

Chemistry and Biochemistry

Web Site: <http://www.odu.edu/chemistry> (<http://www.odu.edu/chemistry/>)

John B. Cooper, Chair
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The Department of Chemistry and Biochemistry offers a program in biochemistry and an American Chemical Society certified program in chemistry, with an optional secondary education emphasis. Chemistry has been called the "central science" because it makes major contributions to agriculture, biology, electronics, engineering, environmental science, medicine, mineralogy and pharmacology. Either undergraduate degree program gives the student the necessary background for continued academic study at the master's and Ph.D. levels, entry into medical, dental, and pharmacy schools, as well as a career in the chemical industry. Students not only gain an excellent education, but also have many research opportunities available to enrich their understanding of real-world problems. Cooperative arrangements exist with the nearby Eastern Virginia Medical School, NASA Langley Research Center and the Thomas Jefferson National Accelerator Facility.

Bachelor of Science–Chemistry Major

Lower-Division General Education

Written Communication *	6
Oral Communication	3
COMM 101R Public Speaking	
Mathematics	3
MATH 163 Precalculus II (required)	
Language and Culture	0-6
Information Literacy and Research (can be met by CHEM 125)	0-3
Human Creativity	3
Interpreting the Past	3
Philosophy and Ethics	3
Literature	3
The Nature of Science	8
PHYS 231N University Physics I & PHYS 232N and University Physics II	
Impact of Technology	3
Human Behavior	3
Total Hours	38-47

* Grade of C or better required in both courses

In addition to completing the University's lower-division general education requirements and upper-division general education requirements, a chemistry major must complete the following courses.

Required Chemistry Courses

CHEM 121N	Foundations of Chemistry I Lecture (cannot earn credit for both 121N and 105N)	3
CHEM 122N	Foundations of Chemistry I Laboratory	1
CHEM 123N	Foundations of Chemistry II Lecture	3
CHEM 124N or CHEM 125	Foundations of Chemistry II Laboratory Foundations of Chemistry II Lab with Introduction to Chemical Research	1-4
CHEM 211	Organic Chemistry I Lecture	3
CHEM 212	Organic Chemistry I Laboratory	2
CHEM 213	Organic Chemistry II Lecture	3
CHEM 214 or CHEM 216	Organic Chemistry II Laboratory Advanced Organic Chemistry Laboratory	2

CHEM 321 & CHEM 322	Analytical Chemistry Lecture and Analytical Chemistry Laboratory	5
CHEM 351	Inorganic Chemistry	3
CHEM 331	Physical Chemistry Lecture I	3
CHEM 332W	Experimental Physical Chemistry I	2
CHEM 333	Physical Chemistry Lecture II	3
CHEM 334W	Experimental Physical Chemistry II	2
CHEM 421 & CHEM 422	Instrumental Analysis Lecture and Instrumental Analysis Laboratory	6
CHEM 441	Biochemistry Lecture	3
CHEM 485	Chemistry and Biochemistry Seminar	1
Select two CHEM Electives from the following:		6
CHEM 415	Intermediate Organic Chemistry	
CHEM 439	Introduction to Pharmaceutical Chemistry	
CHEM 443	Intermediate Biochemistry	
CHEM 449	Environmental Chemistry	
CHEM 451	Advanced Inorganic Chemistry	
CHEM 453	Essentials of Toxicology	
Select one CHEM Laboratory from the following:		2-4
CHEM 352	Inorganic Chemistry Laboratory	
CHEM 442W	Biochemistry Laboratory	

Other required courses

MATH 211	Calculus I	4
MATH 212	Calculus II	4
Total Hours		62-67

Chemistry majors must have a C or better in all courses required for the major, including prerequisite courses, and must complete a minimum of 12 credits in upper-level (300/400) chemistry courses at Old Dominion University. Written permission by the chief departmental advisor or chair is required prior to taking upper-level chemistry courses at other institutions.

Elective Credit

Elective credit may be needed to meet the minimum requirement of 120 credit hours.

Upper-Division General Education

- Option A. Approved Disciplinary Minor (a minimum of 12 hours determined by the department), or second degree or second major.
- Option B: Interdisciplinary Minor (specifically 12 hours, 3 of which may be in the major)
- Option C. International Business and Regional Courses or an approved Certification Program such as teaching licensure
- Option D. Two Upper-Division Courses from outside the College of Sciences and not required by the major (6 hours)

Requirements for Graduation

Requirements for graduation include a minimum cumulative grade point average of 2.00 overall and in the major, a grade of C or better in all courses required for the major, including prerequisite courses, 120 credit hours, which must include both a minimum of 30 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University, completion of ENGL 110C, ENGL 211C or ENGL 221C or ENGL 231C, and the writing intensive (W) course in the major with a grade of C or better, and completion of Senior Assessment. Additional hours may be required to meet the foreign language requirement.

Bachelor of Science - Chemistry with Research Concentration

Students with an interest in pursuing chemical research after graduation or in graduate school or those seeking a deeper understanding of chemical research and applications may pursue a research concentration in Chemistry.

For the research concentration, students must take Senior Thesis I and II (CHEM 490 and CHEM 499) and two of the following research

oriented courses: CHEM 125, CHEM 216, CHEM 497, and CHEM 498.

Courses taken for the research concentration will substitute for courses in the regular curriculum; please consult the chief departmental advisor for specific information on substitutions. Additionally, all regular B.S.-Chemistry degree requirements must be met (with the exception of approved substitutions).

Four-Year Plan - Chemistry - BS (<http://catalog.odu.edu/undergraduate/collegeofsciences/chemistrybiochemistry/chemistry-bs-fouryearplan/>)

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Linked Bachelor's/Master's Degree Programs

The linked B.S. in chemistry and the M.S. in chemistry allows exceptional students to count up to 12 hours of graduate courses toward both a B.S. degree in chemistry and an M.S. degree in chemistry. Students in the combined program must complete Senior Thesis I and II (CHEM 490 and CHEM 499), be accepted into the chemistry master's program, and earn a minimum of 150 credit hours (120 discrete credit hours for the undergraduate degree and 30 discrete credit hours for the graduate degree). Additional requirements apply. Please see the Chief Departmental Advisor.

Bachelor of Science - Chemistry Major with Pre-Med Concentration

Students who perform well in the life sciences will have the option of taking classes to prepare them for medical school, while also having a multitude of career options, post-graduation with chemical instrumentation experience. The pre-med concentration offers training that is directly applicable to medical school curricula, making students attractive applicants for pre-health-related programs. Completing the core science classes will fulfill the chemistry major and standard pre-med requirements at once. Some courses for the pre-med concentration will substitute for courses in the regular curriculum. Please contact the Chief Departmental Advisor. Additional biology coursework, BIOL 121N-BIOL 124N, BIOL 293, BIOL 294, BIOL 250-BIOL 251, is required. A suggested four-year plan follows.

Four-Year Plan - Chemistry - BS - Pre-Med Concentration (<http://catalog.odu.edu/undergraduate/collegeofsciences/chemistrybiochemistry/premedchemistry-bs-fouryearplan/>)

Bachelor of Science—Chemistry Major with Teaching Licensure

This program leads to eligibility for teacher licensure in Virginia and is available only to individuals holding a baccalaureate degree or completing requirements for a Bachelor of Science degree in chemistry. Due to changing University requirements, national accreditation standards, and the Virginia Board of Education licensure regulations, the teacher preparation programs in the College of Sciences are under constant revision. Any changes resulting from these factors supersede the program requirements described in this Catalog. Students are encouraged to obtain current program information from their advisors and the Office of Clinical Experiences website at <https://www.odu.edu/oce> (<https://www.odu.edu/oce/>).

Admission

Students must first declare the chemistry teacher preparation track as their major with the chemistry departmental advisor. All students must apply for and be admitted into the approved chemistry teacher preparation program. Students must meet the required criteria for admission by passing the

Virginia Board of Education prescribed assessments and earn the minimum required grade point averages (GPA).

Virginia Board of Education Prescribed Assessments for Admission to an Approved Teacher Education Program

Old Dominion University students seeking admission to an approved teacher education program must have submitted Praxis Core or approved alternative test of mathematics, reading, and writing (SAT or ACT).

For the most current information on the prescribed Virginia Board of Education admission assessment, visit the Office of Clinical Experiences website at <https://www.odu.edu/oce> (<https://www.odu.edu/oce/>) and review the *Professional Education Handbook*.

Required grade point averages (GPA)

- A cumulative GPA of 2.75 is required.
- A major/content GPA of 2.75 is required - all chemistry courses must be passed with a grade of C (2.0) or above and all other science content courses must be passed with a grade of C- or higher.
- A professional education GPA of 2.75 is required – all professional education courses must be passed with a grade of C- or higher.

Although students may enroll in a limited number of education courses, students must be admitted into the approved chemistry teacher preparation program prior to enrolling in any instructional strategies practicum education course. Students must also meet with an education advisor in the Office of Clinical Experiences.

Continuance

Students must maintain a cumulative GPA of 2.75, a major/content GPA of 2.75 and a professional education GPA of 2.75. Chemistry courses must be passed with a grade of C (2.0) or higher. The remaining courses required for the major and in the professional education core must be completed with a grade of C- or higher for continuance. A professional education GPA of 2.75 is required for continuance. Students must take and pass the Virginia Communication and Literacy Assessment (VCLA) and the Praxis Subject Assessment, Chemistry content knowledge (formerly Praxis II) prior to or while enrolled in the instructional strategies course. All assessments must be passed prior to the start of the Teacher Candidate Internship Orientation session.

Background Clearance Requirement

Old Dominion University requires a background clearance check of candidates interested in many of the professional education programs. Professional education programs have several field experiences that are required for continuance and graduation from the program. The background clearance must be successfully completed prior to a field experience placement. Candidates will be provided a field experience placement when the background check process is completed with resolution of any issues. The process to complete the ODU clearance background check is located at: <http://www.odu.edu/success/academic/teacher-education/placement/background-checks> (<http://www.odu.edu/success/academic/teacher-education/placement/background-checks/>). The ODU clearance process includes: an FBI fingerprint, a child protective service/social service review, and a Virginia State Police sex offender registry review. Candidates interested in the professional education programs are advised to complete this clearance process immediately upon entry into the program since the clearance process takes a minimum of eight weeks to complete.

Virginia Board of Education Prescribed Assessments for Licensure

Virginia Communication and Literacy Assessment (VCLA) – a passing composite score of 470 is required on this reading and writing assessment

Praxis Subject Assessment, Chemistry content knowledge (test code: 5245) – passing score of 153 is required

To review more information on the Virginia Board of Education prescribed assessments visit the Office of Clinical Experiences website at <https://www.odu.edu/oce> (<https://www.odu.edu/oce/>).

Graduation

Requirements for graduation include completion of ENGL 110C, ENGL 211C or ENGL 221C or ENGL 231C, and the writing intensive (W) course in the major with a grade of C or better, completion of the Senior Assessment, a minimum cumulative 2.75 GPA, in the major area, and in the professional education core, with no grade less than a C in the major and C- in the professional education core; successful completion of the Teacher Candidate Internship and a minimum of 126 credit hours, which must include both a minimum of 32 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University. Note that a C (2.0) must be earned in all chemistry courses used to satisfy departmental requirements.

Additional hours may be required to meet the foreign language requirement. The professional education core satisfies the Upper-Division General Education requirement.

The curriculum is as follows:

Lower-Division General Education

Written Communication *	6
Oral Communication	3
COMM 101R Public Speaking	
Mathematics	3
MATH 163 Precalculus II (required)	
Language and Culture	0-6
Information Literacy and Research (can be met by CHEM 125)	0-3
Human Creativity	3
Interpreting the Past	3
Philosophy and Ethics	3
Literature	3
The Nature of Science	8
PHYS 231N University Physics I & PHYS 232N and University Physics II	
Impact of Technology	3
Human Behavior	3
Total Hours	38-47

* Grade of C or better required in both courses

In addition to completing the University's lower-division general education requirements and upper-division general education requirements, a chemistry major seeking teacher licensure must complete the following courses.

Required Chemistry courses

CHEM 121N	Foundations of Chemistry I Lecture	3
CHEM 122N	Foundations of Chemistry I Laboratory	1
CHEM 123N	Foundations of Chemistry II Lecture	3
CHEM 124N or CHEM 125	Foundations of Chemistry II Laboratory Foundations of Chemistry II Lab with Introduction to Chemical Research	1-4
CHEM 211	Organic Chemistry I Lecture	3
CHEM 212	Organic Chemistry I Laboratory	2
CHEM 213	Organic Chemistry II Lecture	3
CHEM 214 or CHEM 216	Organic Chemistry II Laboratory Advanced Organic Chemistry Laboratory	2
CHEM 321 & CHEM 322	Analytical Chemistry Lecture and Analytical Chemistry Laboratory	5
CHEM 351	Inorganic Chemistry	3
CHEM 331	Physical Chemistry Lecture I	3

CHEM 332W	Experimental Physical Chemistry I	2
CHEM 333 & CHEM 334W	Physical Chemistry Lecture II and Experimental Physical Chemistry II	5
CHEM 421 & CHEM 422	Instrumental Analysis Lecture and Instrumental Analysis Laboratory	6
CHEM 441	Biochemistry Lecture	3
CHEM 449	Environmental Chemistry	3
CHEM 485	Chemistry and Biochemistry Seminar	1
Select one CHEM elective from the following:		3
CHEM 415	Intermediate Organic Chemistry	
CHEM 439	Introduction to Pharmaceutical Chemistry	
CHEM 443	Intermediate Biochemistry	
CHEM 451	Advanced Inorganic Chemistry	
Select one CHEM Laboratory from the following:		2-4
CHEM 352	Inorganic Chemistry Laboratory	
CHEM 442W	Biochemistry Laboratory	
Other Required courses		
MATH 211	Calculus I	4
MATH 212	Calculus II	4
Total Hours		62-67

Chemistry majors must have a C or better in all courses required for the major, including prerequisite courses, and must complete a minimum of 12 credits in upper level (300/400) chemistry courses at Old Dominion University. Written permission by the chief departmental advisor or chair is required prior to taking upper level chemistry courses at other institutions.

The professional education core courses and requirements

STEM 101	Step 1 – Inquiry Approaches to Teaching STEM	1
STEM 102	Step 2 - Inquiry Based STEM Lesson Design	1
STEM 201	Knowing and Learning in STEM Education	3
STEM 202	Classroom Interactions in STEM Education	3
STEM 401	Project Based Instruction in STEM Education	3
STEM 402	Perspectives on STEM	3
STEM 485	Apprentice Teaching	9
CHEM 468	Research Methods in Mathematics and Science	3
Total Hours		26

Four-Year Plan - Chemistry Major with Teaching Licensure - BS (<http://catalog.odu.edu/undergraduate/collegesciences/chemistrybiochemistry/chemistry-chemistryed-bs-fouryearplan/>)

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Preparation for Medically Related Fields

Students seeking careers in pharmacy, medicine, dentistry, or veterinary science are advised to complete a major in a specific discipline. Such students electing either chemistry or biochemistry as their major must meet all of the requirements listed above for the degree of Bachelor of Science with a major in chemistry or biochemistry. In addition, students must complete all of the prerequisite coursework specified for admission into the professional program of their choice. Students should consult the Office of Admissions of such professional programs for specific prerequisite coursework and other entrance requirements. Students are also advised to

register with the Prehealth Advisory Committee at Old Dominion University (683-6790).

Bachelor of Science–Biochemistry Major

Lower-Division General Education

Written Communication *	6
Oral Communication	3
COMM 101R Public Speaking	
Mathematics	3
MATH 163 Precalculus II (required)	
Language and Culture	0-6
Information Literacy and Research (can be met by CHEM 125)	0-3
Human Creativity	3
Interpreting the Past	3
Philosophy and Ethics	3
Literature	3
The Nature of Science	8
BIOL 121N General Biology I	
BIOL 122N General Biology I Lab	
BIOL 123N General Biology II	
BIOL 124N General Biology II Lab	
Impact of Technology	3
Human Behavior	3
Total Hours	38-47

* Grade of C or better required in both courses

In addition to completing the University's lower-division general education requirements and upper-division general education requirements, a biochemistry major must complete the following courses.

Required Chemistry Courses

CHEM 121N	Foundations of Chemistry I Lecture	3
CHEM 122N	Foundations of Chemistry I Laboratory	1
CHEM 123N	Foundations of Chemistry II Lecture	3
CHEM 124N	Foundations of Chemistry II Laboratory	1-4
or CHEM 125	Foundations of Chemistry II Lab with Introduction to Chemical Research	
CHEM 211	Organic Chemistry I Lecture	3
CHEM 212	Organic Chemistry I Laboratory	2
CHEM 213	Organic Chemistry II Lecture	3
CHEM 214	Organic Chemistry II Laboratory	2
or CHEM 216	Advanced Organic Chemistry Laboratory	
CHEM 321	Analytical Chemistry Lecture	5
& CHEM 322	and Analytical Chemistry Laboratory	
CHEM 331	Physical Chemistry Lecture I	6
& CHEM 333	and Physical Chemistry Lecture II	
CHEM 441	Biochemistry Lecture	3
CHEM 442W	Biochemistry Laboratory	4
CHEM 443	Intermediate Biochemistry	3
CHEM 485	Chemistry and Biochemistry Seminar	1
Other Required courses		
MATH 211	Calculus I	4
MATH 212	Calculus II	4
PHYS 231N	University Physics I	8
& PHYS 232N	and University Physics II	
BIOL 293	Cell Biology	3
BIOL 294	Genetics	3
Total Hours		62-65

Biochemistry majors must have a C or better in all courses required for the major, including prerequisite courses, and must complete a minimum of 12 credits in upper-level (300/400) chemistry courses at Old Dominion University. Written permission by the chief departmental advisor or chair is required prior to taking upper-level chemistry courses at other institutions.

Biochemistry majors can attain an ACS-certified degree for chemistry content if they also complete the following.

CHEM 332W	Experimental Physical Chemistry I
CHEM 351	Inorganic Chemistry
Two of the following lecture electives	
CHEM 411	Natural Products Chemistry in the Carribean
CHEM 415	Intermediate Organic Chemistry
CHEM 421	Instrumental Analysis Lecture
CHEM 449	Environmental Chemistry
CHEM 451	Advanced Inorganic Chemistry
Two of the following laboratory electives:	
CHEM 334W	Experimental Physical Chemistry II
CHEM 352	Inorganic Chemistry Laboratory
CHEM 422	Instrumental Analysis Laboratory

Elective Credit

Elective credit may be needed to meet the minimum requirement of 120 credit hours.

Upper-Division General Education

- Option A. Approved Disciplinary Minor (a minimum of 12 hours determined by the department), or second degree or second major.
- Option B: Interdisciplinary Minor (specifically 12 hours, 3 of which may be in the major)
- Option C. International Business and Regional Courses or an approved Certification Program such as teaching licensure
- Option D. Two Upper-Division Courses from outside the College of Sciences and not required by the major (6 hours)

Requirements for Graduation

Requirements for graduation include a minimum cumulative grade point average of 2.00 overall and in the major, a grade of C or better in all courses required for the major, including prerequisite courses, 120 credit hours, which must include both a minimum of 30 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University, completion of ENGL 110C, ENGL 211C or ENGL 221C or ENGL 231C, and the writing intensive (W) course in the major with a grade of C or better, and completion of Senior Assessment. Additional hours may be required to meet the foreign language requirement. Biochemistry majors may not use the chemistry minor to fulfill upper-division general education requirements.

Bachelor of Science - Biochemistry with Research Concentration

Students with an interest in pursuing biochemical research after graduation or in graduate school or those seeking a deeper understanding of biochemical research and applications may pursue a research concentration in Biochemistry. For the research concentration, students must take Senior Thesis I and II (CHEM 490 and CHEM 499) and two of the following research oriented courses: CHEM 125, CHEM 216, CHEM 497, and CHEM 498. Courses taken for the research concentration will substitute for courses in the regular curriculum; please consult the Chief Departmental Advisor for specific information on substitutions. Additionally, all regular B.S.-Biochemistry degree requirements must be met (with the exception of approved substitutions).

Four-Year Plan - Biochemistry - BS (<http://catalog.odu.edu/undergraduate/collegeofsciences/chemistrybiochemistry/biochemistry-bs-fouryearplan/>)

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Linked Bachelor's/Master's Degree Programs

The linked B.S. in biochemistry and the M.S. in chemistry allows exceptional students to count up to 12 hours of graduate courses toward both a B.S. degree in biochemistry and an M.S. degree in chemistry. Students in the combined program must complete Senior Thesis I and II (CHEM 490 and CHEM 499), be accepted into the chemistry master's program, and earn a minimum of 150 credit hours (120 discrete credit hours for the undergraduate degree and 30 discrete credit hours for the graduate degree). Additional requirements apply. Please see the Chief Departmental Advisor.

Bachelor of Science—Biochemistry Major with Teaching Licensure

This program leads to eligibility for teacher licensure in Virginia and is available only to individuals holding a baccalaureate degree or completing requirements for a Bachelor of Science degree in biochemistry. Due to changing University requirements, national accreditation standards, and the Virginia Board of Education licensure regulations, the teacher preparation programs in the College of Sciences are under constant revision. Any changes resulting from these factors supersede the program requirements described in this Catalog. Students are encouraged to obtain current program information from their advisors and the Office of Clinical Experiences website at <https://www.odu.edu/oce> (<https://www.odu.edu/oce/>).

Admission

Students must first declare the biochemistry teacher preparation track as their major with the chemistry departmental advisor. All students must apply for and be admitted into the approved biochemistry teacher preparation program. Students must meet the required criteria for admission by passing the Virginia Board of Education prescribed assessments and earn the minimum required grade point averages (GPA).

Virginia Board of Education Prescribed Assessments for Admission to an Approved Teacher Education Program

Old Dominion University students seeking admission to an approved teacher education program must have submitted Praxis Core or approved alternative test of mathematics, reading, and writing (SAT or ACT).

For the most current information on the prescribed Virginia Board of Education admission assessment, visit the Office of Clinical Experiences website at <https://www.odu.edu/oce> (<https://www.odu.edu/oce/>) and review the *Professional Education Handbook*.

Required grade point averages (GPA)

- A cumulative GPA of 2.75 is required.
- A major/content GPA of 2.75 is required - all chemistry courses must be passed with a grade of C (2.0) or above and all other science content courses must be passed with a grade of C- or higher.
- A professional education GPA of 2.75 is required – all professional education courses must be passed with a grade of C- or higher.

Although students may enroll in a limited number of education courses, students must be admitted into the approved biochemistry teacher preparation program prior to enrolling in any instructional strategies practicum education course. Students must also meet with an education advisor in the Office of Clinical Experiences.

Continuance

Students must maintain a cumulative GPA of 2.75, a major/content GPA of 2.75 and a professional education GPA of 2.75. Chemistry courses must be passed with a grade of C (2.0) or higher. The remaining courses required for the major and in the professional education core must be completed with a grade of C- or higher for continuance. A professional education GPA of 2.75 is required for continuance. Students must take and pass the Virginia Communication and Literacy Assessment (VCLA) and the Praxis Subject Assessment, Chemistry content knowledge (formerly Praxis II) prior to or while enrolled in the instructional strategies course. All assessments must be passed prior to the start of the Teacher Candidate Internship Orientation session.

Background Clearance Requirement

Old Dominion University requires a background clearance check of candidates interested in many of the professional education programs. Professional education programs have several field experiences that are required for continuance and graduation from the program. The background clearance must be successfully completed prior to a field experience placement. Candidates will be provided a field experience placement when the background check process is completed with resolution of any issues. The process to complete the ODU clearance background check is located at: <http://www.odu.edu/success/academic/teacher-education/placement/background-checks> (<http://www.odu.edu/success/academic/teacher-education/placement/background-checks/>). The ODU clearance process includes: an FBI fingerprint, a child protective service/social service review, and a Virginia State Police sex offender registry review. Candidates interested in the professional education programs are advised to complete this clearance process immediately upon entry into the program since the clearance process takes a minimum of eight weeks to complete.

Virginia Board of Education Prescribed Assessments for Licensure

Virginia Communication and Literacy Assessment (VCLA) – a passing composite score of 470 is required on this reading and writing assessment

Praxis Subject Assessment, Chemistry content knowledge (test code: 5245) – passing score of 153 is required

To review more information on the Virginia Board of Education prescribed assessments visit the Office of Clinical Experiences website at <https://www.odu.edu/oce> (<https://www.odu.edu/oce/>).

Graduation

Requirements for graduation include completion of ENGL 110C, ENGL 211C or ENGL 221C or ENGL 231C, and the writing intensive (W) course in the major with a grade of C or better, completion of the Senior Assessment, a minimum cumulative 2.75 GPA, in the major area, and in the professional education core, with no grade less than a C in the major and C- in the professional education core; successful completion of the Teacher Candidate Internship and a minimum of 126 credit hours, which must include both a minimum of 32 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University. Note that a C (2.0) must be earned in all chemistry courses used to satisfy departmental requirements.

Additional hours may be required to meet the foreign language requirement. The professional education core satisfies the Upper-Division General Education requirement.

The curriculum is as follows:

Lower-Division General Education

Written Communication *	6
Oral Communication	3
COMM 101R	Public Speaking
Mathematics	3
MATH 163	Precalculus II (required)
Language and Culture	0-6

Information Literacy and Research (can be met by CHEM 125)	0-3
Human Creativity	3
Interpreting the Past	3
Philosophy and Ethics	3
Literature	3
The Nature of Science	8
BIOL 121N General Biology I & BIOL 122N and General Biology I Lab	
BIOL 123N General Biology II & BIOL 124N and General Biology II Lab	
Impact of Technology	3
Human Behavior	3
GEOG 101S Environmental Geography	
Total Hours	38-47

* Grade of C or better required in both courses

In addition to completing the University's lower-division general education requirements and upper-division general education requirements, a biochemistry major seeking teacher licensure must complete the following courses.

Required Chemistry courses

CHEM 121N	Foundations of Chemistry I Lecture	3
CHEM 122N	Foundations of Chemistry I Laboratory	1
CHEM 123N	Foundations of Chemistry II Lecture	3
CHEM 124N	Foundations of Chemistry II Laboratory	1-4
or CHEM 125	Foundations of Chemistry II Lab with Introduction to Chemical Research	
CHEM 211	Organic Chemistry I Lecture	3
CHEM 212	Organic Chemistry I Laboratory	2
CHEM 213	Organic Chemistry II Lecture	3
CHEM 214	Organic Chemistry II Laboratory	2
or CHEM 216	Advanced Organic Chemistry Laboratory	
CHEM 321	Analytical Chemistry Lecture	5
& CHEM 322	and Analytical Chemistry Laboratory	
CHEM 331	Physical Chemistry Lecture I	3
CHEM 333	Physical Chemistry Lecture II	3
CHEM 441	Biochemistry Lecture	3
CHEM 442W	Biochemistry Laboratory	4
CHEM 443	Intermediate Biochemistry	3
CHEM 485	Chemistry and Biochemistry Seminar	1

Other Required courses

MATH 211	Calculus I	4
MATH 212	Calculus II	4
BIOL 293	Cell Biology	3
BIOL 294	Genetics	3
PHYS 231N	University Physics I	4
PHYS 232N	University Physics II	4
Total Hours		62-65

Biochemistry majors must have a C or better in all courses required for the major, including prerequisite courses, and must complete a minimum of 12 credits in upper level (300/400) chemistry courses at Old Dominion University. Written permission by the chief departmental advisor or chair is required prior to taking upper-level chemistry courses at other institutions.

The professional education core courses and requirements

STEM 101	Step 1 – Inquiry Approaches to Teaching STEM	1
STEM 102	Step 2 - Inquiry Based STEM Lesson Design	1

STEM 201	Knowing and Learning in STEM Education	3
STEM 202	Classroom Interactions in STEM Education	3
STEM 401	Project Based Instruction in STEM Education	3
STEM 402	Perspectives on STEM	3
STEM 485	Apprentice Teaching	9
CHEM 468	Research Methods in Mathematics and Science	3
Total Hours		26

Four-Year Plan - Biochemistry Major with Teaching Licensure - BS (<http://catalog.odu.edu/undergraduate/collegeofsciences/chemistrybiochemistry/biochemistryed-bs-fouryearplan/>)

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Minor in Chemistry

The chemistry minor consists of 13 credits of which nine credits must be selected from the following:

Select nine credits from the following:	9
CHEM 213	Organic Chemistry II Lecture
CHEM 321	Analytical Chemistry Lecture
CHEM 331	Physical Chemistry Lecture I
CHEM 333	Physical Chemistry Lecture II
CHEM 351	Inorganic Chemistry
CHEM 411	Natural Products Chemistry in the Caribbean
CHEM 415	Intermediate Organic Chemistry
CHEM 439	Introduction to Pharmaceutical Chemistry
CHEM 441	Biochemistry Lecture
CHEM 443	Intermediate Biochemistry
CHEM 449	Environmental Chemistry
CHEM 451	Advanced Inorganic Chemistry
CHEM 453	Essentials of Toxicology
Select four credits from the following:	4
CHEM 214	Organic Chemistry II Laboratory
CHEM 322	Analytical Chemistry Laboratory
CHEM 332W	Experimental Physical Chemistry I
CHEM 334W	Experimental Physical Chemistry II
CHEM 352	Inorganic Chemistry Laboratory
CHEM 442W	Biochemistry Laboratory
CHEM 452	Advanced Inorganic Chemistry Laboratory
CHEM 497	Independent Study
CHEM 498	Independent Study
Total Hours	13

The courses designated for the minor and taken by students must be completed with an overall cumulative grade point average of 2.00 or better. CHEM 121N/CHEM 122N and CHEM 123N/CHEM 124N must be completed as prerequisites for the minor in chemistry and are not included in the calculation of the grade point average for the minor. Additional prerequisite courses may also be required and are not included in the grade point average for the minor. Students electing the minor must complete a minimum of six credit hours in the minor requirement through courses offered by Old Dominion University. Any substitutions must be approved in writing by the chief departmental advisor.

Honors in Chemistry

The honors program provides qualified students the opportunity for supervised individual study in their areas of interest. Admission to the program requires a cumulative GPA of 3.25 or higher and a GPA of 3.50 or higher in the major. Students must take two upper-division courses designated by the department to be honors courses. These are termed "Contract Honors Courses." A description of the procedures for these contract courses is found in the Honors College section of this Catalog.

Advanced Placement

Students who receive a qualifying score on the Advanced Placement of the College Board exam in chemistry may receive credit for introductory chemistry courses. The appropriate credit will be determined after consultation with an advisor. See the equivalency charts on the Office of Undergraduate Admissions website at <https://www.odu.edu/admission/undergraduate/credit> (<https://www.odu.edu/admission/undergraduate/credit/>). Students may also refer to the section of this Catalog on Prior Learning Assessment Credit Options at the Undergraduate Level.

CHEMISTRY AND BIOCHEMISTRY Courses

CHEM 103. Preparatory Chemistry. 3 Credits.

An introductory course designed to acquaint the student with the basic principles of chemistry. Prerequisite: knowledge of basic algebra.

CHEM 105N. Introductory Chemistry. 3 Credits.

This course is the first part of a two-semester sequence of chemistry covering topics in general, organic, and biological chemistry. In this part, an introduction to the principles of inorganic (general) chemistry is provided. The topics to be covered include measurements, atoms and elements, compounds and their bonds, energy and matter, gases, solutions, acids and bases, chemical reactions and quantities, chemical equilibrium, and nuclear chemistry. This course does not meet the prerequisite for CHEM 123N, and cannot be used toward the CHEM major or minor. Students wishing to pursue advanced study in chemistry should take CHEM 121N, CHEM 122N, CHEM 123N, and CHEM 124N. Credit for CHEM 105N is not allowed if a student has prior credit for CHEM 121N. CHEM 105N + CHEM 106N satisfy four credits of the University's Nature of Science general education requirement. Corequisite: CHEM 106N. Prerequisite: knowledge of basic algebra.

CHEM 106N. Introductory Chemistry Laboratory. 1 Credit.

An introduction to common laboratory techniques and the process of science is provided. CHEM 105N + CHEM 106N satisfy four credits of the University's Nature of Science general education requirement. Pre- or corequisite: CHEM 105N.

CHEM 107N. Introductory Organic and Biochemistry. 3 Credits.

This course is the second part of a two-semester sequence of chemistry covering topics in general, organic, and biological chemistry. In this part, an introduction to organic compounds and their role in biological systems is provided. The topics to be covered include the structure, nomenclature, and reactivity of organic compounds, the structure and function of important biomolecules, and the chemistry of metabolic pathways. This course does not meet the prerequisite for CHEM 211, and cannot be used toward the CHEM major or minor. Students wishing to pursue advanced study in chemistry should take CHEM 121N, CHEM 122N, CHEM 123N, and CHEM 124N. CHEM 107N + CHEM 108N satisfy four credits of the University's Nature of Science general education requirement. Corequisite: CHEM 108N. Prerequisite: CHEM 105N with a grade of C or better.

CHEM 108N. Introductory Organic and Biochemistry Laboratory. 1 Credit.

Laboratory experiments involving organic compounds and biomolecules are performed. CHEM 107N + CHEM 108N satisfy four credits of the University's Nature of Science general education requirement. Prerequisite: CHEM 106N with a grade of C or better. Pre- or corequisite: CHEM 107N.

CHEM 120. Foundations of Chemistry I Laboratory for Online Degree Programs. 1 Credit.

In this course, students perform laboratory experiments to complement the topics presented in the companion lecture course, CHEM 121N. CHEM 121N + CHEM 126 does not satisfy the university's Nature of Science requirement. This is a distance learning course restricted to students in an online degree program. Pre- or corequisite: CHEM 121N.

CHEM 121N. Foundations of Chemistry I Lecture. 3 Credits.

This is the first of a two-course series, designed for science and engineering majors, that prepares the student for subsequent studies in molecular science and constitutes the foundation for all upper-level chemistry courses. Topics include the descriptive chemistry of selected elements, modern atomic and molecular structure, stoichiometry, thermochemistry, and gas laws. A student receiving credit for CHEM 121N cannot receive additional credit for CHEM 103 or CHEM 105N or CHEM 137N. CHEM 121N + CHEM 122N satisfy 4 credits of the University's Nature of Science general education requirement. Prerequisites: MATH 102M or MATH 103M or higher with a grade of C or better and a qualifying score on the Chemistry Placement Exam or successful completion of the Chemistry Placement online modules or CHEM 103 or CHEM 105N with a grade of C or better. Pre- or corequisites: CHEM 122N or CHEM 120.

CHEM 122N. Foundations of Chemistry I Laboratory. 1 Credit.

Laboratory experiments are designed to complement the topics presented in the companion lecture course, CHEM 121N. A student receiving credit for CHEM 122N cannot receive additional credit for CHEM 106N. CHEM 121N + CHEM 122N satisfy 4 credits of the University's Nature of Science general education requirement. Pre- or corequisite: CHEM 121N.

CHEM 123N. Foundations of Chemistry II Lecture. 3 Credits.

This is the second of a two-course series, designed for science majors, that prepares the student for subsequent studies in molecular science and constitutes the foundation for all upper-level chemistry courses. Topics include states of matter, solutions, electrochemistry, thermodynamics, equilibria, and kinetics. CHEM 123N + CHEM 124N satisfy 4 credits of the University's Nature of Science general education requirement. Prerequisites: CHEM 121N with a grade of C or better.

CHEM 124N. Foundations of Chemistry II Laboratory. 1 Credit.

Laboratory experiments are designed to complement the topics in the companion lecture course, CHEM 123N. CHEM 123N + CHEM 124N satisfy 4 credits of the University's Nature of Science general education requirement. Prerequisites: CHEM 121N and CHEM 122N with grades of C or better. Pre- or corequisite: CHEM 123N.

CHEM 125. Foundations of Chemistry II Lab with Introduction to Chemical Research. 4 Credits.

This course introduces students to information literacy and research in chemistry. Students will develop skills in searching, evaluation, citing and ethics associated with information required for research projects. Further, students will gain experience in experimental design and chemical research. Corequisite: CHEM 123N. Prerequisites: CHEM 121N with a grade of B or better AND CHEM 122N with a grade of B or better AND permission of the instructor.

CHEM 171T. Influence of Polymers on Society. 3 Credits.

In this course, the history of synthetic and natural polymers will be studied from their initial development to modern day. Through these studies, students will learn how polymers are produced, the properties of polymers, and the many application of polymers. Further, the impact these materials have on society will be examined in many different areas such as medicine, electronics, consumer goods and the environment.

CHEM 173T. Nutritional Biochemistry. 3 Credits.

Students will explore the role biotechnology plays in understanding and advancing nutrition and the effects this has on human health, development and societies. The key biological molecules such as vitamins, amino acids, proteins, fats and carbohydrates and their nutritional functions will be discussed. Nutritional biochemistry as it relates to human development, medicine and the evolution of human species will be explored. Students will review present day nutritional issues such as popular diets, organic foods, farming practices and advances such as genetically modified foods.

CHEM 175T. Neurotechnology. 3 Credits.

Neurotechnology is the technology used to understand (assessment neurotechnology) and moderate (intervention neurotechnology) brain chemistry with regards to various aspects of consciousness, thought, memory, perception, addiction and other higher order activities and disorders in the brain. From pharmaceutical drugs to brain scanning, the impact of neurotechnology affects nearly everyone either directly or indirectly - for example: drug use for depression, sleep, ADD, or neurotic behavior; cancer scanning; stroke rehabilitation; etc. This course will explore the basics of neurotechnology and its impact on human behavior and performance as well as broader impacts on society. Further, students will learn how neurotechnology is used to assess and intervene in the neurochemistry of the brain with a particular emphasis on addictive behavior and neurodegenerative disorders.

CHEM 195. Selected Topics. 1-3 Credits.

Selected laboratory or lecture topics designed for students who need to supplement a transfer course to fulfill a course requirement. Prerequisite: permission of the chief departmental advisor or chair of the department.

CHEM 211. Organic Chemistry I Lecture. 3 Credits.

Introduction to organic compounds, isomerism and nomenclature, stereochemistry and conformational analysis, in depth mechanistic understanding of proton transfer reactions, substitution and elimination reactions, and addition to C=C bonds. Prerequisites: CHEM 123N with a grade of C or better.

CHEM 212. Organic Chemistry I Laboratory. 2 Credits.

Experience is offered in fundamental laboratory techniques applicable to the characterization, separation and purification of various organic compounds including stereoisomers and introduction to organic reactions. Prerequisites: CHEM 124N or CHEM 125 with a grade of C or better. Pre- or corequisite: CHEM 211 with a grade of C or better.

CHEM 213. Organic Chemistry II Lecture. 3 Credits.

Chemistry of carbon compounds with in-depth treatments of reaction mechanisms, modern spectral techniques, and new synthetic methods to meet the needs of chemistry and biochemistry majors. Prerequisite: CHEM 211 with a grade of C or better.

CHEM 214. Organic Chemistry II Laboratory. 2 Credits.

Experience is offered in synthetic, separation, and analytical methods of organic chemistry. Modern synthetic and spectroscopic techniques are introduced. Prerequisites: CHEM 212 with a grade of C or better. Pre- or corequisite: CHEM 213 with a grade of C or better.

CHEM 216. Advanced Organic Chemistry Laboratory. 2 Credits.

Experience is offered in advanced organic reactions and spectroscopic techniques. In addition, students will carry out a short, customized, research project in Organic Chemistry or Organic Materials. Prerequisites: CHEM 211 and CHEM 212 with a grade of C or better; approval by the course instructor or coordinator. Pre- or corequisite: CHEM 213.

CHEM 321. Analytical Chemistry Lecture. 3 Credits.

A study of the fundamental principles of quantitative chemical analysis including the application of principles of equilibria to analytical processes. Emphasis is given to gravimetric and titrimetric methods as well as consideration of electrical, optical, and other methods of chemical analysis. Prerequisites: CHEM 123N and MATH 163 or MATH 205 with a grade of C or better.

CHEM 322. Analytical Chemistry Laboratory. 2 Credits.

Statistical principles or measurements and error analysis are integrated with experiments designed to evaluate and refine techniques of fundamental measurements to a level of analytical competency. These techniques are applied to the analysis of samples using gravimetric, titrimetric, electrical and optical methods. Prerequisites: CHEM 124N or CHEM 125 with a grade of C or better. Pre- or corequisite: CHEM 321 or permission of the instructor.

CHEM 331. Physical Chemistry Lecture I. 3 Credits.

Quantum chemistry, molecular structure, and spectroscopy. Prerequisites: CHEM 321, CHEM 213, MATH 212 and PHYS 231N-PHYS 232N with a grade of C or better.

CHEM 332W. Experimental Physical Chemistry I. 2 Credits.

A laboratory class focusing on a variety of physical chemical techniques. Topics may include electronic, vibrational (Raman) and NMR spectroscopies, calorimetry, viscosity, and atomic force microscopy. This is a writing intensive course, aiming to achieve an in-depth understanding of the physical principles underlying the techniques. Prerequisites: grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C. Pre- or corequisite: CHEM 331 with a grade of C or better.

CHEM 333. Physical Chemistry Lecture II. 3 Credits.

Chemical thermodynamics of pure substances and solutions, chemical equilibrium, electrochemistry, chemical kinetics, and statistical thermodynamics. Prerequisites: CHEM 331 with a grade of C or better.

CHEM 334W. Experimental Physical Chemistry II. 2 Credits.

A laboratory class focusing on a variety of physical chemical techniques. Topics may include X-Ray Diffraction, Bomb Calorimetry, Thermal Gravimetric Analysis (TGA), Conductance of Solutions, and Polymer Physical Properties. This course may also include a team project that will incorporate many of the techniques learned in the physical chemistry lab sequence. This project will introduce the students to working as a team to address a specific challenge such as one might encounter in an industrial or government laboratory setting. This is a writing intensive course. Prerequisites: grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C. Pre- or corequisite: CHEM 332W and CHEM 333 with a grade of C or better.

CHEM 339T. The Chemistry of the Environment. 3 Credits.

This class explores the impact of chemical technologies on current environmental topics using basic chemical principles and the scientific method as standards for evaluating and understanding pressing environmental issues. Topics include global and ocean warming, air pollution, atmospheric ozone depletion, effects of enhanced UV light, acid rain and ocean acidification, toxic heavy metals, radioactivity and nuclear power plant disasters, indoor air quality and radon, water pollution, sewage and water treatment, drinking water quality, waste disposal and plastics, pesticides, and the food chain. The course will use math to a modest degree including basic Algebra. It is highly recommended that students have passed a college level algebra math class (e.g., MATH 102M or MATH 103M or higher) and one year of high school chemistry. Prerequisites: Any General Education Nature of Science (N) course.

CHEM 343T. Science and Technology in Art. 3 Credits.

This combined lecture and lab course will explore the chemical and physical properties of artists' materials from pigments and binders to ceramics. Topics will include the nature of light and color, historical origins and development of pigments and artistic methods, synthesis of dyes and pigments, and the application of technology to art historical analysis. The course will include hands-on experience with modern laboratory equipment and field trips to local museums and conservation labs. Prerequisites: Completion of one Nature of Science general education course or permission of the instructor.

CHEM 351. Inorganic Chemistry. 3 Credits.

This foundational course provides an introduction to inorganic chemistry. Topics include periodic law, bonding theory, oxidation/reduction, acid/base theory, descriptive chemistry of the main group, an introduction to transition metal coordination chemistry, and human applications of inorganic chemistry. Prerequisites: Grade of C or better in CHEM 123N.

CHEM 352. Inorganic Chemistry Laboratory. 2 Credits.

Synthesis of metal and nonmetal inorganic compounds and organometallic compounds, their characterization by physical methods, and a study of their properties. Prerequisite: CHEM 124N or CHEM 125. Pre- or corequisite: CHEM 351 with a grade of C or better.

CHEM 365. Undergraduate Teaching Experience. 1-3 Credits.

Teaching experience in a chemistry classroom or laboratory setting under the direct supervision of the course instructor. Prerequisite: junior standing and/ or approval of the appropriate departmental coordinator. Available for Pass/Fail grading only.

CHEM 367. Cooperative Education. 1-3 Credits.

May be repeated for credit. Student participation for credit is based on the academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and the Cooperative Education program prior to the semester in which the work experience is to take place. Available for pass/fail grading only. (qualifies as a CAP experience) Prerequisite: approval by the department and Cooperative Education/Career Development Services in accordance with the policy for granting credit for Cooperative Education programs.

CHEM 369. Chemistry Practicum. 1-3 Credits.

A student may choose a coop, internship, research, or student teaching experience to gain out-of-class experience related to the major. Prerequisites: CHEM 331/CHEM 332W (Chemistry major) or CHEM 441/CHEM 442W (Biochemistry major) and the approval of the appropriate departmental coordinator.

CHEM 411/511. Natural Products Chemistry in the Caribbean. 4 Credits.

A bioinorganic and natural products course that entails the chemistry of the use of chromium, vanadium, and herbs in medicine and the use of tunicates as biomonitors of heavy metal pollution in Jamaica. This is a study abroad course intended for the Maymester term. Prerequisites: CHEM 211 and CHEM 212 with a C or better.

CHEM 415/515. Intermediate Organic Chemistry. 3 Credits.

An in-depth look at organic reaction mechanisms, including polar, pericyclic, radical and organometallic reactions. Prerequisites: CHEM 211-CHEM 213 with a grade of C or better.

CHEM 421/521. Instrumental Analysis Lecture. 3 Credits.

Designed to be taken concurrently with CHEM 422/CHEM 522. A study of the basic principles of spectroscopic, chromatographic, and electrochemical methods of quantitative chemical analysis. Methods of chemical instrumentation are also included. Prerequisites: CHEM 321 with a grade of C or better.

CHEM 422/522. Instrumental Analysis Laboratory. 3 Credits.

An intensive laboratory study of the principles of analytical chemistry. Experiments in spectroscopic, chromatographic, and electrochemical methods are conducted to illustrate fundamental principles and to provide the opportunity to develop skills in the use of instrumentation for chemical measurement. Prerequisites: CHEM 322 with a grade of C or better.

CHEM 439/539. Introduction to Pharmaceutical Chemistry. 3 Credits.

An introduction to the fundamental concepts of drug action including pharmacodynamics (effect of drugs on the body) and pharmacokinetics (ADME: absorption, distribution, metabolism and elimination) of drugs; an introduction to the process of new drug discovery and synthesis will also be taught. Prerequisites: CHEM 213 and CHEM 214 (or CHEM 216) with a grade of "C" or higher; CHEM 321 and CHEM 441 recommended.

CHEM 441/541. Biochemistry Lecture. 3 Credits.

This course is a one-semester survey of the major molecular constituents, bioenergetics, enzymes, nucleic acid structure, and genetic information transfer pathways fundamental to biochemistry. Prerequisite: CHEM 213 with a grade of C or better.

CHEM 442W/542. Biochemistry Laboratory. 4 Credits.

Principles and techniques of biochemical and immunological procedures involving protein characterization and isolation, enzymology, bioinformatics, and common molecular biology techniques for nucleic acids will be presented. This is a writing intensive course. Prerequisites: CHEM 214 with a grade of C or better and ENGL 211C or ENGL 221C or ENGL 231C with a grade of C or better. Pre- or corequisite: CHEM 441/CHEM 541 with a grade of C or better.

CHEM 443/543. Intermediate Biochemistry. 3 Credits.

This course presents and in-depth study of protein structure, folding, and synthesis. The major metabolic pathways will be studied in detail regarding thermodynamics and mechanism of regulation or control of individual enzymes and entire metabolic pathways. Concepts of metabolic disease will be introduced and effects on integrated metabolism will be presented. Prerequisite: CHEM 441/CHEM 541 with a grade of C or better or equivalent.

CHEM 449/549. Environmental Chemistry. 3 Credits.

An overview of the natural chemical systems operating in the atmosphere, in the terrestrial environment (both water and soils), and in the oceans, and the potential effects that human activities may have on them. Specific topics include the origin and evolution of the earth and life, the chemistry of the atmosphere (including the ozone layer and greenhouse effect), the organic and inorganic components of soil and water, chemical weathering of rocks, metal complexation, biological processes in soil and water, and global-scale chemical processes. Prerequisites: CHEM 123N, CHEM 213 and CHEM 321 with a grade of C or higher or permission of the instructor.

CHEM 451/551. Advanced Inorganic Chemistry. 3 Credits.

Theoretical aspects of modern inorganic chemistry: bonding theories, stereochemistry, acid-base theories, coordination compounds, organometallic and bioinorganic compounds. Prerequisites: CHEM 351 with a grade of C or better.

CHEM 452/552. Advanced Inorganic Chemistry Laboratory. 2 Credits.

Synthesis of metal and nonmetal inorganic compounds and organometallic compounds, their characterization by modern physical methods, and a study of their properties. Prerequisites: CHEM 351 and CHEM 352.

CHEM 453/553. Essentials of Toxicology. 3 Credits.

Fundamental principles of toxicology: dose-response relationship, toxicologic testing, chemical and biological factors influencing toxicity, organ toxicology, carcinogenesis, mutagenesis, teratogenesis. Prerequisite: CHEM 213 with a grade of C or higher.

CHEM 460/560. Frontiers in Nanoscience and Nanotechnology. 1 Credit.

Nanotechnology presents unparalleled opportunities for advances in technology and medicine. Simultaneously, nanotechnology presents new challenges to organisms and to our environment. These undefined risk factors threaten to slow the development of new technologies and novel medical therapies. This course will review: structure, synthesis and properties of key nanomaterials; key applications of nanomaterials in technology and medicine; and impacts of nanomaterials on plant and animal physiology and the environment more generally. This course will be team-taught by faculty members in Biological Sciences, Chemistry and Biochemistry, and Engineering. Prerequisite: junior standing.

CHEM 468. Research Methods in Mathematics and Science. 3 Credits.

Emphasizes the tools and techniques used to solve scientific problems. Topics include use and design of experiments, use of statistics to interpret experimental results, mathematical modeling of scientific phenomena, and oral and written presentation of scientific results. Students will perform four independent inquiries, combining skills from mathematics and science to solve research problems. Required for Chemistry teaching licensure track; not available as upper-division elective in content area. Prerequisites: CHEM 331, STEM 201, and admission to the MonarchTeach program.

CHEM 485. Chemistry and Biochemistry Seminar. 1 Credit.

The formal presentation of a chemical or biochemical topic before students and faculty. Students will also take Major Field Test during this course. Prerequisite: CHEM 331 and Senior standing.

CHEM 490. Senior Thesis I. 1 Credit.

Part one of a two-semester thesis project involving literature research, development of scientific writing skills, and obtaining lab experience using a variety of techniques and equipment. Each student will undertake a research experience under the supervision of a departmental faculty member. A preliminary report of research findings is required at the end of the semester. Prerequisite: Chemistry or Biochemistry major; Senior standing; Cumulative GPA of 3.20 or higher.

CHEM 494. Entrepreneurship in Chemistry and Biochemistry. 3**Credits.**

A high level of economic activity and development for any industrialized nation has at its core a strong STEM component. Within this component, the fields of chemistry and biochemistry form one of the strongest interdisciplinary links by providing an understanding of the processes and products at a molecular level. This course will allow students to combine their academic knowledge in chemistry and biochemistry with the needs of real-world businesses to formulate an economically viable business plan that encompasses a scientifically and economically sound proof-of-concept. Prerequisite: Junior standing.

CHEM 495. Selected Topics. 1-3 Credits.

Study of selected topics. Prerequisite: permission of the instructor.

CHEM 497. Independent Study. 1 Credit.

An opportunity is afforded students to undertake independent study or an original investigation under the direction of a faculty member. Prerequisites: course background appropriate to the proposed study project and approval of the department chair and the faculty/research advisor.

CHEM 498. Independent Study. 2 Credits.

An opportunity is afforded students to undertake independent study or an original investigation under the direction of a faculty member. Prerequisites: course background appropriate to the proposed study project and approval of the department chair and the faculty/research advisor.

CHEM 499. Senior Thesis II. 2 Credits.

Continuation of CHEM 490. The research culminates in a thesis that includes a literature review, description of methods, results and conclusions, and an oral presentation. Prerequisite: CHEM 490 and a cumulative GPA of 3.20 or better.