faculty members. Recognition programs should be in place to foster and reward significant contributions and innovations by the faculty and by individual faculty members.

2.3 Program Organization. The administration of the program must rest in an appropriate department that includes full-time faculty members with chemistry degrees. The department must have an adequate budget and significant influence over faculty selection and promotion, curriculum development, and assignment of teaching responsibilities. Departmental input regarding allotment of office, classroom, laboratory, and other spaces must be solicited. If part of a larger unit, the chemistry faculty must have substantive autonomy over the functions relating to the chemistry courses.

2.4 Program Budget. A chemistry program requires continuing and stable financial support. The institution must have the ability and desire to make a sustained commitment to the program at a level that is consistent with the resources of the institution and its educational mission. Adequate support enables a program to provide:

- a qualified faculty with the scientific breadth to offer the courses and educational experiences described in these guidelines;
- nonacademic staff and resources for administrative support services, stockroom operation, and instrument and equipment maintenance;
- a physical plant that meets modern safety standards with appropriate chemical storage, waste-handling, and disposal facilities;
- sufficient budgets to cover the costs of teaching a laboratory-based discipline;
- resources for capital equipment acquisition, long-term maintenance, and expendable supplies to ensure that equipment remains useful throughout its lifetime;
- support for maintaining and updating instructional technology;
- modern chemical information resources appropriate for the breadth and depth of courses offered;
- services to support student learning;
- opportunities for professional development for the faculty, including sabbatical leaves;
- funds and support to encourage faculty members to attend professional meetings and promote scholarly growth;
- resources to support faculty-mentored research as appropriate to the institutional mission; and

- personnel support to assist with the acquisition and administration of external funding.

2.5 Student Support Services. An institution must have support services in place to help students move toward attaining their goals. Student support services must be appropriate for the student body and be consistent with the institutional mission. Support services should include:

- advising staff who work with the faculty to enable students to achieve their academic goals;
- staff specialized in helping students with career and transfer resources;
- academic and personal support for students with physical, communication, learning, and other disabilities;
- tutorial services for students to improve their study skills and become more effective learners;
- open and reliable access to technology, such as computers;
- programs and organizations to support and engage targeted communities of students, such as student clubs;
- programs that increase the participation of underrepresented groups; and
- assistance for students in acquiring financial aid.

3. Faculty and Staff

Providing a current and effective chemistry program requires an energetic and accomplished faculty. The chemistry faculty must be responsible for defining the overall goals of the program, facilitating student learning of content knowledge, developing students' professional skills, and modernizing the program as the discipline evolves. Mechanisms must be in place to maintain the professional competence of faculty members, to provide faculty development and mentoring, and to allow for regular feedback regarding faculty performance. Similar mechanisms are needed for instructional and support staff.

3.1 Faculty. The chemistry faculty should have the range of educational backgrounds, the expertise, and the commitment to provide a sustainable, robust, and engaging environment for student learning. Everyone who teaches chemistry courses that result in a grade on a college transcript from the institution, regardless of location or mode of delivery, is considered part of the chemistry faculty and must meet institutional standards.

The program should have the following attributes:

- The minimum academic preparation required of any chemistry faculty member is a master's degree in a discipline of chemistry. The ability to communicate an understanding and appreciation of chemistry to others is essential. Further academic training (a doctoral or second master's degree in a related field) is highly desirable, particularly if it stresses depth and breadth of knowledge in chemistry.
- Full-time, permanent faculty should be sufficient in number to teach the full range of courses on a regular basis, with the number of credit hours taught by permanent faculty exceeding 75% of the total chemistry offerings.
- Qualified individuals outside the full-time, permanent faculty (i.e., contingent faculty)[2] should only be used to provide specific expertise and accommodate term-to-term fluctuations in enrollment. Excessive reliance on contingent faculty is strongly discouraged. When hired, such faculty should be fairly compensated, given equivalent facilities and professional development opportunities to those of full-time, permanent faculty, and integrated into the program's activities.
- The collective expertise of the faculty should reflect the breadth of the major areas of modern chemistry. If an institution has a mission that more narrowly defines its programs, the faculty expertise may reflect that focus.
- The department's climate and institutional policies should foster the development of a faculty with a wide range of backgrounds and experiences who can serve as role models for student bodies diverse in gender, ethnicity, race, and disability.

The ACS *Academic Professional Guidelines,* which describe responsibilities of students, faculty, and administration, should be followed. The institution should also comply with the *1940 Statement of Principles on Academic Freedom and Tenure.*[3]

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2 Contingent faculty are often referred to as adjunct, part-time, or nonpermanent faculty.
3 "The 1940 Statement of Principles on Academic Freedom and Tenure." *Law and Contemporary Problems 53, no. 5 (Summer 1990).*

3.2 Teaching Contact Hours. Contact hours are the actual time spent in the direct supervision of students in a classroom and/or laboratory. When determining faculty teaching assignments, each laboratory contact hour should be equivalent to a classroom contact hour. The number of contact hours in classroom and in laboratory instruction for faculty or instructional staff members *should not exceed 15 total hours per week.* Additionally, an instructor should carry no more than 450 student contact hours (i.e., the number of students multiplied by the number of contact hours) per week. Teaching assignments that exceed this standard risk lowering the quality of the chemistry program and the academic institution. Fifteen contact hours is an upper limit; a smaller number should be the normal teaching obligation. Faculty and instructional staff members in the most effective programs usually have substantially fewer contact hours, particularly when they supervise student research projects or assume administrative or support activities.

Faculty members, after fulfilling teaching obligations, must have adequate time for the following professional activities:

- holding office hours to meet with students;
- fulfilling service responsibilities to the department, the campus, and the community;
- developing new courses and curriculum innovations;
- assessing and improving curriculum;
- keeping abreast of new developments in chemistry and new educational pedagogies;
- participating in professional activities including conferences; and
- engaging in scholarship in chemistry, chemistry education, and teaching effectiveness.

No faculty member should be responsible for more than 25 students in a laboratory at one time.[4] Many laboratories require smaller numbers for safe and effective instruction (e.g., 20 students is the recommended maximum for an organic chemistry laboratory).

3.3 Professional Development. Sound policies regarding salaries, duties, promotions, sabbatical leaves, and tenure are essential. Institutional policies and practices should provide opportunities and resources for scholarly activities, which allow faculty and instructional staff members to stay current in their specialties and in modern pedagogy in order to teach effectively.

- The institution should provide opportunities and funding for renewal and professional development through sabbaticals, participation in professional meetings, and other professional activities. Faculty and instructional staff members should use these opportunities. Institutions should provide resources to ensure program continuity during sabbaticals and other leaves.
- The institution should offer mechanisms by which faculty members are mentored. Proper mentoring integrates all members of the instructional staff into the culture of their particular academic unit, their institution, and the chemistry profession, ensuring the stability and vitality of the program.

In addition to supporting scholarly activities, the institution should provide regular training in the areas of safety, technology, and assessment.

3.4 Support Staff. A sustainable and robust program requires an adequate number of secretarial, administrative, and support personnel, along with technical staff to maintain instrumentation, support laboratory functions, and assure regulatory and safety compliance. The number of support staff members should be sufficient to allow faculty members to devote their time and effort to academic responsibilities and scholarly activities. One full-time laboratory technician for every four full-time or full-time-equivalent chemistry faculty members is needed. Part-time and student help are not adequate substitutes for full-time laboratory technicians.

To foster the development of a safe environment and a safety-conscious culture, all technical staff members, including part-time and student help, should receive regular training in chemical safety protocols, proper use of equipment, and waste management.

4. Infrastructure

A modern infrastructure is essential for an effective and rigorous chemistry program. Institutional support for program infrastructure is needed for sustainability through inevitable fluctuations in faculty, leadership, and funding levels.

4 *Safety in Academic Chemistry Laboratories, Vol. 2, Accident Prevention for Faculty and Administrators,* 7th Edition. American Chemical Society: Washington, DC; 2003.

4.1 Organization of Facilities. A program must have appropriate classroom, laboratory, other instructional, office, and common space that is safe, well-equipped, modern, and properly maintained. Laboratory and stockroom space must conform to applicable government standards and regulations.

- Chemistry classrooms should be reasonably close to instructional and research laboratories. Classrooms should adhere to modern standards for lighting, ventilation, and comfort and have proper demonstration facilities, projection capabilities, and Internet access. Classrooms should also be flexible learning spaces that are able to accommodate new pedagogies.
- Faculty offices should be configured for instructional and other professional activities. They should also accommodate confidential discussions with students and colleagues. Offices should have networked computers that provide access to library resources. Faculty offices should be reasonably close to teaching and laboratory facilities and positioned to facilitate student contact. Contingent faculty members should have comparable offices.
- Laboratories must have properly functioning utilities, fume hoods, safety showers, eyewashes, first aid kits, and fire extinguishers.
- Laboratory capacities should not exceed 25 students.[5] At least 50 square feet of net space per student should be provided, including lab tables and benches.
- Laboratory facilities must be able to accommodate students with disabilities in accordance with federal and state regulations.
- A properly maintained chemical stockroom should be in the vicinity of teaching and research space. The stockroom must provide safe storage, handling, and preparation areas and permit easy distribution of chemicals to required areas.
- Laboratories should have facilities appropriate for the type of work conducted in them. These facilities should permit maintaining experimental arrangements for extended periods of time during ongoing research projects.

4.2 Equipment and Instrumentation. Programs should have a suite of modern chemical instrumentation and specialized laboratory apparatus appropriate for the courses offered, providing hands-on laboratory experiences in synthesis, characterization, and analysis.

- Programs must have certain essential equipment, such as electronic balances, volumetric glassware, pH meters, colorimeters, thermometers or temperature probes, hot plates and/or Bunsen burners, and filtration equipment.
- Standard items, such as automated data-collection devices with associated probes, bench-top centrifuges, melting point apparatus, microscale or full-scale organic kits, gas chromatographs, and UV-Vis spectrometers, are highly recommended for programs serving students pursuing careers in science or health.
- Students pursuing chemistry careers should have access to instrumentation such as FTIR, FT-NMR, and mass spectrometers, if not at the institution, at other locations.

Chemical instrumentation is an evolving area of chemistry. Faculty members should have opportunities to keep abreast of these changes and improve the program's instrumentation.

4.3 Computational Capabilities and Software. Students should have access to computing facilities and software that support laboratory data acquisition and analysis, interactive simulations, and computational chemistry. Software with scientific word processing and illustration capabilities should be available.

4.4 Chemical Information Resources. Both faculty and students should have access to the chemical literature. Physical and electronic repositories should include current chemistry and related science periodicals, plus a range of other reference materials, commensurate with the size and nature of the chemistry offerings and the scholarly activity of the students and faculty. Important reference materials, or electronic access to these materials, should be within or near the science building.

- The chemical literature continues to expand at a rapid rate. The library should provide access to journal articles that are not readily available on site by supplying other mechanisms, such as interlibrary loan, electronic transmission, or document delivery services.
- Instruction on the use of information from the chemical literature should be equivalent to that in the institutions to which students

5 NFPA 101, *Life Safety Code*, 2006 Edition; National Fire Protection Association: Quincy, MA, 2005.

commonly transfer. Trained science librarians should be involved in the design and facilitation of these activities.

4.5 Chemical Safety Resources. The program must be conducted in a safe environment with adherence to federal, state, and local regulations regarding chemical storage, hazardous waste management, and laboratory safety. This includes the following attributes:

- a written chemical hygiene plan and proper facilities and personnel for chemical waste disposal;
- safety information and reference materials, such as material safety data sheets (MSDSs), and personal protective equipment readily available to all students and faculty;
- a policy of maximum stockroom chemical holdings, including small quantities for especially hazardous materials;
- personnel designated to coordinate all aspects of the chemical safety program in cooperation with institutional and other departmental safety programs; and
- segregated storage areas designated for acids, bases, reducing agents, oxidizing agents, and toxic materials. Cabinets and refrigerators that store flammable materials must meet the federal and state Occupational Safety and Health Administration (OSHA) regulations. National Fire Protection Association (NFPA) labeling codes must be used on all reagents and storage facilities.

5. Curriculum

The chemistry curriculum must be driven by the needs of the students, the mission of the institution, and the standards of the discipline. Recognizing that these may change over time, the curriculum should reflect two specific areas of need: (1) students who require education in the scientific method but do not require a significant amount of science for their ultimate academic and career goals; and (2) students for whom chemistry will be a substantial part of their academic path. This latter group includes students in allied health and all other health science fields, as well as those in science, technology, and engineering. Education majors may fall into either group, as appropriate for local certification.

5.1 Pedagogy. Sound pedagogy informed by research on student learning is the cornerstone of an effective chemistry curriculum. The institution must regularly review its chemistry program to ensure that it provides excellent content with good pedagogy and builds skills that students need to be valuable professionals.

As an experimental science, chemistry must be taught using appropriate and substantial laboratory work that provides opportunities for open-ended investigations, which promote independent thinking, critical thinking and reasoning, and a perspective of chemistry as a scientific process of discovery. Courses should be taught in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles.

Faculty members must be provided with opportunities to maintain their knowledge of best practices in chemistry pedagogy and modern theories of learning and cognition. Current examples of effective pedagogy include problem- or inquiry-based learning, peer-led instruction, group learning, learning communities or networks, writing throughout the curriculum, and technology-aided instruction.

5.2 Prerequisites. The diversity in the educational background, learning readiness, academic ability, and educational goals of students must be considered in curriculum development. The institution must accept that all students are not prepared to begin chemistry at the same level and that all programs requiring chemistry do not cover identical topics. The prerequisites for each chemistry course should be carefully determined, in consultation with colleagues at other institutions if appropriate, and assessed by the faculty. Prerequisites should be clearly stated and publicized in the college catalogues, in the schedule of classes, and in any other curriculum publications.

Students are best served when everyone involved in admitting students to chemistry classes respects the importance of adhering to prerequisites. Failure to do so reduces student retention and graduation rates, as well as the quality of the learning environment. An effective assessment of each student's preparation and readiness for a course can be achieved by testing, transcript evaluation, and/or counseling. Students who do not have the prerequisites for a given chemistry course should be redirected to the necessary preparatory course(s) in chemistry, mathematics, and/or other developmental skills.

5.3 Consistency of Course Offerings. Content and learning outcomes of a course should be monitored to ensure a consistent level of academic rigor. All sections of a course that result in a grade on an official transcript from the institution, regardless of location or mode of delivery, must be taught by qualified faculty members and use course materials with similar coverage and levels of difficulty.

5.4 General Education Chemistry Courses. General education chemistry courses should be transferable and include a laboratory component that satisfies the science requirement for graduation. The mathematical requirement is usually elementary algebra. The goal of such courses should be to educate students in the process of science, the atomic and molecular perspective of matter, and chemistry's relationship to other sciences, technology, and society. Such courses may be interdisciplinary.

5.5 Preparatory Chemistry Courses. Students may need chemistry courses to prepare them for college-level programs of study. Such courses emphasize concepts, critical thinking, and chemical calculations required to be successful in chemistry and should include a laboratory component equivalent to that in a high school chemistry course.

5.6 Specialty Chemistry Courses. Focused programs of study, such as those for primary and secondary educators, emergency first responders, and medical technicians, may require specialty chemistry courses. The curricula for such programs should be developed in close consultation with the appropriate professional or academic body for which the course is developed. The content of specialty chemistry courses, being directly relevant to the careers of its students, should, at a minimum, be taught at the level of preparatory chemistry courses (Section 5.5). The laboratory component should concretely demonstrate the application of chemistry within the specialty field.

5.7 Chemistry for Allied Health and Health Sciences. Chemistry courses required for students in allied health and health science programs should be developed in consultation with the programs in which the students are enrolled and to which they will transfer. The laboratory component should concretely demonstrate the application of chemistry within the health sciences. Prerequisites should be specified.

5.8 General Chemistry. Traditionally, general chemistry is a first-year college course sequence designed for science majors and students who aspire to become professional chemists. Completion of general chemistry course work ensures a common background in basic chemical concepts such as stoichiometry, states of matter, atomic structure, molecular structure and bonding, thermochemistry, equilibria, and kinetics. Course work must include a laboratory component.

Common outcomes of general chemistry should include knowledge of basic chemical concepts, strength in quantitative problem solving, preparation for higher-level course work, maturation of students' knowledge of chemistry, and application of mathematical skills. Students also need to be competent in basic laboratory skills, including laboratory safety, keeping a notebook, use of electronic balances and volumetric glassware, preparation of solutions, chemical measurements using pH electrodes and spectrophotometers, data analysis, and report writing. The diversity of institutions and students requires a wide variety of approaches to optimize the progress of students.

The prerequisites for general chemistry are typically the equivalent of one year of high school chemistry with a laboratory component and three years of high school mathematics, including two years of algebra. For students whose preparation is deficient, successful completion of a preparatory chemistry course, or its equivalent, as well as the necessary mathematics courses, should be required.

5.9 Organic Chemistry. Traditionally, organic chemistry is a second-year course sequence designed for science majors and students who aspire to become professional chemists. Articulation of organic chemistry course work, including the laboratory, should be established with institutions to which students transfer. Typically, the equivalent of two semesters of general chemistry with laboratory is a prerequisite for organic chemistry.

5.10 Laboratory Experience. To learn chemistry, students must directly manipulate chemicals, study their properties and reactions, and use laboratory equipment and modern laboratory instruments. Laboratory work in chemistry courses must be designed to give students an understanding that experimental work is the foundation of chemical knowledge. This hands-on experience is necessary for students to understand, appreciate, and apply chemical concepts. It should also develop student competence and confidence. Depending on the level and nature of the course, laboratory experiences should include the following activities:

- anticipating, recognizing, and responding properly to potential hazards in laboratory procedures;
- keeping accurate and complete experimental records;
- performing accurate quantitative measurements;
- interpreting experimental results and drawing reasonable conclusions;
- analyzing data statistically, assessing the reliability of experimental results, and discussing the sources of systematic and random error in experiments;
- communicating effectively through oral and written reports;
- planning and executing experiments through the use of appropriate chemical literature and electronic resources; and
- synthesizing and characterizing inorganic and organic compounds.

Computer simulations that mimic laboratory procedures have the potential to be useful supplements, but should not be considered equivalent replacements for hands-on experiences critical to chemistry courses at any level.

5.11 Frequency of Course Offerings. The institution should schedule courses so students can complete a full sequence of general or organic chemistry in a single academic year, or both general and organic sequences in two academic years. An annual listing of chemistry courses should be published and widely distributed, permitting students to schedule courses in proper sequence. The schedule of chemistry courses should be coordinated with the schedule of the other required courses within common degree tracks. Ideally, the lecture and laboratory components of a course are taken concurrently.

5.12 Transfer Students. Faculty, counselors, and advisers from two-year chemistry programs should be in regular communication with their counterparts at institutions that accept a significant number of transfer students in order to ensure that the curricula of both institutions are appropriately coordinated. Two-year programs should convey the educational backgrounds and academic goals of their students to the receiving institutions. Both transferring and receiving institutions should assist students in making a successful transition.

Although specific courses are most commonly articulated by two-year and four-year institutions, it is recommended that program articulation be used to better serve students. Transferring students should be counseled to take the full general chemistry course sequence, full organic chemistry course sequence (if appropriate), cognate mathematics and physics courses, and general education courses in patterns comparable to the course work of freshmen and sophomores at the institutions to which the students plan to transfer.

6. Student Research and Scholarly Activities

Engaging two-year college students in original research and other scholarly activities has many benefits. It allows students and faculty members to integrate and reinforce chemistry knowledge, develop their scientific and professional skills, create new scientific knowledge, and add new contributions to other knowledge bases. It fosters interactions among students and faculty members and enhances student interest in science. Research activities are also effective in keeping faculty members current in chemistry fields and in a position to enrich contemporaneous course content. Such activities help students, faculty members, and administrators develop an understanding and appreciation of the importance of scientific research in maintaining American competitiveness in the global workforce. In addition, experimental work can provide a basis and rationale for acquiring modern instrumentation.

Student-centered research projects can be pursued independently or integrated into the curriculum. Projects can be conducted on campus, in the facilities of partnering institutions, or in other scientific facilities. Developing group or interdisciplinary projects can help broaden the applicability and relevance of chemistry in allied fields.

A suitable project:

- is well-defined with clear goals and objectives,
- stands a reasonable chance of completion in the available time,

- applies and develops an understanding of in-depth concepts,
- uses a variety of methods and instrumentation, and
- is grounded in the chemical literature.

Implementing a student-centered research program requires resources, including faculty time, laboratory space, instrumentation, chemical literature, supplies, and student stipends. The investment is justified by its impact on student learning and the richness it adds to students' and faculty members' scientific experiences.

7. Development of Student Skills

Although formal course work provides students with an education in chemical concepts and training in laboratory practices, students should go beyond course content alone to be effective and productive scientists. They need to master a variety of lifelong skills that will allow them to become successful professionals.

In addition to providing students with an education in chemical concepts, training in laboratory practices, and opportunities for critical thinking, programs should help students be effective and productive professionals. Strategies for helping students develop ethical behaviors and skill sets needed for successful careers include offering courses dedicated to skills and ethics, integrating activities into regular curricular offerings, and engaging students in research experiences. Regardless of the approaches used, programs should also assess the development of student skills.

7.1 Problem-Solving Skills. Chemistry education should provide students with the tools to solve problems. Students should be able to define problems clearly, develop testable hypotheses, design and execute appropriate experiments, analyze data, and draw appropriate conclusions. Students should use appropriate laboratory skills and instrumentation to solve problems while understanding the fundamental uncertainties in experimental measurements.

7.2 Chemical Literature Skills. Students going beyond general chemistry should be able to use the peer-reviewed scientific literature effectively and evaluate technical articles critically. They should learn how to retrieve specific information from the chemical literature, including *Chemical Abstracts* and other compilations, with online, interactive database-searching tools.

7.3 Laboratory Safety Skills. Programs should promote a safety-conscious culture in which students understand the concepts of safe laboratory practices and apply them at all times. Programs should train students in the aspects of modern chemical safety appropriate to their educational level and scientific needs. A high degree of safety awareness should begin during the first laboratory course, and both classroom and laboratory discussions must stress safe practices. Students should understand responsible disposal techniques, understand and comply with safety regulations, understand and use material safety data sheets (MSDSs), recognize and minimize potential chemical and physical hazards in the laboratory, and know how to handle laboratory emergencies effectively.

7.4 Communication Skills. Effective communication is vital in all careers. Since speech and English composition courses alone rarely give students sufficient experience in oral and written communication of technical information, the chemistry curriculum should include writing and speaking opportunities, and the chemistry faculty should evaluate them critically. Students should be able to present information in a clear and organized manner, create visual representations of complex data sets, write well-organized and concise scientific reports, cite sources properly, and use appropriate technology, such as poster preparation software, word-processing software, chemical structure drawing programs, and computerized presentations.

7.5 Team Skills. Solving problems often involves working in teams. Students should be able to work effectively in groups, as leaders or team members, to solve problems and interact productively with a diverse group of peers. The faculty should incorporate well-structured team experiences in classroom and laboratory components of the chemistry curriculum.

7.6 Ethics. Ethics should be an intentional part of the instruction in chemistry programs. Students should conduct themselves responsibly and be aware of the role of chemistry in contemporary societal and global issues. As role models, faculty and staff members must exemplify ethics in their scholarship and professional conduct.

8. Student Mentoring and Advising

Effective mentoring and advising fosters student success and must be an integral part of the institutional environment. Academic advisers, counselors, and faculty members should help students develop educational goals and guide their professional development via networking opportunities, confidence building, and career planning. A strong collaboration among the chemistry faculty, counselors, and advisers at the institution and their contacts at local high schools, receiving institutions, and industries should be fostered and sustained in order to increase students' matriculation, transfer, job placement, and achievement of career goals.

Programs should provide information about combining a basic chemistry education with studies in other disciplines. For example, a major in chemistry with supporting work in biology is good preparation for students planning careers in medicine, dentistry, or pharmacy. In addition, many careers in the chemical industry, government, and other areas are open to graduates who have a solid background in chemistry combined with computer science, law, economics, environmental science, library science, history, literature, or philosophy.

8.1 Faculty Advisers and Mentors. Given their regular interaction with students, faculty members can be particularly effective advisers and mentors. Faculty members should encourage students to consider the career options available within chemistry. Student-centered research, which provides exceptional mentoring opportunities, can be an enriching experience for faculty members as well. Faculty members serving as advisers or participating in formal advising programs should be compensated or given reassigned time.

8.2 Counselors and Advisers. Counselors and advisers should be familiar with the career opportunities for students in transfer programs, along with the academic preparation necessary for entry into various chemistry courses. They should encourage students with strong interests and abilities in chemistry to continue their education in the chemical sciences. Two-year colleges should use discipline-specific counselors and advisers to promote familiarity with chemistry and chemistry-related programs and to facilitate articulation with four-year college programs and industry. Students anticipating transfer to a four-year degree program should be counseled to complete all terms of sequential courses (the general chemistry sequence and the organic chemistry sequence, if appropriate) as well as mathematics and other science sequences before transfer.

9. Program Self-Evaluation and Assessment

Self-evaluation should be an ongoing process leading to continual improvement of a program. A transparent and reflective self-evaluation process that collects, considers, and acts on evidence should produce prepared students, support ongoing professional development and scholarly activities of faculty members, and develop an infrastructure that strongly supports the educational mission of the program.

9.1 Program Goals and Objectives. Institutions must ensure that infrastructural support is consistent with program goals and objectives. The chemistry faculty should implement a variety of assessment techniques and tools, providing the necessary data for making informed decisions at the classroom, course, and program levels. These decisions should lead to the implementation of practices that effectively address the needs of the students.

9.2 Teaching and Student Learning. Assessment of teaching and student learning should be an integral part of the institutional mandate. Programs should have established procedures to regularly assess and evaluate their effectiveness with respect to curriculum and pedagogy. For example, the ACS Examinations Institute provides a wide variety of tests to assess student learning while providing national norms and statistics. Institutional research offices often have access to student data on preparedness, advancement through programs, and subsequent performance at four-year institutions. These offices should provide opportunities to survey students during and after enrollment.

9.3 Innovations in Instruction. Ongoing assessment and continuing instructional revision improves student learning and reinforces improvements in curriculum and pedagogy. Faculty members should be encouraged to seek professional development opportunities through teaching and learning centers and to develop new pedagogical initiatives. When new courses and pedagogical initiatives are developed, their effectiveness and value should be assessed. Innovation and experimentation in the educational process, coupled with a strong assessment component, should preserve the vitality of chemistry education.

10. Partnerships

Two-year college programs should enhance the impact and success of their activities through various partnerships. Regardless of whether the goal is to increase matriculation from secondary schools, facilitate transfer to other postsecondary institutions, foster scholarly activities, enhance student exploration of career opportunities, or advance other strategic objectives, programs should engage stakeholders in meaningful, ongoing dialogue that develops trust and mutually beneficial relations. Establishing clear responsibilities and regular communications should help leverage resources and expertise, positioning two-year college programs to respond to the changes occurring in education and the workforce.

10.1 Campus Units. The quality and success of chemistry programs is dependent upon interactions among campus units. Strong coordination and ongoing communication should occur among the chemistry faculty, staff providing support services, and counselors and advisers who help students with course placement, sequencing, transfer options, and career opportunities. By establishing collaborative activities, programs will leverage and increase the effectiveness of their efforts. Such activities may be supported by external funds.

Interactions among departments and disciplines should also be encouraged. The institution should provide opportunities for interdisciplinary discussions and collaborations among faculties, ensuring that students receive a well-rounded collegial perspective on chemistry.

10.2 Higher Education Institutions. Partnerships between two-year and other post-secondary programs take on many forms and have many benefits. Collaborative faculty projects and group meetings, articulation conferences and workshops for faculty, and undergraduate research are just a few examples. In addition to enriching students and faculty members, such partnerships foster student transfer, increase student retention, and enhance and expand program offerings.

Successful student transfer requires candid and ongoing conversations between faculties at two-year colleges and receiving institutions. This is particularly important when curricular changes are being made and when students enroll in and transfer to a number of different receiving institutions. The conversations should serve to align curricular content and allow for exchange of ideas in delivering effective instruction and developing new approaches to strengthening student success at both transfer and receiving institutions.

Two-year college chemistry programs choosing to match the first two years of an ACS-approved program in chemistry must be familiar with the current guidelines for bachelor's degree programs and the way in which the ACS-approved program has implemented them. Students wishing to obtain a bachelor's degree from an ACS-approved program, particularly a certified degree, should also consult with a representative from that program and refer to *Undergraduate Professional Education in Chemistry: ACS Guidelines and Evaluation Procedures for Bachelor's Degree Programs.*

Each institution involved should have a mechanism for coordinating and communicating to students, faculty, counselors, and advisers the terms of articulation agreements. Agreements that specifically describe the courses and learning outcomes for efficient transfer are the keys to student-centered advising.

Partnerships with other institutions of higher education can leverage resources, enhancing and expanding the offerings of two-year programs. If two or more institutions in the same geographical area are unable to offer a complete two-year chemistry program individually, the institutions should consider combining resources and facilities to provide a full two-year chemistry program. Institutions with programs in place can also benefit from cooperative agreements, gaining access to libraries, laboratory facilities, and sophisticated instrumentation on other campuses. Second-year and specialized occupational courses, in particular, can be improved by such partnerships. They can also make participation in research by faculty members and independent study students a reality.

10.3 K–12 Institutions. Partnerships with high schools that promote early enrollment in college or offer advanced standing for certain high school courses are valuable ways to recruit students and increase the number of enrollments of first-generation and other students who are not likely to matriculate directly into college. Any course offered at a secondary school that results in a grade appearing on a college transcript must be taught by an individual qualified to teach the comparable course at the college. Such an arrangement should involve close oversight, review, and assessment by the college chemistry faculty to ensure similar levels of academic rigor and consistent learning outcomes.

Partnerships with K–12 institutions can be very beneficial for programs preparing students for careers in teaching, providing professional development for in-service teachers, and preparing chemists to transition to careers in K–12 education.

10.4 Nonacademic Institutions. Two-year college programs can obtain scientific expertise and resources from nonacademic institutions. Cooperative agreements with industrial and government laboratories can provide access to libraries, laboratory facilities, and sophisticated instrumentation, enhancing the curricular offerings and research opportunities of two-year programs. Research positions and internships for faculty and students are also possible.

Nonacademic institutions can also assist with career development. Laboratories, museums, and workforce development agencies are among those institutions that can host field trips and serve as sources of speakers and potential role models and mentors for students. Interactions between faculty and employees of these institutions can provide valuable insights and information to be shared with students during chemistry courses and conversations about careers.

Acknowledgments

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***Guidelines for Chemistry in Two-Year College Programs*, 2009**

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***Guidelines for Chemistry Programs in Two-Year Colleges,* 1997**

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***Guidelines for Chemistry and Chemical Technology Programs in Two-Year Colleges*, 1988**

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Appendix E: Program Learning Outcomes Assessment Plan for Chemistry

Curriculum Map
Assigned to each required course the program Learning Outcome is identified as *introduced* (**I**) or being further *practiced and reinforced* (**R**).
In addition, in courses where assessment evidence will be collected is indicated by an **A.**

Required Courses	**Program Learning Outcomes**			
	Students will be prepared to successfully transfer into a chemistry program at a four-year institution	Students will demonstrate a foundational knowledge of general inorganic, organic and analytical chemistry principles and concepts by being able to apply their content knowledge to the solution of problems	While adhering to all safety rules, students will be able to competently perform routine laboratory tasks in the chemistry laboratory using the instrumentation for measurement and analysis which is commonly available.	Students will be able to effectively collect, interpret, evaluate and communicate scientific data in multiple formats using computer technology as appropriate.
CHEM 121		I	I	I
CHEM 122	I	R (A)	R (A)	R (A)
CHEM 221		I	I	I
CHEM 222	I (A)	R (A)	R (A)	R (A)
CHEM 214	I	R (A)	R (A)	R (A)

Assessment Plan for of Program Learning Outcomes for Chemistry

Outcome		Assessment Methodology	Evaluation Period	Benchmark
Students will be prepared to successfully transfer into a chemistry program at a four-year institution		1. Overall GPA at completion of CHEM 222 2. IR's Performance Indicator of *Success at Departure* 3. Data from *National Student Loan Clearing House*	Biennial (Commencing end of Spring 2017)	1. 80% of *Chemistry* students will have an overall GPA of 3.00 or higher. This aligns with Temple's website that states: "Our average GPA for transfer admission is 3.00" 2. 80% of students coded *Chemistry* will be designated as *Successful at Departure* 3. 80% of students coded *Chemistry* and designated as *Successful at Departure* from the College will transfer to a four-year year school after leaving CCP
Students will demonstrate a foundational knowledge of general inorganic, organic and analytical chemistry principles and concept by	….. of inorganic chemistry	1. Final Exam grade in CHEM 122 2. Course grade in CHEM 122	Annually (Commencing end of Spring 2017)	1. 80% of students coded *Chemistry* will have a grade of 75 or better on final exam of CHEM 122 2. 80% of students coded *Chemistry* will have a course grade of C or better in CHEM 122
Students will demonstrate a foundational knowledge of general inorganic, organic and analytical chemistry principles and concept by	….. of organic chemistry	1. Final Exam grade in CHEM 222 2. Course grade in CHEM 222	Annually (Commencing end of Spring 2017)	1. 80% of students coded *Chemistry* will have a grade of 75 or better on final exam of CHEM 222 2. 80% of students coded *Chemistry* will have a course grade of C or better in CHEM 222

being able to apply their content knowledge to the solution of problems.	…. of analytical chemistry	Final Exam grade in CHEM 214	Annually (Commencing Spring 2017)	80% of students coded *Chemistry* will have a grade of 75 or better on each test given during the semester
While adhering to all safety rules, students will be able to competently perform routine laboratory tasks in the chemistry laboratory using the instrumentation for measurement and analysis which is commonly available.		1. Laboratory grade in CHEM 122 2. Laboratory grade in CHEM 222 3. Laboratory grade in CHEM 214	Annual (Commencing end of Spring 2017)	1. 80% of students coded *Chemistry* will have laboratory grade of B or better in CHEM 122 2. 80% of students coded *Chemistry* will have laboratory grade of B or better in CHEM 222 3. 80% of students coded *Chemistry* will have laboratory grade of B or better in CHEM 214
Students will be able to effectively collect, interpret, evaluate and communicate scientific data in multiple formats using computer technology as appropriate.		1. Laboratory Report grade on *Determining Equilibrium Constant of FeSCN* (CHEM 122; requires use of Visible Spectrophotometer) 2. Laboratory Report grade on *Fischer Esterification* (CHEM 222; requires use of Infrared Spectrophotometer) 3. Laboratory report grade on *Analysis of*	Annual (Commencing end of Spring 2017)	1. 80% of students coded *Chemistry* will have a report grade of 75 or better on the identified CHEM 122 experiment 2. 80% of students coded *Chemistry* will have a report grade of 75 or better on the identified CHEM 222 experiment 3. 80% of students coded *Chemistry* will have a report grade of 75 or better on the identified CHEM 214 experiment

	Benzoic Acid (CHEM 214; requires use of UV spectro-photometer)		

Appendix F: Job Qualifications and Employment Data

Chemistry Related Job Title

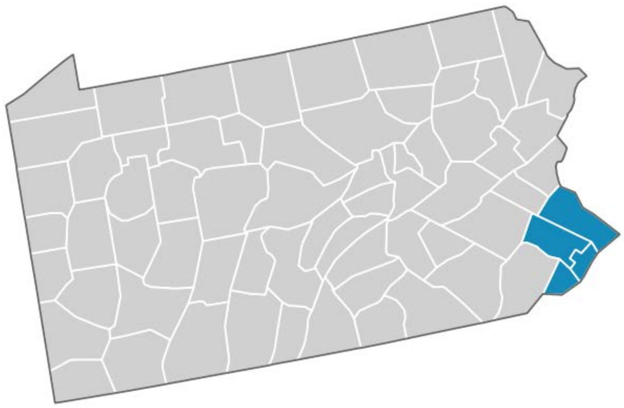
U.S. Bureau of Labor Statistics
and
Occupation Reports for Philadelphia and Region

Community College of Philadelphia

1700 Spring Garden Street
Philadelphia, Pennsylvania 19130
215.751.8350

Occupation Report

Philadelphia + NE area



Report Info

Dataset Version	2014.2 Class of Worker
Class of Worker Categories	QCEW Employees
Timeframe	2010 - 2015
Region Name	Phila area
Counties	

Bucks, PA (42017)	Delaware, PA (42045)	Montgomery, PA (42091)
Philadelphia, PA (42101)		

Chemists and Materials Scientists

SOC 19-2030

Overview

Annual Openings Estimate (2014)	68
Related Completions (2010)	280
Current Job Postings	Only Available for 5-Digit

Gender	
Male	60%
Female	40%

Age	
14-18	0%
19-24	3%
25-44	50%
45-64	45%
65+	3%

2,621	**-8.0%**	**$38.06/hr**
Jobs (2014)	**% Change (2010-2015)**	**Median Earnings**
National Location Quotient: 2.36	Nation: 4.7%	Nation: $35.21/hr

Phila area | Growth

2,825	**2,598**	**-227**	**-8.0%**
2010 Jobs	**2015 Jobs**	**Change (2010-2015)**	**% Change (2010-2015)**

Occupation	2010 Jobs	2015 Jobs	Change	% Change
Chemists (19-2031)	2,639	2,424	-215	-8%
Materials Scientists (19-2032)	186	173	-13	-7%

Phila area | Percentile Earnings for Chemists and Materials Scientists (19-2030)

$22.48/hr	**$38.06/hr**	**$58.89/hr**
10th Percentile Earnings	**Median Earnings**	**90th Percentile Earnings**

	Region	2010 Jobs	2015 Jobs	% Change
●	Phila area	2,825	2,598	-8.0%

Occupation	2010 Jobs	2015 Jobs	Change	% Change
• Nation		92,195	96,517	4.7%
• NE Region		3,271	2,979	-8.9%

Educational programs

4	280
Programs (2010)	Completions (2010)

Program	2008	2009	2010	2011	2012
Chemistry, General (40.0501)	294	305	279	307	351
Chemical Physics (40.0508)	0	1	1	2	0
Materials Sciences, Other (40.1099)	0	0	0	17	0
Materials Science (40.1001)	0	0	0	0	0

Inverse Staffing Patterns

Industry	Occupation Jobs in Industry (2014)	% of Occupation in Industry (2014)	% of Total Jobs in Industry (2014)
Pharmaceutical Preparation Manufacturing (325412)	743	28.3%	6.9%
Research and Development in Biotechnology (541711)	371	14.1%	4.9%
Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology) (541712)	361	13.8%	4.9%
Testing Laboratories (541380)	197	7.5%	9.7%
Federal Government, Civilian, Excluding Postal Service (901199)	145	5.5%	0.5%

Source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics

Chemists and Materials Scientists

Summary

Chemists and materials scientists perform experiments that require creative problem solving and detailed record keeping.

Quick Facts: Chemists and Materials Scientists	
2012 Median Pay	$73,060 per year $35.13 per hour
Entry-Level Education	Bachelor's degree
Work Experience in a Related Occupation	None
On-the-job Training	None
Number of Jobs, 2012	96,200
Job Outlook, 2012-22	6% (Slower than average)
Employment Change, 2012-22	5,400

Chemists and materials scientists study substances at the atomic and molecular levels and the ways in which substances react with each other. They use their knowledge to develop new and improved products and to test the quality of manufactured goods.

Education

A bachelor's degree in chemistry or in a related field is needed for entry-level chemist jobs. Although some materials scientists hold a degree in materials science, these scientists commonly have a degree in chemistry, physics, or engineering. Many jobs require master's degrees or Ph.D.s and may also require significant levels of work experience. Chemists and materials scientists with Ph.D.s and postdoctoral experience typically lead basic and applied research teams.

Many colleges and universities offer degree programs in chemistry. There are few programs specifically in materials science, but the number of programs is gradually increasing. Some engineering schools offer degrees in the joint field of materials science and engineering.

Undergraduate chemistry majors typically are required to take courses in analytical, organic, inorganic, and physical chemistry. In addition to chemistry coursework, they also take classes in mathematics, biological sciences, and physics. Computer science courses are essential, because chemists and materials scientists need computer skills to perform modeling and simulation tasks, manage and manipulate databases, and to operate computerized laboratory equipment.

Laboratory experience, either at a college or university, or through internships, fellowships, or work-study programs in industry, is also useful.

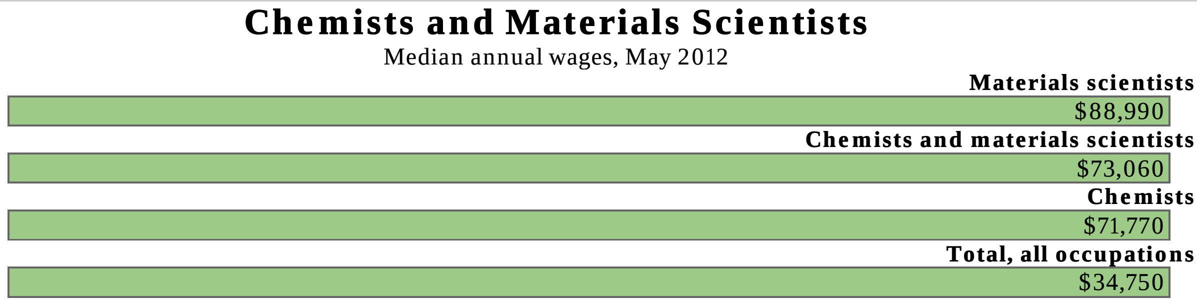
Graduate students studying chemistry commonly specialize in a subfield, such as analytical chemistry or inorganic chemistry. For example, those interested in doing research in the pharmaceutical industry usually develop a strong background in medicinal or organic chemistry.

Advancement

Chemists typically receive greater responsibility and independence in their work as they gain experience. Greater responsibility also is gained through further education. Ph.D. chemists usually lead research teams and have control over the direction and content of projects, but even Ph.D. holders have room to advance as they gain experience. They may take on larger, more complicated, and more expensive projects as they become more proficient in managing research projects.

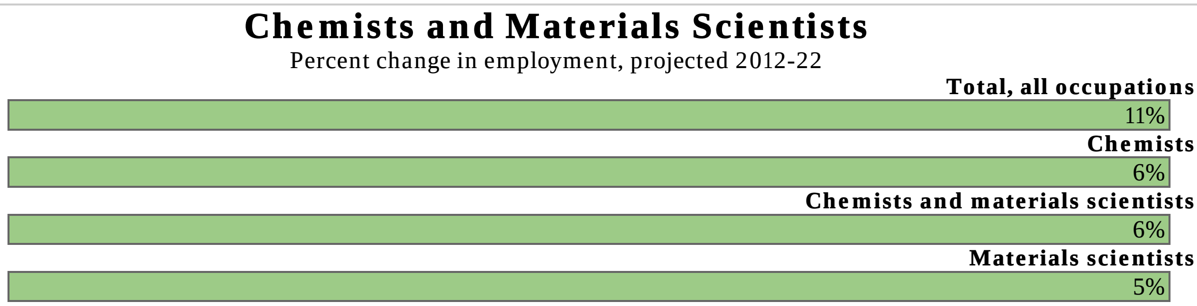
Some chemists and materials scientists become natural sciences managers.

Pay



Note: All Occupations includes all occupations in the U.S. Economy.
Source: U.S. Bureau of Labor Statistics, Occupational Employment Statistics

Job Outlook



Note: All Occupations includes all occupations in the U.S. Economy.
Source: U.S. Bureau of Labor Statistics, Employment Projections program

Employment of chemists and materials scientists is projected to grow 6 percent from 2012 to 2022, slower than the average for all occupations.

Employment of chemists is projected to grow 6 percent, as they will continue to be needed in scientific research and development and to monitor the quality of products and processes.

Employment of materials scientists is projected to grow 5 percent, owing to demand for cheaper, safer, and better quality materials for a variety of purposes, such as electronics, energy, and transportation.

Chemists research and solve a wide range of problems and are employed in a similarly wide range of industries. About a quarter of all chemists are employed in chemical manufacturing industries; but the remainder work at colleges and universities, in government, and for independent testing and research laboratories. Some chemical manufacturing industries, such as pharmaceutical manufacturing, increasingly may be outsourcing their research and development activities, rather than doing the research in-house. This is likely to cause faster growth in the employment of chemists in small, independent research and development firms than in the more traditional large manufacturers. However, as the economy improves and the expansion in domestic natural gas production lowers the cost of energy and raw inputs, manufacturers may have less of an incentive than they have in the past to outsource their research and development (R&D) activities.

Environmental research will offer many new opportunities for chemists and materials scientists. For example, chemical manufacturing industries will continue to develop technologies and processes that reduce pollution and improve energy efficiency at manufacturing facilities. Chemists also will continue to be needed to monitor pollution levels at manufacturing facilities and to ensure compliance with local, state, and federal environmental regulations.

Job Prospects

In addition to job openings resulting from employment growth, some job openings will result from the need to replace chemists and materials scientists who retire or otherwise leave the occupations.
Chemists and materials scientists with advanced degrees, particularly those with a Ph.D. and work experience, are expected to experience better opportunities. Large pharmaceutical and biotechnology firms provide openings for these workers at research laboratories, and many others work in colleges and universities. Furthermore, chemists with advanced degrees will continue to fill most senior research and upper-management positions.

Employment projections data for Chemists and Materials Scientists, 2012-22

Occupational Title	SOC Code	Employment, 2012	Projected Employment, 2022	Change, 2012-22		Employment by Industry
				Percent	Numeric	
SOURCE: U.S. Bureau of Labor Statistics, Employment Projections program						
Chemists and materials scientists	—	96,200	101,600	6	5,400	—
Chemists	19-2031	87,900	92,900	6	5,000	[XLS]
Materials scientists	19-2032	8,300	8,800	5	400	[XLS]