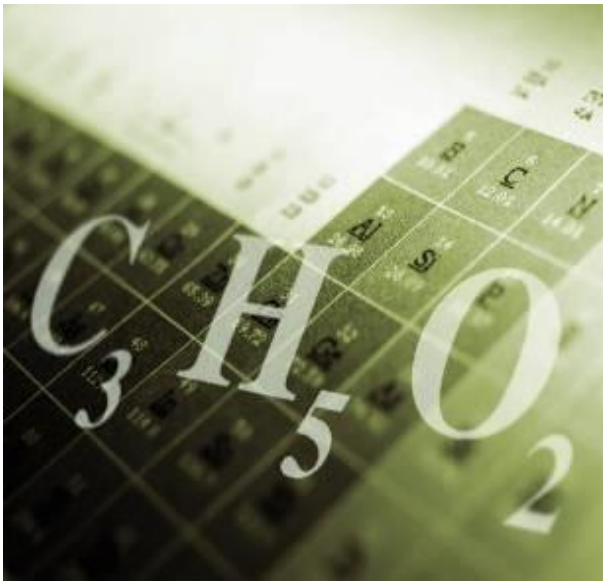
Binghamton University

Department of Chemistry

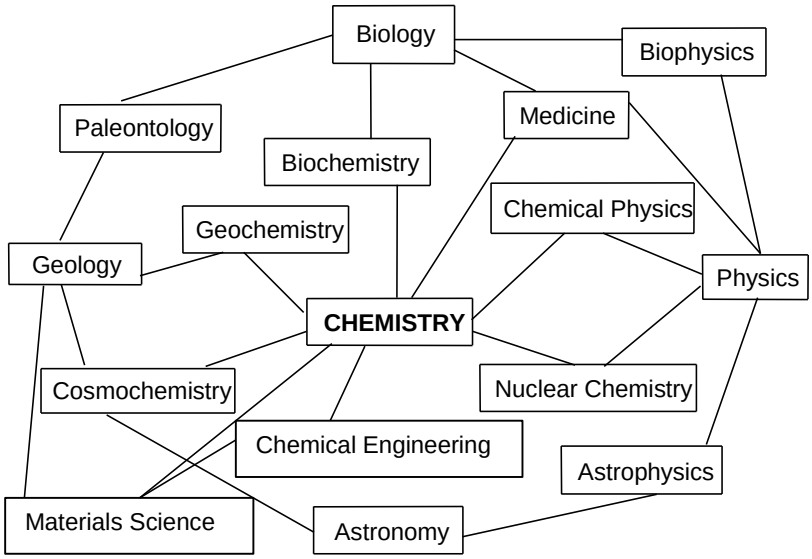



# Undergraduate Student Handbook

2023 -2024

*Revised 6-23*

# WHAT IS CHEMISTRY?




*CHEMISTRY. THE CENTRAL SCIENCE*

Chemistry is the "Central Science." Such diverse subjects as art, anthropology, geology, biology, materials science, environmental science, engineering, nursing, and psychology have areas in which fundamental principles and process details are understood in terms of chemistry. Though these kindred sciences cannot be completely reduced to chemistry, it is true that in order to comprehend these sciences one must understand the appropriate principles of chemistry. This fact is recognized by the various departments and programs comprising the Division of Science and Mathematics at Harpur College. Of the 16 degrees offered in the Division, 10 require at least introductory chemistry. Some of the most significant developments in science have come at the interface between chemistry and kindred sciences. Examples of these interfacial sciences are biochemistry; molecular biology; geochemistry; materials chemistry; environmental chemistry; neurochemistry; and chemical physics.

The four traditional sub-disciplines of chemistry have had a long history – some predating the development of alchemy in the Middle Ages. The roots of **Inorganic** chemistry are in the ancient arts of metallurgy and ceramics; those of **Organic** chemistry are in the study of substances important to the domestic arts which are involved in or derived from life processes. As chemistry developed, the questions of which substances were present and in what amounts led to the emergence of **Analytical** chemistry, and the questions of quantitative measurement and prediction of the physical properties of matter became the focus of **Physical** chemistry. Other aspects of chemistry cut across these traditional divisions, e.g., electrochemistry and polymers.

Important interfaces have developed in recent years between these traditional areas and kindred sciences: biophysical chemistry, bio-organic and bio-inorganic chemistry, inorganic and organic materials chemistry (including polymers). In modern life, chemistry is involved in the rational design of drugs, the development of new materials (including the new superconductors and materials for microelectronics applications), and in dealing with environmental problems, including measurement of levels of pollutants and their elimination.

Even though most chemists specialize in organic, inorganic, analytical chemistry, physical, polymer, materials, or biological chemistry, a thorough grounding in the first four "traditional" areas is necessary for any career in chemical science. The requirements for the BA and BS chemistry majors reflect this necessity in that certain courses are required of all majors. If all chemists were trained exactly alike, chemistry would lose much of the diversity of its impact. For this reason, there is a measure of flexibility in course requirements once the basic requirements have been met. Hence the student may develop some focus within chemistry or in an interface area, even as an undergraduate. In the section which follows, the requirements for the baccalaureate degrees in chemistry are presented and discussed briefly.

# DIFFERENCES BETWEEN BA AND BS DEGREES

One of the most common questions is "Which degree should I get - a BS or a BA?" This is an important question, but also one that does not have a simple answer. Even among the Chemistry Department faculty, there is a difference of opinion. At the same time, the following guidelines may help in your decision.

1. The BA degree gives you exposure to the four main areas of Chemistry (Analytical, Inorganic, Organic, and Physical) but requires fewer courses than the BS degree. As such, it provides more opportunity to explore other areas and interests. This extra flexibility can be quite useful if your goal is admission to a graduate program or professional school outside of Chemistry (for example, Medical School, Law School, Optometry, etc.). For these career goals, a detailed knowledge of Chemistry is not as critical as the breadth of science knowledge.

2. The BS degree gives you more in-depth exposure to the core areas of Chemistry by requiring more courses. This can be of greatest help if you desire to obtain a job in the Chemical industry directly out of college. You might also want to consider the BS degree with ACS certification. There is still sufficient flexibility in the BS degree program to allow pursuit of other interests and also to focus your choice of courses toward the area(s) you find most interesting.

3. If your goal is admission to graduate school in Chemistry, then either the BS or the BA option is open, although the BS pathway will give you a greater advantage by virtue of the fact that you will have greater depth of preparation. Your choice depends entirely on what interests you and how many courses outside (and inside) of Chemistry you wish to take. The single largest factor that tends to help graduate school admissions (besides maintaining decent grades) is whether you have done independent research or not. Independent research is viewed quite favorably for admission to graduate school and will also greatly help you to get started quickly in research in graduate school.

In the final analysis, the choice of BA or BS is yours to make. Consult with your Chemistry major advisor early in your undergraduate career about which pathway would be most beneficial to you. Also, it is worth noting that you can change your mind. If you are initially pursuing a BS degree, then the change to a BA is very simple and usually results in no delays as far as graduation is concerned. Changing from a BA to a BS, on the other hand, can be simple early on, but may result in you having to spend an extra semester or two if you make the change late (junior or senior year). Remember, either the BA or the BS degree in Chemistry opens the doors to a wide range of career opportunities.

# REQUIREMENTS FOR CHEMISTRY DEGREES

The BA and BS degree programs in Chemistry share a common core set of requirements as seen in the following chart, although the BS degree is more prescriptive and has more required chemistry courses.

## CORE COURSES IN CHEMISTRY

| Sub-discipline | BA degree | Additional courses for BS degree |
|---|---|---|
| General | CHEM 111 (or 107-108) and CHEM 496 | |
| Analytical | CHEM 221 | CHEM 422 |
| Inorganic | CHEM 341 | CHEM 442, 443, 444, 445, or 484 |
| Organic | CHEM 231 and CHEM 332 | CHEM 335 |
| Physical | CHEM 351 (or for BA only, CHEM 361) | CHEM 455 and CHEM 451 |
| Math | MATH 224/225 and 226/227 | |
| Physics | PHYS 121 (or 131) and 122 (or 132) | |

Beyond the core courses the **Chemistry BA** requires 14 credits of elective courses in chemistry. Of these electives, 1½ courses (6 credit hours) must be selected from a list of laboratory courses (CHEM 335, 422, 445, 455, 462, and 497/498). The other 2 electives can be any courses offered by the Chemistry Department. These courses can include CHEM 397 and CHEM 497 (independent research), although only 4 credits of CHEM 397 can count toward the BA degree. The BA degree also requires that one additional course from the Division of Science and Mathematics (for example, BIOL 113, PSYC 111, MATH 223, or another chemistry elective) be taken. If CHEM 107-108 is chosen as the introductory course, the additional course in the Division of Science and Mathematics is not required.

The **Chemistry BS** degree requirements are more specific and extensive. In addition to the BA core, this program requires *Organic Chemistry Laboratory* (CHEM 335); *Instrumental Methods* (CHEM 422); a second course in inorganic chemistry (CHEM 442, 443, 444, 445, or 484), *Quantum Chemistry and Spectroscopy* (CHEM 451), and *Physical Chemistry Laboratory* (CHEM 455). In addition to the chemistry core courses, the BS degree requires four elective courses selected from the Division of Science and Mathematics or which are professionally related. (Additional BS degrees are described later in this section)

The Chemistry Department also offers a **five-year program in Chemistry and Materials Science**. Upon completion of this program, students receive a BS in Chemistry and a MS degree in Materials Science. Students interested in this program should consult Professor Jeff Mativetsky in the Physics Department.

The Chemistry Department participates in a five-year program resulting in the combined **Chemistry BA degree and School of Education MAT degree**. Students who are interested in pursuing a high school teaching career should consider this option. Interested students should consult the Undergraduate Program Director in the Chemistry Department. For the 2023-2024 academic year the Undergraduate Program Director is Professor Clarice Kelleher.

The Chemistry Department offers two physical chemistry courses: CHEM 351 (*Physical Chemistry*) and CHEM 361 (*Biophysical Chemistry*). CHEM 351 is the required course for the Chemistry BS majors. CHEM 361 is the required course for CHEM BS with Emphasis in Biological Chemistry. Chemistry BA

majors can take either CHEM 351 or CHEM 361. CHEM 351 and 361 are both introductory physical chemistry courses covering the same subject, albeit with different emphases and examples. Therefore, students can obtain credit for only one of these courses, and if one is on their record, they cannot register for the other.

**The American Chemical Society (ACS) Certified BS** degree requires the core BS courses and either *Inorganic/Materials Chemistry Laboratory* (CHEM 445) or at least 2 credits of *Advanced Independent Research* (CHEM 497) on Inorganic or Materials chemistry areas and at least 2 addition credits of independent research (CHEM 397, 497, or 498) in any area of Chemistry. BIOL 113 and *Biochemistry* (BCHM 403) are also required for ACS certification.

**The BS with Emphasis in Materials** is targeted at those students with an interest in the area of solids, polymers, ceramics, and similar materials. This program requires four courses in the area of materials chemistry; one of these courses must be a laboratory course relevant to materials. If you are interested in this degree program, you should consult faculty associated with the Institute for Materials Research.

**The BS with Emphasis in Biological Chemistry** is a degree target at students who are interested in the chemistry of biology. This track differs from the BS degree in that it requires CHEM 361 instead of CHEM 351 and these additional courses: BIOL 113 and 115, BCHM 403, and an upper-level biologically-related chemistry elective.

## LIMITS ON GPA, GRADING OPTION AND INDEPENDENT STUDY

For students entering Fall 2014 and subsequently, the following applies: A cumulative GPA of 2.0 or better is required for all courses used to satisfy the requirements of a chemistry major. A grade of C- or better is necessary for a chemistry course to satisfy the requirements of a chemistry major.

Harpur College policy states that a student not on probation may elect to use the Pass/Fail option in a maximum of 24 hours of coursework. However, among courses used for the chemistry degree, not more than two with a grade of P may be included. The foundation courses CHEM 221, 231, 341 and 351/361 must be taken for a letter grade and cannot be taken as Pass/Fail. CHEM 496 cannot be taken as Pass/Fail.

No more than 12 credits of CHEM 397 and 497/498 may be used to satisfy the major and no more than four of these credits may be CHEM 397.

CHEM 391, Practicum in College Teaching does not count toward chemistry course credits for the major or minor. CHEM 391 credits do count toward upper Harpur College upper level credits.

## DEGREE RESIDENCY REQUIREMENTS

Residency requirement: BA students must take CHEM 496 and at least six other chemistry courses (24 credits) in the major, including at least four upper-level chemistry courses, while in residence at Binghamton University

Residency requirement: BS students must take CHEM 496 and at least seven other chemistry courses in the major, including at least five upper-level chemistry courses, while in residence at Binghamton University.

# THE TYPICAL COURSE SEQUENCE

With the type of degree and general course requirements in hand, the obvious question is "When do I need to take all of these courses?" The answer is that there is a great deal of flexibility in building a schedule leading to a degree in Chemistry. The first year, in particular, can vary a lot depending upon your background. A student with a strong high school Chemistry background and AP credit may not need to take General Chemistry (CHEM 107/108 if AP = 5; IB = 6,7 *or* CHEM 111 if AP = 4) at all and can start in Organic Chemistry (CHEM 231).

There are a number of course sequences outlined in the following charts (varying based on major and introductory chemistry options). It is important to bear in mind that not all of the upper level Chemistry courses are offered every semester. As a result, you need to plan carefully to make certain that you fulfill the prerequisites in time to take certain courses in the semester in which they are offered.

All of the required courses for the Chemistry degree are guaranteed to be offered during their scheduled semesters (*e.g.*, CHEM 351, every fall semester; CHEM 451 every spring semester). However, some of the upper level elective courses (particularly the Topics courses CHEM 481-486) might not be offered every year. The Chemistry Department has a good idea which electives will be offered by the time of pre-registration and this information can be obtained from either of the Chemistry Department offices (S2 room 226, and outside of SN 2104) You should talk with your chemistry advisor regarding course scheduling prior to registering for the coming semester's courses.

For all course sequences, Chem 104/105/106 can replace Chem 107/108 as major requirements. However, it is strongly recommended to choose the Chem 107/108 sequence, because it is targeted to Chemistry majors.

# CHEMISTRY COURSE OFFERINGS BY SEMESTER

| Course | Name | Semester offered |
|---|---|---|
| 100 | Basic Chemistry | fall |
| 101 | Introduction to Chemistry I | fall |
| 102 | Introduction to Chemistry II | spring |
| 107 | Introductory Chemistry I | fall |
| 108 | Introductory Chemistry II | spring |
| 111 | Chemical Principles | fall |
| 221 | Introduction to Analytical Chemistry | spring |
| 231 | Organic Chemistry I | fall; spring; summer term I |
| 332 | Organic Chemistry II | fall; spring; summer term II |
| 335 | Organic Chemistry Laboratory | fall; spring; summer term III |
| 341 | Inorganic Chemistry | fall |
| 351 | Introduction to Physical Chemistry | fall |
| 361 | Biophysical Chemistry | fall |
| 391 | Practicum in College Teaching | fall; spring |
| 397 | Independent Work | fall; spring; summer |
| 411 | Techniques for Studying Solids | usually every fall |
| 421 | Advanced Analytical Chemistry | spring or fall |
| 422 | Instrumental Methods of Analysis | fall |
| 431 | Physical Organic Chemistry | most falls |
| 432 | Chemical Synthesis | most springs |
| 434 | Bioorganic Chemistry | spring |
| 442 | Introduction to Physical Inorganic | alternate spring |
| 443 | Molecular Photochemistry | alternate spring |
| 444 | Chemistry of Solids | spring |
| 445 | Inorganic/Materials Chemistry Lab | usually every fall |
| 451 | Quantum Chem, Spectroscopy, Kinetics | spring |
| 454 | Computational Chemistry | usually every fall |
| 455 | Experimental Physical Chemistry | spring |
| 481 | Topics in Materials Chemistry | usually every year |
| 482 | Topics in Analytical Chemistry | usually every year |
| 483 | Topics in Organic Chemistry | usually every year |
| 484 | Topics in Inorganic Chemistry | usually every year |
| 485 | Topics in Physical Chemistry | usually every year |
| 486 | Topics in Biophysical Chemistry | occasionally |
| 496 | Senior Seminar | fall; spring |
| 497 | Advanced Independent Study | fall; spring |
| 498 | Advanced Independent Research - Honors | fall; spring |

## SAMPLE COURSE SEQUENCE FOR BA DEGREE WITH CHEM 107-108

| Year | Fall Semester | Spring Semester |
|---|---|---|
| Freshman | CHEM 107<br>MATH 224/225 | CHEM 108<br>MATH 226/227 |
| Sophomore | CHEM 231<br>PHYS 131* | CHEM 221<br>CHEM 332<br>PHYS 132* |
| Junior | CHEM 341<br>CHEM 351 or 361 | CHEM Elective<br>CHEM Elective |
| Senior | CHEM 496<br>CHEM Elective | CHEM Elective |

CHEM electives must include 1½ courses (6 credits) selected from CHEM 335, 422, 445, 455, 497/498 (these are lab courses). Additional all-college elective courses would be taken to complete a full course load.
* Physics with calculus (PHYS 131 and 132) is strongly recommended but not required (PHYS 121 and 122 can be taken instead.)

## SAMPLE COURSE SEQUENCE FOR BA DEGREE WITH CHEM 111

| Year | Fall Semester | Spring Semester |
|---|---|---|
| Freshman | CHEM 111<br>MATH 224/225 | CHEM 231<br>MATH 226/227 |
| Sophomore | CHEM 332<br>PHYS 131* | CHEM 221<br>PHYS 132* |
| Junior | CHEM 341<br>CHEM 351 or 361 | CHEM Elective<br>CHEM Elective |
| Senior | CHEM 496<br>CHEM Elective | CHEM Elective<br>Science Elective |

CHEM Electives must include 1½ courses selected from CHEM 335, 422, 445, 455, 497/498 (these are lab courses). Science Elective can be any course within the Division of Science and Mathematics (e.g., BIOL 113, PSYC 111, MATH 323 or chemistry elective). Additional all-college elective courses would be taken to complete a full course load.
*Physics with calculus (PHYS 131 and 132) is strongly recommended but not required (PHYS 121 and 122 can be taken instead.)

## SAMPLE COURSE SEQUENCE FOR BS DEGREE WITH CHEM 107-108

| Year | Fall Semester | Spring Semester |
|---|---|---|
| Freshman | CHEM 107<br>MATH 224/225 | CHEM 108<br>MATH 226/227 |
| Sophomore | CHEM 231<br>PHYS 131* | CHEM 221<br>CHEM 332<br>CHEM 335<br>PHYS 132* |
| Junior | CHEM 341<br>CHEM 351<br>CHEM 422 | CHEM 451<br>Inorganic CHEM II<br>CHEM 455 |
| Senior | CHEM 496<br>Science Elective<br>Science Elective | Science Elective<br>Science Elective |

Inorganic CHEM II can be CHEM 442, 443, 444, 445 or 484.
Science Electives can be any course within the Division of Science and Mathematics (e.g., BIOL 113, PSYC 111, MATH 323, or chemistry elective).
Additional all-college elective courses would be taken to complete a full course load.
* Calculus based physics (PHYS 131 and 132) is strongly recommended but not required (PHYS 121 and 122 can be taken instead.)

## SAMPLE COURSE SEQUENCE FOR BS DEGREE WITH CHEM 111

| Year | Fall Semester | Spring Semester |
|---|---|---|
| Freshman | CHEM 111 | CHEM 231 |
| | MATH 224/225 | MATH 226/227 |
| Sophomore | CHEM 332 | CHEM 221 |
| | CHEM 335 | Science Elective |
| | PHYS 131* | PHYS 132* |
| Junior | CHEM 341 | CHEM 451 |
| | CHEM 351 | Inorganic CHEM II |
| | CHEM 422 | CHEM 455 |
| Senior | CHEM 496 | Science Elective |
| | Science Elective | Science Elective |

Inorganic CHEM II can be CHEM 442, 443, 444, 445 or 484.

Science Electives can be any course within the Division of Science and Mathematics (e.g., BIOL 113, PSYC 111, MATH 323, or chemistry elective).

Additional all-college elective courses would be taken to complete a full course load.

*Physics with calculus (PHYS 131 and 132) is strongly recommended but not required (PHYS 121 and 122 can be taken instead.)

# SAMPLE COURSE SEQUENCE FOR ACS CERTIFIED BS DEGREE WITH CHEM 107-108

| Year | Fall Semester | Spring Semester |
|---|---|---|
| Freshman | CHEM 107 | CHEM 108 |
| | MATH 224/225 | MATH 226/227 |
| Sophomore | CHEM 231 | CHEM 221 |
| | PHYS 131* | CHEM 332 |
| | BIOL 113 | CHEM 335 |
| | | PHYS 132* |
| Junior | CHEM 341 | CHEM 451 |
| | CHEM 351 | BCHM 403 |
| | CHEM 422 | CHEM 455 |
| Senior | CHEM 496 | Science Elective |
| | Inorganic CHEM II | Lab Elective |

Inorganic CHEM II can be CHEM 442, 443, 444, or 484.

The Science Electives can be any course within the Division of Science and Mathematics (e.g., BIOL 114, PSYC 111, MATH 323, or chemistry elective).

Lab Elective can be either CHEM 445, or two credits of CHEM 497 or 498 involving inorganic chemistry and two credits of CHEM 397, 497, or 498.

Additional all-college elective courses would be taken to complete a full course load.

*Physics with calculus (PHYS 131 and 132) is strongly recommended but not required (PHYS 121 and 122 can be taken instead.)

# SAMPLE COURSE SEQUENCE FOR ACS CERTIFIED BS DEGREE WITH CHEM 111

| Year | Fall Semester | Spring Semester |
|---|---|---|
| Freshman | CHEM 111 | CHEM 231 |
| | MATH 224/225 | MATH 226/227 |
| Sophomore | CHEM 332 | CHEM 221 |
| | BIOL 113 | CHEM 335 |
| | PHYS 131* | PHYS 132* |
| Junior | CHEM 341 | CHEM 451 |
| | CHEM 351 | BCHM 302 |
| | CHEM 422 | CHEM 455 |
| Senior | CHEM 496 | Science Elective |
| | Lab Elective I | Lab Elective II |
| | Inorganic CHEM II | |

Inorganic CHEM II can be CHEM 442, 443, 444, or 484.

The Science Elective can be any course of at least two credits within the Division of Science and Mathematics (e.g., BIOL 114, PSYC 111, MATH 323, or chemistry elective).

Lab Elective I is two credits of laboratory work.

Lab Elective II can be either CHEM 445, or two credits of CHEM 497 or 498 involving inorganic chemistry and two credits of CHEM 397, 497, or 498.

Additional all-college elective courses would be taken to complete a full course load.

*Physics with calculus (PHYS 131 and 132) is strongly recommended but not required (PHYS 121 and 122 can be taken instead.)

## SAMPLE COURSE SEQUENCE FOR BS DEGREE WITH EMPHASIS IN BIOLOGICAL CHEMISTRY WITH CHEM 107-108

| Year | Fall Semester | Spring Semester |
|---|---|---|
| Freshman | CHEM 107 | CHEM 108 |
| | MATH 224/225 | MATH 226/227 |
| Sophomore | CHEM 231 | CHEM 221 |
| | PHYS 131* | CHEM 332 |
| | BIOL 113 and 115 | CHEM 335 |
| | | PHYS 132* |
| Junior | CHEM 341 | CHEM 451 |
| | CHEM 361 | CHEM 455 |
| | CHEM 422 | BCHM 403 |
| Senior | CHEM 496 | CHEM Elective |
| | Inorganic CHEM II | Science Elective |

Inorganic CHEM II can be CHEM 442, 443, 444, 445 or 484.

Science Electives can be any course within the Division of Science and Mathematics (e.g., Bio114, PSYC 111, MATH 323, or chemistry elective).

CHEM elective to be selected from a list of biologically-related chemistry courses including CHEM 434 and 485K.

Additional all-college elective courses would be taken to complete a full course load.

*Physics with calculus (PHYS 131 and 132) is strongly recommended but not required (PHYS 121 and 122 can be taken instead.)

# SAMPLE COURSE SEQUENCE FOR BS DEGREE WITH EMPHASIS IN BIOLOGICAL CHEMISTRY WITH CHEM 111

| Year | Fall Semester | Spring Semester |
|---|---|---|
| Freshman | CHEM 111 | CHEM 231 |
| | MATH 224/225 | MATH 226/227 |
| Sophomore | CHEM 332 | CHEM 221 |
| | BIOL 113 and 115 | CHEM 335 |
| | PHYS 131* | PHYS 132* |
| Junior | CHEM 341 | CHEM 451 |
| | CHEM 361 | CHEM 455 |
| | CHEM 422 | BCHM 403 |
| Senior | CHEM 496 | CHEM Elective |
| | Inorganic CHEM II | Science Elective |

Inorganic CHEM II can be CHEM 442, 443, 444, 445 or 484.
Science Electives can be any course within the Division of Science and Mathematics (e.g., BIOL 114, PSYC 111, MATH 323, or chemistry elective).
CHEM elective to be selected from a list of biologically-related chemistry including CHEM 434 and 485K.
Additional all-college elective courses would be taken to complete a full course load.
*Physics with calculus (PHYS 131 and 132) is strongly recommended but not required (PHYS 121 and 122 can be taken instead.)

# SAMPLE COURSE SEQUENCE FOR BS DEGREE WITH EMPHASIS IN MATERIALS CHEMISTRY

| Year | Fall Semester | Spring Semester |
|---|---|---|
| Freshman | CHEM 111 | CHEM 231 |
| | MATH 224/225 | MATH 226/227 |
| Sophomore | CHEM 332 | CHEM 221 |
| | CHEM 335 | Science Elective |
| | PHYS 131* | PHYS 132* |
| Junior | CHEM 341 | CHEM 451 |
| | CHEM 351 | CHEM 444 |
| | CHEM 422 | Materials Lab** |
| Senior | CHEM 496 | Materials Elective |
| | Materials Elective | CHEM 455 |

*Physics with calculus (PHYS 131 and 132) is strongly recommended but not required (PHYS 121 and 122 can be taken instead.)

**Materials laboratory can be CHEM 445 OR CHEM 497/498

# Chemistry Minor

## CHEMISTRY MINOR REQUIREMENTS

Requirements for the minor are:

- CHEM 107 and 108;
- 16 credits of chemistry courses CHEM 200 or above. At least 8 credits must be numbered 300 or above.

No more than two credits of CHEM 397, 497 or 498 may be used to satisfy the minor. Chemistry minor students must take four chemistry courses (16 credits) in the minor with at least 8 credits upper-level (CHEM 300 or above) chemistry courses, in residence at Binghamton University.

CHEM 111 may be substituted for CHEM 107-108. If this substitution is made, an additional chemistry course (4 credits) numbered 200 or above is required. Only courses that fulfill the chemistry major requirements may be used to fulfill the chemistry minor requirements. Keep in mind that the chemistry courses 200 and above taken to satisfy the minor must be different from chemistry courses used to fulfill a student's major requirement, For example, a student earning a Biology degree cannot use CHEM 231 and CHEM 332 to satisfy the chemistry minor, but a Philosophy major can use those courses to satisfy the minor. Among the courses for the chemistry minor, no more than one with a grade of Pass may be included.

## OTHER USEFUL INFORMATION

**AP Credit** - Binghamton University recognizes good performance on the Advanced Placement (AP) exam in Chemistry. For a score of 5 on this exam, Binghamton University gives 8 credits of CHEM 107/108, thereby fulfilling the General Chemistry requirement. For a score of 4, the Chemistry Department will grant credit for CHEM 111, CHEM 107, CHEM 104 or unspecified chemistry credit. The assignment of credit will be made after a student consults a chemistry advisor. For a score of 3, 4 credits equivalent to CHEM 101 is awarded, which can be counted toward the number of credits required for graduation, but does not count toward the Chemistry major.

**Pre-Health Curriculum** - Most students interested in a health career major in one of the sciences. Chemistry students interested in Pre-Health Curriculum should choose the CHEM 107/108 or 104/105/106 sequences. For those who major in Chemistry, all of the science requirements are fulfilled with the exception of two courses in Biology - BIOL 117 and 118. Fortunately, these courses can be used to fulfill the science elective requirements of the BS degree. Students interested in a pre-health curriculum should contact the Pre-Health Advisor in the Harpur College Advising office.

## WHAT IF I DECIDE TO BECOME A CHEMISTRY MAJOR LATE?

A lot of students do not know what major they want to choose right away and take a general mix of courses in the first couple of semesters. That works fine for the Chemistry major, provided that General Chemistry, Organic Chemistry, MATH and Physics have been taken in the first couple of years. Fortunately, these are the same basic requirements for majoring in a number of the sciences so there is still a lot of room for changing majors in the first two years without much problem.

If you have not completed all of those courses by the end of your sophomore year, Summer school is the ideal way to catch up. At Binghamton University, General Chemistry, Organic Chemistry, Physics, and Calculus are all offered during the summer. You can also take these courses at another college or university over the summer as well. If you take courses outside of BU, you must fill out the appropriate Binghamton University transfer credit form before you take courses at the other college or university. This will require a copy of the catalog description of the course that you wish to take and an approval from instructor who teaches the course at Binghamton.

## THE WRITING REQUIREMENT

To obtain a baccalaureate degree at Harpur College, you must complete the writing requirement. Courses satisfying this requirement are designated composition (C) or writing (W). The requirement can be satisfied by any of the following three combinations: 2 C and 3 W courses, 3 C and 1 W courses, or 4 C courses. The Chemistry Department offers several courses that can be used to satisfy the writing requirement as seen in the following table. Although it is possible to satisfy the writing requirement by using all Chemistry courses, this is not necessarily the best option since the Chemistry courses are all upper level courses that would normally be taken as a junior or senior. To obtain early instruction in writing (and to avoid delays in graduation), it is wise to take some writing (W or C) courses early in your career at Binghamton University.

# WRITING COURSES
# OFFERED BY THE CHEMISTRY DEPARTMENT

| Course | Name | Writing Requirement | Chemistry requirement |
|---|---|---|---|
| CHEM 422 | Instrumental Methods of Analysis | C | Required for BS; elective for BA |
| CHEM 445 | Inorganic/Materials Lab | C | Elective for BS and BA |
| CHEM 455 | Physical Chemistry Lab | C | Required for BS; elective for BA |
| CHEM 496 | Senior Seminar | O, W | Required for BS and BA |

# INDEPENDENT STUDY AND HONORS

There is another exciting aspect to pursuing a degree in Chemistry that many students find the most interesting and satisfying part of their studies - independent research. There are three courses that fall into this category - CHEM 397, 497, and 498. In any of these courses, you will be working directly in the research group of one faculty member on a real research project. This gives you the chance to obtain real research experience and to more fully understand what all goes into a well planned and executed series of experiments.

The details of the independent study courses in the Chemistry department are described in greater detail in another handout (The Guide to Undergraduate Research), but a few of the highlights are outlined below.

CHEM 397 - This is the typical first course for independent study and requires no advance preparation other than finding a faculty member who is doing research that you think is interesting and obtaining permission from them to do research in their group.

CHEM 497 - This is a more advanced level of independent study and requires you to have completed most or all of the core chemistry courses. Continuing to and repeating CHEM 497 requires faculty mentor permission, A written abstract of what research project you intend to pursue and what some of the key experiments will be and Approval by the Chemistry Undergraduate Program Chair. This course can be repeated several times.

CHEM 498 - This is a special independent study course for qualified students who decide (with their faculty advisor's consent) to pursue honors in Chemistry by writing and defending an honors thesis. Successful completion of these requirements will result in the honor "Distinguished Independent Work in Chemistry" being awarded.

As for what research the different faculty members in the department are pursuing, a brief guide follows, but more details can be found in the "Guide to Undergraduate Research" (https://www.binghamton.edu/chemistry/undergraduate-program/undergraduate-research.html) or on the different faculty members web sites (http://chemistry.binghamton.edu/). A maximum of 4 credits of CHEM 397 can count toward chemistry degrees, and a maximum of 12 total credits of independent study can count toward chemistry degrees.

# FACULTY AND RESEARCH INTERESTS

The following list describes briefly each faculty member's research. For a more detailed description, refer to the "Guide to Undergraduate Research" available from the department office or visit our web site at: http://chemistry.binghamton.edu/

| FACULTY MEMBER | LOCATION | PHONE | RESEARCH INTEREST |
|---|---|---|---|
| Ming An | SN 1019 | 7-3224 | Organic, bio-organic, biological, and pharmaceutical chemistry, as well as chemical biology |
| Susan L. Bane | SN 1018 | 7-2927 | Bioorganic and Biophysical Chemistry; ligand receptor mechanisms |
| Claire Besson | SN 2108 | 7-2411 | Inorganic chemistry; metal complexes with applications in molecular spintronics and separation science |
| Brian P. Callahan | SN 1047 | 7-3089 | Chemical biology of protein biogenesis and protein degradation |
| Nikolay G. Dimitrov | SN 1015 | 7-4271 | Electroanalytical Chemistry and Electrochemistry |
| Jiye (James) Fang | SN 1016 | 7-3752 | Inorganic and Materials Chemistry, Nanotechnology |
| Puja Goyal | SN 2016 | 7-4308 | Physical Chemistry |
| Christof T. Grewer | SN 1042 | 7-3250 | Biophysical Chemistry |
| Huiyuan Guo | SN 2020 | 7-4686 | Analytical, Environmental and Biochemistry |
| Jennifer Hirschi | SN 1023 | 7-4626 | Organic, Biological and Computational Chemistry |
| Alistair J. Lees | SN 2033 | 7-2362 | Inorganic Chemistry; synthesis, photophysics and photochemistry of transition metal organometallic complexes |
| Hao Liu | CE 2212 | 7-4671 | Solid-state chemistry; materials characterization; Li/Na-ion batteries |
| Julien Panetier | SN 2018 | 7-4659 | Physical Chemistry, Interests in Computational Chemistry, Artificial Photosynthesis, Electro- and Photocatalysis |
| Wei Qiang | SN 1043 | 7-2517 | Biophysical Chemistry; solid state nuclear magnetic resonance spectroscopy |
| Eriks Rozners | SN 1021 | 7-2441 | Organic, Bioorganic and Biophysical Chemistry of Carbohydrates and Nucleic Acids; Organic Synthesis and Asymmetric Catalysis |
| Sozanne R. Solmaz | SN 1045 | 7-2089 | Chemical Biology; x-ray crystallography; cancer; structures of macromolecular machines for nuclear transport and chromosome segregation |
| Minfei Su | SN 1048 | 7-3092 | Biochemistry and Structural Biology; Cryo-Electron Microscopy |
| John Swierk | SN 2034 | 7-2013 | Inorganic Chemistry; synthesis and spectroscopy of catalytic systems for photochemical energy conversion |
| Mathew J. Vetticatt | SN 1017 | 7-4825 | Organic Chemistry; reaction mechanisms, kinetic isotope effects, computational chemistry, asymmetric catalysis, drug design |
| M. Stanley Whittingham | CE 2214 | 7-4673 | Materials and Inorganic Chemistry; synthesis and properties of new materials |
| Chuan-Jian Zhong | SN 2015 | 7-4605 | Analytical Chemistry, Materials Chemistry, Electrochemistry, Nanotechnology |

# OTHER OPPORTUNITIES

Undergraduates often wish to work during the summer months on a research project in chemistry. There are several ways that this can be accomplished. A faculty member may have a grant which includes summer support for undergraduates. Typically, these openings are filled by students who have done independent research with the particular faculty member during the academic year. A second possibility for summer research is to apply to other universities to work in a research laboratory. Many universities have federally-funded programs which encourage applications nation-wide. (An easy way to learn about these opportunities is to do an internet search for REU, SURF, and SURP + the year, *e.g.* REU 2018.) A third possibility is to apply to industrial chemical companies that often have a summer internship program. Notices of summer research opportunities are also posted on department bulletin boards. The chemistry department has an active community outreach. Find out about how to participate at https://www.binghamton.edu/chemistry/outreach/index.html To get involved email: chem_outreach@binghamton.edu.

# UNDERGRADUATE CHEMICAL SOCIETY

The Undergraduate Chemical Society offers a way for interested students to become an integral part of the SUNY Binghamton Chemistry Department. One vital function of the Undergraduate Chemical Society is to represent student interests in the operation of the Department of Chemistry. The organization chooses representatives to departmental committees such as the Undergraduate Program Committee and coordinates student evaluation of faculty members who are candidates for contract renewal or tenure.

The Undergraduate Chemical Society also offers to students new to Harpur College and the Chemistry Department the experiences of upper-class members and provides an organizational structure and support that frees students to positively impact their community through outreach in chemistry and related sciences.

Finally, members of the Undergraduate Chemical Society enjoy the privileges of belonging to a chartered organization of the Student Association (SA). SA affiliation enables the Undergraduate Chemical Society to sponsor trips to industrial laboratories. You are invited to contact the club via: chemistry@binghamtonsa.org.

# THE FUTURE

## What jobs are there for someone with a Chemistry degree?

One of the attractive features of a chemistry degree is the flexibility it gives one in terms of career paths. It will allow entry into many types of graduate and professional schools, as well as provide immediate entry into an industrial position.

The major employers of BS chemists are the pharmaceutical, petroleum, and large chemical industries, as well as private laboratories and small industries. Depending upon the industry, the responsibilities of the bachelor degree chemist range from being completely independent to functioning as a technician. In general, regulated industries such as pharmaceuticals will utilize Ph.D. chemists as group leaders, heading teams of 3-10 BS, MS and PhD chemists on specific projects. In such industries, your career path to management will be limited without a PhD. The jobs available can be extremely challenging. You will often learn entirely new skills, and utilize specialized state of the art instrumentation.

Another major career path for baccalaureate chemists is sales and marketing. The size of the instrumentation, chemicals, and supplies market is very large. In these jobs, a BS or BA degree will not limit your career path.

The job market for BS or BA chemists is excellent. There is currently a shortage of good BS and BA chemists, and that this situation will continue into the foreseeable future. The unemployment rate for chemists of all types tends to be well under the national average.

In terms of finding a job, there are a few good resources that are readily available. One is *Chemical and Engineering News* (C&EN). In every issue (weekly), there are a number of job advertisements in the back section. A second source of information about jobs is your Chemistry advisor or any other faculty member. The Chemistry Department also maintains a bulletin board posting of current job openings. Finally, this University also has an excellent Career Development Center (LSG-500, Ext. 7-2191) which can help you in your search as well as in preparation of a resume and interview training.

Summer employment during your sophomore or junior years is also an excellent way to gain experience, and to develop a relationship with a potential employer. If you are from the metropolitan NY/NJ area, you should be aware that there are numerous summer job positions in major pharmaceutical companies. Even in the Binghamton area, many potential opportunities exist, such as Proctor & Gamble, Norwich, several private laboratories, NYSEG and others. One of the best sources of information on such jobs is through your professors, who often have professional contacts with other scientists in various industries. These summer jobs often lead to permanent employment.

## What about graduate school?

If you've had four years of undergraduate school, perhaps the last thing you want to do is start all over again and commit yourself to graduate school. At the same time, your opportunity for advancement is limited with a BA or BS, so you will want to decide if you will be doing chemistry as a profession for a number of years and how high you wish to go. If you love the field and want to advance beyond the bench, then why not continue to learn in graduate school, do truly independent research, and be paid for studying at the same time?

That's right. In the sciences, you are in the enviable position that graduate school will usually be "free." Almost invariably, you will be offered a stipend, ranging from about $15,000 to $25,000 per year (plus a tuition waiver) for a Teaching Assistantship (TA) or for a Research Assistantship (RA). Most universities

will support a graduate student for up to four years, usually as a TA. However, typically you will join a research group by your second year, and if the group is well funded, you will be supported by an RA through a grant and be able to work full time on your research without the teaching responsibilities. In addition, there are usually fellowships available, through the university or through agencies like the National Science Foundation (NSF), although some fellowships like the NSF fellowships are very competitive.

The average time required to obtain an MS degree should be two years. A Ph.D. usually takes about five years.

## Selecting a graduate school

You have more control (and responsibility) over the direction of your graduate career than you did with your BS or BA degree. Probably the most important decision you will make will be to select your research advisor. A graduate degree is much like an apprenticeship, and the research group you choose will influence your career for many years. However, there is no crystal ball to help you select the school and the group where you wish to pursue your degree. Some people know exactly what area of specialization they wish to pursue, perhaps by undergraduate research in a given area. If so, selecting a graduate school will be easier, since various universities tend to have strengths in the various fields. If you are not sure of your specific interests (like most people) you should at least be able to narrow your interests to broad areas like organic, inorganic, physical, analytical chemistry or some interdisciplinary area such as nanotechnology or environmental chemistry. Selecting a school with a strong representation in any of these areas is much easier, and can usually be narrowed to two to three good choices. A good source of information on graduate departments is the *ACS Directory of Graduate Research*. Talk to your professors, who can help guide you in matching your personality and interests to those of the departments you are considering.

## How does one apply to graduate school?

The procedure is similar to applying to an undergraduate school. Scores from a Graduate Record Exam (GRE), consisting of Verbal, Quantitative and Specialized sections, will usually be required, along with the admissions application (it is best to have these GRE exams completed by October of the year prior to the fall your expected admission). The career development office can assist you in locating where and when GRE's will be given. Given the paucity of undergraduates wanting to attend graduate school in chemistry, you may be given an all-expense-paid trip to visit the graduate school, once you have been accepted. You should also talk to the professors in the department who do research in areas that match your interests.

The criteria for acceptance to graduate school vary. Your undergraduate record, consisting of courses taken, grades, undergraduate research, extracurricular activities, etc., weighted by the general strength of your school, will be a strong consideration. A second consideration will be your GRE scores. Finally, letters of recommendation count very strongly. The admissions committee will be looking not only for strong grades. They will also try to determine your motivation and perseverance, since these qualities, probably as much or more so than academic skills, will determine your success both in graduate school and in your career.

# Combined Awards (4 + 1) Programs in Chemistry

The 4+1 programs are designed for outstanding students who wish to combine a Bachelor of Science/Arts degree in Chemistry with a Master's degree in Chemistry. The combined program allows students who are interested in a Master's degree to complete two separate degrees in five years, saving time and tuition. This is achieved by completing graduate courses already in the senior year of undergraduate studies.

## 4+1 Programs in Chemistry offered at Binghamton University

- BA/BS Chemistry + MA/MS Chemistry
- BS Chemistry + MS Materials Science and Engineering

## You should consider the 4+1 program if

- you are interested in a career in industry with experience and qualifications in addition to bachelor degree, but you do not want to commit to a PhD degree.
- you want to determine whether research, eventually pursuing a PhD degree, is the right career choice for you.
- you want to increase preparation for Medical School, for example to increase your GPA or to gain more experience.
- you want to achieve a career in teaching, for example in High School, for which Masters degrees make applicants more competitive.

## How does it work?

- You start on a regular track to the Chemistry BS/BA degree for the first three years. In your junior year, you declare your interest in the 4+1 program to the Chemistry Department. The form for application can be found at the Chemistry department website (https://www.binghamton.edu/chemistry/4-plus-1/application-form-4-1-program.pdf). In your senior year (in late fall or early spring), you will **formally apply** for the program via **BU Brain**, choosing "Accelerated Degree Application for Admission". If accepted, you must confirm your intent to enroll in Slate (look for reminder emails about this!). Note: 4+1 students do not have to pay an enrollment deposit. Once you are accepted into the graduate program, and you have completed your Bachelor degree, you take graduate courses and perform graduate research in year five. The MA degree is the non-thesis option with more coursework, the MS degree requires submission and defense of a MS thesis. Sample course sequences will be available in the Undergraduate Student Handbook and on the Chemistry department website.

## The importance of research

- To complete the combined degree track within five years, it is important to begin undergraduate research (independent study) as soon as possible. In fact, experience in undergraduate research will be strongly recommended when you declare your interest in the program to the Chemistry Department. To do that and to apply formally to the program find the downloadable application from at the Chemistry department website (https://www.binghamton.edu/chemistry/4-plus-1/application-form-4-1-program.pdf).

# FAQs for 4 + 1 Programs in Chemistry

## Junior Year

- **Do I need an advisor in the Chemistry department?**
  - Yes
- **For the 4+1 MS degree, should I be enrolled in independent study (research), with a project underway during my junior year?**
  - Ideally, yes. However, it is not mandatory.
- **How many courses should I have completed by the end of my junior year to be eligible?**
  - There is no exact requirement that defines eligibility as the progress to degree of each student often varies. At the same time we generally recommend for successful applicants to have complete most of the core courses in the undergraduate chemistry curriculum like Chemistry 107 & 108, 221, 231, 332, 341, 351 or 361, Mathematics 224 & 226, and Physics 131 & 132,. For students pursuing combined BS + either MA or MS degrees we recommend to have complete also Chemistry 422, 451, 455, and Inorganic Chemistry II (one of 442, 443, 444, 445, or 484).
- **Is there a process for "declaring interest" in the program during the junior year?**
  - Yes. There is a special application form that needs to be filled in and signed by the student and by the student's advisor. You can find the form at the following link:

    https://www.binghamton.edu/chemistry/4-plus-1/application-form-4-1-program.pdf

    You should also contact the undergraduate program director, Dr. Christof Grewer. The completed form needs to be submitted to Dr. Julien Panetier, Director of Graduate Admissions, panetier@binghamton.edu.
- **What is the role of my advisor in this process? Should I have a letter from my advisor *during the junior year* that (a) attests to the student's qualifications (b) commits to serving as MS/MA advisor?**
  - The application process requires only an advisor from the Department of Chemistry to be chosen at the time of application and then the advisor to support the application by signing the form (https://www.binghamton.edu/chemistry/4-plus-1/application-form-4-1-program.pdf). No other formal letter is required at this point.

## Senior Year

- **Can I start taking graduate level classes in Chemistry as a Senior?**
  - Undergraduate students who are within eight credits of graduation may register for up to two graduate-level courses and receive graduate credit, provided that the graduate courses are not used to fulfill an undergraduate degree requirement.

### ➢ How do I formally apply during my senior year?

- The formal application takes place at the end of the senior year but is highly recommended to apply by the end of the first semester of the senior year. The application is submitted to the Graduate School through the standard application means (please, refer to the guidelines for formal application for an MA or MS degree: https://www.binghamton.edu/apps/academics/program/gd/chemistry).

### ➢ What is the deadline for formally applying during my senior year?

- The deadline is the end of the senior year.

### ➢ Is the GRE required?

- The only requirement is GPA of 3.2 or better. GRE is not required for Binghamton University Chemistry majors.

### ➢ Are letters of recommendation required?

- Yes, two letters are required, one of which should be from the advisor.

## Student Statistics

When choosing which of the 64 Harpur college degree programs is suitable for your particular interests, you may want to consider what other students in the chemistry degree program have done.
Over a recent three-year period, graduating seniors have been accepted into doctoral programs in chemistry and material chemistry at the following institutions: Binghamton University, Georgia Institute of Technology and the University of California. Some of the graduating seniors are on a Master's program at the School of Education, University of Buffalo (IMS at Roswell Park Cancer Institute), Stony Brook University (MAT Sec. Ed. Chemistry) and interdisciplinary master's program at Buffalo University.

A third of the graduating seniors have been accepted into the following school of medicine and health-related fields: SUNY-Stony Brook University SDM, SUNY-Buffalo SDM, New York University SDM, Temple University SDM, New York Institute of Technology, Ross University, St. Georges University, University of Medicine and Health Sciences (UMHS), Rochester Institute of Technology, Hofstra University, University of California at Berkley, Long Island Pharmacy School, Adelphi University, Cleveland Chiropractic College in Los Angeles and the Southern California University of Health Sciences. The fields of specialization range from, doctoral degree in pharmacy at Long Island University, D.D.S. degree, at SUNY-Buffalo, Stony Brook University (dental), Boston University (dental), New York Institute of Technology (medical), University of Pennsylvania (dental) and the University of Massachusetts at Boston (dental). One student participated in a chemistry internship over the summer at the Oakridge National Lab. A student who graduated three years ago works as a biochemist in an industry.

*This Handbook was written by the Chemistry Department Undergraduate Program Committee (UPC) in 1992 and revised by the UPC in June of 2023.*