

## Chemistry

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### Introduction

Chemistry is the science concerning the control, properties, reactivity, and detection of atoms and molecules in the world around us. Just as chemistry contributes to our existence, culture, and quality of life, the discipline of chemistry is a central science, with new frontiers continually being explored from which new benefits result. The department serves the entire TCNJ community in addition to chemistry majors in a well-equipped, state-of-the-art facility that is part of the TCNJ Science Complex. Consistent with the goals of TCNJ, the chemistry faculty has substantial contact with each student. Faculty advisors meet regularly with students to assist in defining educational paths that will best allow the pursuit of career goals. Student development is enhanced through a seminar program, which includes discussions of the roles and responsibilities of chemists in today's society. Additionally, students have the opportunity to participate in research with faculty members in each of the sub-disciplines of chemistry and across disciplines via the Biochemistry and Materials Science specializations. The Chemistry Department has a strong sense of community with a Student Chemists Association (part of the American Chemical Society (ACS) Student Affiliates), a student chapter of the American Society for Biochemistry and Molecular Biology (ASBMB), and a chapter of the National Chemistry Honor Society (Gamma Sigma Epsilon).

Students completing the chemistry major will receive a Bachelor of Science (BS) degree. Students planning to pursue a career in chemistry or allied fields should also consider completing the requirements for the ACS certification. TCNJ chemistry graduates have many career options from which to choose. The program trains students for traditional scientific careers working in the chemical industry, as educators, and at state and national government laboratories. It also provides a strong foundation for other careers that rely on a working knowledge of chemistry, including law, business, environmental science, public policy, journalism, and art preservation. Students can pursue advanced degrees in areas such as analytical chemistry, forensics, organic chemistry, inorganic chemistry, materials science, physical chemistry, biochemistry, and computational chemistry at leading Masters and Ph.D.-level programs. TCNJ chemistry graduates are also well-prepared for entrance into dental, medical, and other professional schools.

By combining a chemistry degree with an appropriate specialization or minor, students will also be well prepared to pursue careers that combine several areas of knowledge. For example, students interested in pursuing a career in pharmaceutical sales and marketing can combine a major in chemistry with a minor in marketing.

### **Recommended High School Preparation**

Based on the interdisciplinary nature of modern chemistry, a good level of high school preparation for an entering chemistry major at TCNJ includes a year each of college preparatory chemistry, physics, and biology. The quantitative nature of chemistry requires a solid mathematics background including algebra, geometry, trigonometry, and pre-calculus. Enrollment in Advanced Placement (AP) Chemistry, if available, is useful, but not required. Experience with word processing, spreadsheets, and presentation software is helpful, as is experience in calculus and introductory computer programming. Four years of English encompassing writing skills are also important to success in the study of chemistry.

### **General Department Policies for All Students**

#### **A. Advanced Placement (AP) Scores**

The Chemistry Department policy is for all student course selections to be made by the student in consultation with their academic advisor and/or the department chair. An AP score of 4 can provide credit for CHE 201/General Chemistry I. An AP score of 5 can provide credit for both CHE 201 and 202/General Chemistry I and II. While students with a chemistry AP score of 5 may receive credit for CHE 201 and CHE 202, the department usually recommends that they take CHE 202 before enrolling in higher-level chemistry courses. We find that students benefit in their transition to college by enrolling in CHE 201 and CHE 202 because these courses provide essential laboratory experience and the development of metacognition and college-level study skills.

Students with a significant high school laboratory background, a chemistry AP score of 5, and AP credit in physics or mathematics, may consider enrolling directly in courses such as CHE 310/Analytical Chemistry or CHE 331/Organic Chemistry I. Students may also choose to fulfill the College Core or language course requirements during their first year, in lieu of taking chemistry courses. Decisions about course enrollment should be made in consultation with the student's academic advisor and/or the department chair.

#### **B. Repeating a Course**

Various circumstances may necessitate that a student repeat a course. Students may register for a course up to two times, whether a 'W' or letter grade is received. Exceptions to this rule may only be granted by the department chair. Students wishing to take a course more than two times must complete a [Repeat of Course Authorization Form](#).

### C. Progression in the Chemistry Course Sequence

Enrollment in CHE 202, CHE 310, CHE 331, and CHE 332 requires that the student has earned a minimum grade of C- in the prerequisite courses (see Table). For students who receive grades lower than C- in prerequisite courses, it is recommended that students repeat the course immediately in the next semester. If, after semester grades have been issued, a student discovers that they will not meet this requirement, they should de-register for the subsequent course. The Chemistry Department has the authority to de-register students who have not met course prerequisites and will do so at the end of each semester for students who do not meet the minimum grade requirement. Please note that any student enrolled in courses with improper grade prerequisites is in violation of TCNJ's academic integrity policy.

To enroll in	A minimum grade of C- is required in
CHE 202	CHE 201
CHE 310	CHE 202
CHE 331	CHE 202
CHE 332	CHE 331

## General Departmental Policies for Chemistry Majors

### A. Chemistry Coursework

After being admitted to the TCNJ Chemistry Department, any student interested in enrolling in a chemistry course at another institution (where the course transfer equivalency is not included at [New Jersey Transfer](#)) must receive approval from the Chemistry Department before enrolling. Receiving departmental approval will ensure the eligibility of course(s) for chemistry credit at TCNJ. For additional information on transferring into the TCNJ Chemistry Department or studying abroad, please refer to the *Transferring Into the Major* or *Study Abroad* sections, respectively.

### B. Program Entrance, Retention, and Exit Standards

Every major program at the College has set standards for allowing students to remain in that program, to transfer within the College from one program to another, and to graduate from a program. (Please also see the section below on *Transferring into the Major*.) The following are the standards for all TCNJ Chemistry programs:

- 1) Graduation requires a GPA of 2.0 in courses required for the major.
- 2) Retention in the program is based on achieving the minimum grade of C- in the following "critical content courses" and an average GPA of 2.0 in these courses: CHE 201/General Chemistry I, CHE 202/General Chemistry II, CHE 331/Organic Chemistry I, and CHE 310/Analytical Chemistry.
- 3) Correlate coursework (PHY, MAT) and other non-major courses can be taken at other institutions and transferred to TCNJ, in accordance with TCNJ policy (see TCNJ's comprehensive [Undergraduate Bulletin](#) for full details).
- 4) Enrollment in 300 or 400-level chemistry courses at another institution is generally not approved except in specific situations (e.g., enrollment in a pre-approved

chemistry course during a study abroad semester, or enrollment in a pre-approved course currently not offered at TCNJ).

- 5) Please refer to the section *Transferring into the Major*, for program entrance requirements.

### C. Writing across the Chemistry Curriculum

The intellectual and scholarly growth of all TCNJ students is fostered through TCNJ's writing intensive curriculum. "The goal is for students to become ... good writers who can communicate clearly and effectively to an array of audiences for a range of purposes." Students who graduate from TCNJ with a degree in Chemistry are expected to research, conduct, and document chemical experiments and to communicate their findings to both chemists and non-chemists. The Chemistry Department's mid- and upper level courses provide a variety of writing assignments that in combination fulfill TCNJ's mid-level and capstone writing intensive requirements. Below is a grid listing the writing activities associated with courses at the 300- and 400-levels.

Writing Level	Writing Activity	Identified Courses
Introductory level	Laboratory notebooks	CHE 331, CHE 332, CHE 310
Mid-level	Layman summary	CHE 371, CHE 430, CHE 451
	Journal style paper	CHE 372, CHE 430, CHE 451, CHE 493 (typically occurs at the completion of 1 course unit)
	Scientific article analysis	CHE 430, CHE 451, CHE 493
	Laboratory Reports	CHE 371, CHE 372, CHE 430, CHE 451
	Scientific abstract	CHE 393 and CHE 493
	Poster presentation	CHE 451, CHE 493 (typically occurs at the completion of 1 course unit)
	Oral presentation	CHE 316, CHE 430, CHE 451, or select advanced options courses
Advanced level	Original research proposal	CHE 451, select advanced options courses
	Literature review	Select advanced options courses, including CHE 493
	Research report	CHE 493
	Research poster or oral presentation	CHE 393 and 493
	Lesson Plans	CHE 490

### Transferring Into the Major

Students may transfer majors as either internal or external transfers. Whatever the circumstances, students who transfer into the TCNJ Chemistry major must meet with the Chemistry Department chair to discuss an academic plan following TCNJ's policies on [Undergraduate Transfer Credit](#), [Undergraduate Residence Requirements](#), and [Types of Majors and Minors Defined](#).

Any currently enrolled student has the ability to apply and be considered for entrance into an academic major in accordance with program entrance standards (see section on *Departmental/Program Entrance, Retention, and Exit Standards*). Students seeking to change a major should begin the process as early as possible in the semester in which they wish to change their major. This will help to ensure that students will meet any departmental deadlines and/or the campus wide deadline dates as established by the Office of Records and Registration and posted annually on the [academic and registration calendar](#). It also will provide time for the new program/plan (if approved) to be effective for the next registration period. Students may download the [Undergraduate Change of Major Form](#). Students should also print a copy of their TCNJ unofficial transcript from the PAWS Student Services Center and submit it with the form. Successful applicants for internal transfer to the chemistry major will have achieved or exceeded the grade performance standard for CHE 201/General Chemistry I listed above, and a grade of C- in MAT 127/Calculus A. In the event of limited capacity, internal transfer candidates may also be evaluated using the following criteria.

1. GPA in chemistry courses and correlate courses for the major (physics and mathematics)
2. Number of chemistry courses or correlate courses completed
3. Overall GPA

### Programs Within Chemistry

Students can obtain one of two possible BS degrees in chemistry, one of which is certified by the American Chemical Society (ACS). In addition to the description of these options provided here, students should seek guidance from their academic advisors for further information. Chemistry degrees include:

**BS Chemistry Degree.** This degree is well suited for all students interested in pursuing chemistry and related fields.

**ACS BS Chemistry Degree.** This degree is certified by the American Chemical Society and is well-suited for students desiring a more research-oriented experience.

**In addition to the two chemistry degree tracks, students can pursue the following programs and areas of specialization:**

- 1) **Biochemistry Specialization.** This specialization is meant for students who are interested in molecular biology, biochemistry, biophysics, bioanalytical, bioorganic, and/or bioinorganic chemistry. Students pursuing this specialization gain insight into the interdisciplinary nature of chemistry, biology and physics and typically wish to pursue interdisciplinary postgraduate goals (i.e. in industry, medical, or graduate programs).
- 2) **Materials Science Specialization.** This specialization is appropriate for students interested in materials science, biophysical chemistry, nanotechnology, crystal engineering, magnetism, and related fields that bridge the fields of Chemistry and Physics.
- 3) **Chemistry Secondary Education Degree.** In conjunction with the Department of Education, students enroll in educational courses, which lead to certification in teaching chemistry at the secondary level in the state of New Jersey. Enrollment in this degree program should be completed no later than the second semester of the first year in order to complete the degree in four years.
- 4) **Seven-year BS Chemistry/MD Program.** This program applies only to students who enter TCNJ as part of the TCNJ/NJMS Seven-Year BS Chemistry/MD program. (See the [Seven-Year Medical Program](#) for general information about the BS/MD program.) Please note that the Seven-year BS Chemistry/MD Program is an accelerated program through Rutgers New Jersey Medical School and is not the typical route to a medical degree (typically, students complete a four-year bachelor's degree in biology, chemistry, or another major prior to starting medical school; see the section below titled *Pre-Health Profession Option for Chemistry Majors*).

Students entering TCNJ as chemistry majors are initially enrolled in the BS in Chemistry program but may transfer to other degree tracks, including the ACS BS degree, or add a specialization using the Change of Major form. Students will consult with their academic advisor about their academic plan before completing the [Undergraduate Change of Major form](#). Both degree tracks require the completion of a Chemistry Core curriculum, followed by additional requirements that depend on degree track and optional specializations. The Chemistry Core courses are required for all TCNJ students enrolled in the chemistry program (see table on next page):

<b>Chemistry Core Courses (8.5 Course Units)</b>	
CHE 201/General Chemistry I	1 course unit
CHE 202/General Chemistry II	1 course unit
CHE 310/Analytical Chemistry	1 course unit
CHE 331/Organic Chemistry I	1 course unit
CHE 332/Organic Chemistry II	1 course unit
CHE 371/Quantum Chemistry or CHE 372/Chemical Thermodynamics and Kinetics	1 course unit
CHE 430/Biochemistry	1 course unit
CHE 451/Inorganic Chemistry - Structure and Bonding	1 course unit
CHE 099, 316, 317/Chemistry Seminars	0.5 course unit total
<b>Correlate Courses (4 Course Units)</b>	
MAT 127, 128/Calculus A, B	2 course units
PHY 201, 202/Physics I, II	2 course units
<b>300/400 Level Options Courses* ( 1 Course Unit at 300/400 level, see Chemistry Degree Programs Table below)</b> <i>See course descriptions for prerequisites</i>	1 course unit
CHE 370/Special Topics in Chemistry CHE 371/Quantum Chemistry CHE 372/Chemical Thermodynamics and Kinetics CHE 393/Independent Research I CHE 410/Advanced Analytical Chemistry– Instrumental Analysis CHE 452/Inorganic Chemistry– Reactions and Mechanisms CHE 470/Advanced Topics in Chemistry CHE 474/Special Topics in Biochemistry CHE 476/Special Topics in Organic Chemistry CHE 478/Special Topics in Materials Science CHE 490/Student Teaching	
<b>400 Level Options Courses (2 Course Units at 400 level, see Chemistry Degree Programs Table below)</b> <i>See course descriptions for prerequisites</i>	2 course units
CHE 410/Advanced Analytical Chemistry– Instrumental Analysis CHE 452/Inorganic Chemistry– Reactions and Mechanisms CHE 470/Advanced Topics in Chemistry CHE 474/Special Topics in Biochemistry CHE 476/Special Topics in Organic Chemistry CHE 478/Special Topics in Materials Science	

\*Courses outside the department (such as Genetics, Molecular Immunology and Human Disease, Mathematical Physics, Linear Algebra, or Modern Physics) can be substituted for a 300-level options course upon approval by the department chair.

<b>ACS Chemistry Degree Program</b>
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The TCNJ Chemistry Department is approved by the American Chemical Society to grant an ACS certificate to all students who complete the additional requirements. The ACS approval program benefits all students by ensuring that all TCNJ chemistry courses, teaching pedagogy, laboratory experience, building facilities, instrumentation and instructors meet the standards set by the ACS. The TCNJ program offers a broad-based, excellent chemistry education that gives students intellectual, experimental and communication skills to become effective scientific professionals. Employers find graduates of approved programs to be better prepared for technical employment. TCNJ Chemistry recommends that students wishing to become chemical professionals (in industry or graduate school) pursue the additional requirements of the ACS degree pathway. The ACS certificate is met by taking the Chemistry Core courses with the addition of a second semester of physical chemistry. The ACS standards for laboratory hours are met by completing the following courses: the Chemistry Core courses above plus both semesters of physical chemistry, and additional research experiences described below that culminates with an original research report. All majors (BS in Chemistry and ACS BS in Chemistry) are eligible to participate in research experiences.

<b>Chemistry Degree Program</b>	<b>Additional requirements beyond the BS in Chemistry course requirements</b>	<b>Materials Science Specialization</b>	<b>Biochemistry Specialization</b>
ACS BS in Chemistry	CHE 371/Quantum Chemistry and CHE 372/Chemical Thermodynamics and Kinetics are both required; two course units of CHE 393/Independent Research I (one unit counts toward 300/400 level options requirement); and one course unit of CHE 493/Independent Research II (does not count toward 400 level options requirement).	Available option	Available option

<b>Dual Degree Programs</b>	<b>Available Chemistry degree options</b>	<b>Additional requirements</b>
Secondary Education Chemistry Degree Programs	BS in Chemistry or ACS BS in Chemistry	See full description of program, below
Seven-year BS Chemistry/MD Program	BS Chemistry Degree	See description of program, below



## 1. Materials Science Specialization

The Materials Science Specialization is an interdisciplinary program open to chemistry and physics majors in the School of Science, who have a strong interest in creating new organic, biological, or inorganic materials and/or exploring the properties and applications of these materials. Students should have a background in chemistry and physics and be comfortable with mathematics. Chemistry students are free to pursue research projects in either the Chemistry Department or Physics Department. Chemistry majors who successfully complete this program will graduate with a BS in Chemistry or ACS BS in Chemistry and a Materials Science Specialization. Students will be prepared to pursue a wide variety of careers or graduate study in chemistry, biophysics, or materials science.

To complete the Materials Science Specialization, students must take the standard Chemistry Core courses (CHE 371/Quantum Chemistry and CHE 372/Chemical Thermodynamics and Kinetics must both be taken when this specialization is applied to the BS in Chemistry degree); the required Chemistry Correlate Courses; PHY 306/Mathematical Physics or MAT 229 Multivariable Calculus; and PHY 311/Analog and Digital Electronics or PHY 451/Advanced Lab or CHE 410/Instrumental Analysis. Students are also required to take either two CHE 478/Special Topics in Materials Science courses (including those that may be cross-listed from other CHE 47X) or one CHE 478 (or cross-listed CHE 47X) and PHY 345/Physics of Clouds and Climate or PHY 436/Condensed Matter or PHY 478/Photonics, Optics, and Materials. Students must complete at least one PHY course greater than 200-level.

## 2. Biochemistry Specialization

The Biochemistry specialization brings together the fields of molecular biology, genetics, general, organic and physical chemistry, and meets the interests and needs of a growing population of TCNJ chemistry students with interdisciplinary interests. Students pursuing the specialization see the interconnectedness of these disciplines and wish to pursue post graduate goals that tie together biological aspects of chemistry through medical, graduate or industrial positions. Students will graduate with a BS in Chemistry or ACS BS in Chemistry with a specialization in Biochemistry.

To complete the Biochemistry Specialization, students must take the standard Chemistry Core courses, the required Correlate Courses, and both BIO 201/Foundations of Biological Inquiry and BIO 211/Cell Biology and Biochemistry. Students are also required to take either two CHE 474/Advanced Topics in Biochemistry courses (including those that may be cross-listed from other CHE 47X) or one CHE 474 (or cross-listed CHE 47X) and BIO 471/Genomics and Bioinformatics or BIO 470/Special Topics class from an approved list.

Students may apply for a specialization at any time but are encouraged to do so in their sophomore year to facilitate planning and timely completion. To enroll in a specialization program, students should first consult their academic advisor and then formally apply for their chosen specialization using the [Undergraduate Change of Major Form](#).

### 3. Chemistry Secondary Education Program

The Chemistry Secondary Education program provides TCNJ students with a BS degree in Chemistry and Secondary Education certification. Pursuing certification for the ACS BS in Chemistry might be possible with consultation with an academic advisor and department chair. Students must complete the requirements for one of the Chemistry Degree Programs, as listed above. In addition to meeting the requirements for the major, the Chemistry Secondary Education student must meet the College requirements of the College Core, the professional education sequence (see below), and state certification. This requires careful course planning with the student's academic advisor(s) starting with the first semester of classes. In order to advance to candidacy in the program and participate in Clinical Practice I (SED 399/Pedagogy in Secondary Schools, PHY 390/Pedagogy in Secondary Schools, and RAL 328/Reading in Secondary Education), students must fulfill one of the following: 1) passed the Praxis Core Academic Skills of Educators test with scores of 156 in reading, 150 in math, and 162 in writing (<https://www.ets.org/praxis/about/core/content/>); 2) achieved SAT scores of 610 (Reading) and 570 (Math) or higher ; or 3) achieved ACT scores of 23 or higher in both Reading and Math. In addition, students must achieve a grade of B- or better in EFN 299, SED 224, and SPE 103. Prior to Clinical Practice II (CHE 490/Student Teaching and SED 498/Collaborative Capstone for Professional Inquiry), students must achieve a minimum of B- in all Clinical I courses, have a 3.0 GPA (overall), and take the Praxis II in the content area. To earn certification, students must earn a B- in all Clinical II courses, pass the Praxis II, earn a 3.0 GPA (overall), and pass edTPA, the student teaching portfolio assessment. These requirements should be discussed with the student's academic advisor(s).

<b>Professional Education Sequence (9 Course Units)</b>	
SED 099/ Education Seminar	0 course units
SED 224/Adolescent Learning and Development	1 course unit
EFN 299/School and Communities	1 course unit
SPE 103/Social and Legal Foundations of Special Ed.	1 course unit
SED 399/Pedagogy in Secondary Schools	1.5 course units
PHY 390/Methods of Teaching Science	1 course unit
RAL 328/Reading in Secondary Education	0.5 course unit
CHE 490/Student Teaching	2 course units
SED 498/Collaborative Capstone for Professional Inquiry	1 course unit

<b>Recommended First-Year Sequence (Actual courses may vary with advisement and course availability):</b>	
<b>Fall Semester</b>	<b>Spring Semester</b>
FYW 102/First Year Writing <sup>a</sup> CHE 099/Orientation to Chemistry XXX/College Core/Language <sup>b</sup> CHE 201/General Chemistry I MAT 127/Calculus A PHY 201/General Physics I	SED 099/ Education Seminar CHE 202/General Chemistry II MAT 128/Calculus B PHY 202/General Physics II FYS/First Year Seminar

<sup>a</sup> It is recommended that students exempted from this course take another College Core or language course. <sup>b</sup>It is recommended that students exempted from the language requirement take another College Core course.

#### **4. Seven-year BS Chemistry/MD Program degree**

Admission to this program is dependent on dual acceptance into TCNJ and Rutgers NJMS programs. Applicants are reviewed and evaluated prior to matriculation at TCNJ. Certain changes to the Chemistry Core curriculum have been made to allow for timely completion of the chemistry degree, including: 1) substitution of BIO 231/Genetics for one 300-level Chemistry options course with laboratory; 2) enrollment in Molecules, Cells, and Systems at NJMS as a substitute for CHE 430/Biochemistry; and 3) enrollment in CHE 393 at TCNJ as substitute for NJMS research requirement. Students in the Seven-year BS Chemistry/M.D. Program should take BIO 201/Foundations of Biological Inquiry their first year at TCNJ.

<b>Relevant Changes to the College Core Curriculum for the BS Chemistry/M.D. Program</b>
1. BIO 231/Genetics (counts as one 300 level chemistry options course) 2. Phase I: Core Biomedical Curriculum/Molecules Cells, and Systems at NJMS (counts as CHE 430/Biochemistry)

#### **Pre-Health Profession Options for Chemistry Majors**

Students interested in health-related careers such as medicine, dentistry, pharmacy, etc. may study for admission to these professional schools through the chemistry major. Careful selection of courses within this major and within free electives will prepare the student to meet health professional school admission requirements. (See also the [Medical Career Advisory Committee](#)).

**Chemistry Minor**

A minor in chemistry comprises five full CHE courses (at least three of the five courses must be taken at TCNJ) including CHE 202 and four other CHE courses numbered 310 or higher, but not including CHE 316, 317, 399, or 490. Only one course unit of CHE 393 can count toward the minor course requirements. The minimum grades in CHE 201, CHE 202, CHE 331 and CHE 310 and the minimum GPA for retention and completion of the minor are the same as for the major. Applicants interested in obtaining a minor in chemistry should consult with the department chair before completing the [TCNJ Application for Minor form](#) and provide a copy of their unofficial transcript, which should include at least three completed TCNJ Chemistry courses. The Application for Minor form should be submitted to the Chemistry main office, C-108.

**Study Abroad**

Students pursuing a degree in chemistry may study abroad for a semester. Any student interested in studying abroad should meet with their faculty advisor before the sophomore year in order to plan a curriculum so that the student may complete their studies in four years. An appointment with the College's [Center for Global Engagement](#) is also required.

Students are free to choose the overseas institution where they wish to study under the guidance of the Center for Global Engagement. It is recommended that students plan to take courses that will count toward the College Core while studying abroad. Students who plan to take Chemistry courses while abroad must receive pre-approval from the Chair of Chemistry in order for the courses to count toward requirements for the major.