ine the ways that Revelation, the sacramental life, and the teachings of the Church call Catholics to seek holiness and to witness to their faith in the world. Specific topics may include social and economic justice, politics and public policy, lay and religious apostolates, education, and marriage and family. Course material may include sources from philosophy, theology, history, economics, and political science.
Prerequisite: CATH 101 and Junior standing

**CATH 483, 484 Seminar (2 credits)**
**CATH 485, 486 Seminar (4 credits)**
See the description of these courses at the beginning of the "Curricula" section of this catalog.

**CATH 487, 488 Topics (2 credits)**
**CATH 489, 490 Topics (4 credits)**
The subject matter of these courses will vary from year to year, but will not duplicate existing courses. Descriptions of these courses are available in the Searchable Class Schedule on Murphy Online,
https://banner.stthomas.edu/pls/banner/prod/bwckschd.

**CATH 491, 492 Research (2 credits)**
**CATH 493, 494 Research (4 credits)**
See the description of these courses at the beginning of the "Curricula" section of this catalog.

**CATH 495, 496 Individual Study (2 credits)**
CATH 497, 498 Individual Study (4 credits)
See the description of these courses at the beginning of the "Curricula" section of this catalog.



## Chemistry (CHEM)

College of Arts and Sciences, Department of Chemistry
O'Shaughnessy Science Hall (OSS) 402, (651) 962-5575
Brom (chair), Borgerding, Boyd, Hartshorn, Ippoliti, Mabbott, Marsh, Ojala , Olson, Wammer; Cain, Krueger

The Department of Chemistry offers two degree programs in the field of chemistry: a Bachelor of Science (B.S.) degree and a Bachelor of Arts (B.A.) degree. The department is accredited by the American Chemical Society (ACS) for the professional training of chemists, and the B.S. degree is certified by the American Chemical Society. The B.S. has either a chemistry or a biochemistry concentration option. This degree is recommended for students who plan to pursue graduate study in chemistry in preparation for college teaching or advanced research in academic, industrial or government laboratories. The B.S. degree is also an advantage to those students who choose to work as a professional chemist in industry immediately following graduation.

The B.A. degree requires fewer chemistry courses and offers the possibility of completing a double major if students have a strong interest in another field. Both degrees offer some latitude in the selection of upper level courses, thus providing the student with flexibility to pursue an interest in a particular area of chemistry. Students graduating with either the B.S. or the B.A. may also qualify for departmental honors.

Students graduating with a major in chemistry will have the necessary knowledge to prepare them for a career in chemistry or for graduate school, and the confidence and skill to succeed. They will have the ability to read, comprehend, write, and speak with clarity and understanding in technical areas. They will constantly apply critical thinking to their readings in the technical literature. They will have developed good laboratory skills and be familiar with modern instrumentation and with the use of computers in technical fields. They will have developed the skills necessary to analyze their data and to draw conclusions from it.

Chemistry is an excellent major for students interested in biochemistry, food science, forensic science, medicine, medicinal chemistry, dentistry, pharmaceutical chemistry, pharmacology, pharmacy, patent law, polymer science, chemical engineering, environmental science, materials science and other interdisciplinary fields. The major is also suited to students with a complementary interest in other sciences, or in computers, education, economics or business.

Students interested in teacher licensure should consider the various combinations of science education in the Department of Teacher Education in this catalog.

The Departments of Chemistry and Biology jointly offer a B.S. degree in biochemistry. The curriculum for this degree may be found under "Biochemistry" in this catalog.

All graduating senior majors are required to take an achievement test for purposes of assessment of the major and College accreditation.

In order to receive a degree in chemistry from the University of St. Thomas, transfer students must complete a minimum of sixteen credits in chemistry at the university in addition to the two-credit seminar sequence.

The department offers a number of courses for non-majors to fulfill the laboratory science component of the core curriculum.

**Graduation with Honors in Chemistry**
Students graduating with a B.A. or B.S. degree in chemistry may also qualify for departmental honors. Students interested in this designation must consult with the department chair one year (or more) prior to their graduation date. Requirements include:
1. a minimum cumulative GPA of 3.25 and a major field GPA of 3.50;

2. completion of four credits in research (CHEM 492-494); (participation in one summer of research in chemistry at St. Thomas may be applied in place of two credits; research must be completed at least one semester before graduation);
3. preparation of a written thesis in the format of the primary literature;
4. successful defense of the thesis before a panel composed of:
   - thesis director (chair of committee)
   - two additional UST chemistry faculty
   - one UST faculty member outside the chemistry department
   - one faculty member from another institution selected in consultation with the thesis adviser (while off-campus examiners are typically chemists, committee members from other disciplines such as biochemistry and physics may be employed when appropriate).
5. presentation of research at an off-campus meeting such as the Minnesota Section ACS Undergraduate Research Symposium, Minnesota Academy of Sciences, NCUR, regional ACS meeting, or national ACS meeting.
6. All requirements must be completed by April 20 for spring commencement, or early enough to allow for notification of the registrar and academic dean when graduating in another term.



## Major in Chemistry (B.S.) (ACS-certified)

CHEM 111 General Chemistry I (4 credits) *and* CHEM 112 General Chemistry II (4 credits)
*or*
CHEM 115 Accelerated General Chemistry (4 credits)

*Plus:*
CHEM 201 Organic Chemistry I (4 credits)
CHEM 202 Organic Chemistry II (4 credits)
CHEM 300 Quantitative Analysis (4 credits)
CHEM 320 Instrumental Analysis (4 credits)
CHEM 331 Chemical Thermodynamics and Reaction Dynamics (4 credits)
CHEM 332 Quantum Chemistry and Molecular Spectroscopy (4 credits)
CHEM 340 Organic Spectroscopy (2 credits)
CHEM 400 Advanced Inorganic Chemistry (4 credits)
CHEM 440 Biochemistry I (4 credits)
CHEM 481-484 Student Seminar Sequence (2 credits total)
CHEM 492 Research (2 credits) (or a summer research project sponsored by the department)

*Plus four credits from:*
CHEM 250 Organometallic Chemistry (2 credits)
CHEM 295 Topics (2 credits)
CHEM 296 Topics (2 credits)
CHEM 298 Topics (4 credits)
CHEM 391, 392 Research (1 credit each)
CHEM 420 Bioanalytical and Forensic Chemistry (2 credits)
CHEM 430 Polymer Chemistry (2 credits)
CHEM 442 Biochemistry II (4 credits)*
CHEM 488 Topics (2 credits)
CHEM 492 Research (2 credits each)
CHEM 494 Research (4 credits each)
*required for a B.S. in Chemistry with a biochemistry concentration, plus a research project in biochemistry

**Allied requirements**
MATH 113 Calculus I (4 credits) (or equivalent)
MATH 114 Calculus II (4 credits)
PHYS 111 Introduction to Classical Physics I (4 credits)
PHYS 112 Introduction to Classical Physics II (4 credits)

*Strongly recommended:*
MATH - additional courses numbered 200 or above (typically 200 and/or 240).

**Course Sequence**
All chemistry majors are advised to take General Chemistry (CHEM 111-112 or CHEM 115) and MATH 113-114 (Calculus) during the freshman year, then CHEM 201-202 and PHYS 111-112 (Introductory Physics) during the sophomore year. (Note that PHYS 109-110 is not acceptable for the chemistry major). Other sequences of math and physics are much less desirable. If necessary, MATH 113 can be started in the second semester of freshman year; then MATH 114 can be taken concurrently with PHYS 111 during first semester sophomore year.

## Major in Biochemistry (B.S.)

*See Biochemistry*

## Major in Chemistry (B.A.)

CHEM 111 General Chemistry I (4 credits) *and* CHEM 112 General Chemistry II (4 credits)
*or*
CHEM 115 Accelerated General Chemistry (4 credits)

*Plus:*
CHEM 201 Organic Chemistry I (4 credits)
CHEM 202 Organic Chemistry II (4 credits)
CHEM 300 Quantitative Analysis (4 credits)
CHEM 320 Instrumental Analysis (4 credits)
CHEM 481-484 Seminar (2 credits total)

*Plus four credits from the following:*
CHEM 331 Chemical Thermodynamics and Reaction Dynamics (4 credits)
CHEM 332 Quantum Chemistry and Molecular Spectroscopy (4 credits)

*Plus at least eight credits in courses chosen from the following list:*
CHEM 250 Organometallic Chemistry (2 credits)
CHEM 295 Topics (2 credits)
CHEM 296 Topics (2 credits)
CHEM 331 Chemical Thermodynamics and Reaction Dynamics (4 credits)
CHEM 332 Quantum Chemistry and Molecular Spectroscopy (4 credits)
CHEM 340 Organic Spectroscopy (2 credits)
CHEM 391, 392 Research (1 credit)
CHEM 400 Advanced Inorganic Chemistry (4 credits)
*Note:* CHEM 332 is a prerequisite for 400
CHEM 420 Bioanalytical and Forensic Chemistry (2 credits)
CHEM 430 Polymer Chemistry (2 credits)
CHEM 440 Biochemistry I (4 credits)
CHEM 442 Biochemistry II (4 credits)
CHEM 492 Research (2 credits each)
CHEM 494 Research (4 credits each)
*Note:* Only 4 credits of research may be applied to the degree.

**Allied requirements**
MATH 113 Calculus I (4 credits) *and* MATH 114 Calculus II (4 credits)*
PHYS 111 Introductory Physics I (4 credits) *and* PHYS 112 Introductory Physics II (4 credits)
*Students not placing into MATH 113 must take MATH 108, 109 and 114 in order to satisfy the overall calculus requirement.
*Note:* Math and physics requirements are specified above. MATH 200 and/or 240 are highly recommended.

## Teacher Licensure

Elementary Education with a Co-major in Science and Mathematics for Elementary Education
Elementary Education with a Specialty in Science (5-8)
Co-major in Science (5-8) – Chemistry (9-12) and a Co-major in Secondary Education
*See Education*

## Minor in Chemistry

A minor in chemistry shall consist of 24 credits in chemistry courses. A minimum of 8 credits in chemistry must be successfully completed at St. Thomas to earn a minor in the field.
CHEM 111 General Chemistry I (4 credits) *and* CHEM 112 General Chemistry II (4 credits)
*or*
CHEM 115 Accelerated General Chemistry (4 credits)

*Plus:*
CHEM 201 Organic Chemistry I (4 credits)

*Plus sufficient credits from the following to yield a total of 24:*
*Note:* Some of these courses have prerequisites beyond the core, or require permission of the instructor.
CHEM 202 Organic Chemistry II (4 credits)
CHEM 250 Organometallic Chemistry (2 credits)
CHEM 295 Topics (2 credits)
CHEM 296 Topics (2 credits)
CHEM 298 Topics (4 credits)
CHEM 300 Quantitative Analysis (4 credits)
CHEM 320 Instrumental Analysis (4 credits)
CHEM 331 Chemical Thermodynamics and Reaction Dynamics (4 credits)
CHEM 332 Quantum Chemistry and Molecular Spectroscopy (4 credits)

CHEM 340 Organic Spectroscopy (2 credits)
CHEM 420 Bioanalytical and Forensic Chemistry (2 credits)
CHEM 430 Polymer Chemistry (2 credits)
CHEM 440 Biochemistry I (4 credits)
CHEM 442 Biochemistry II (4 credits)
CHEM 492 Research (2 credits each)
CHEM 494 Research (4 credits each)*

*A student may take four credits of research for the minor with the approval of the department chair. No special approval is needed for CHEM 492 (2 credits).

**CHEM 100 Chemistry in Our World (4 credits) (CHEM 101)**
An introduction to chemistry and its applications to modern society and personal life. The course is intended for non-majors and satisfies a general requirement for one semester of a laboratory science course. The chemistry studied includes the structure of matter, elements and compounds, chemical bonding, reactions, energy changes and an introduction to organic chemistry. The emphasis in the course is the relevance of chemistry to everyday life, and the applications studied will include various topics such as environmental problems, energy resources, chemistry and health, and consumer chemistry. Lecture plus three laboratory hours per week. This course fulfills the core-area in natural science in the Natural Science and Mathematical and Quantitative Reasoning requirement in the core curriculum for non-majors. Offered fall semester and summer (when enrollment allows).
NOTE: Students who receive credit for CHEM 100 may not receive credit for CHEM 101.



**CHEM 101 Environmental Chemistry (4 credits) (CHEM 100)**
An introduction to chemistry with particular emphasis on environmental science. Basic chemistry topics covered include the structure of matter, elements, compounds, reactions, energy and energy changes. These fundamentals lead to the study of currently relevant environmental problems and their proposed solutions, for example the depletion of ozone in the stratosphere, global warming, acid rain, smog, water pollution, and the study of energy resources. Lecture plus three laboratory hours per week. This course fulfills the core-area in natural science in the Natural Science and Mathematical and Quantitative Reasoning requirement in the core curriculum for non-majors. Offered spring semester.
NOTE: Students who receive credit for CHEM 101 may not receive credit for CHEM 100.

**CHEM 111 General Chemistry I (4 credits) (CHEM 100, 101, 115)**
This course, together with CHEM 112, provides a two-semester introduction to chemistry. Topics include atomic structure, molecular structure, chemical bonding, the periodic table, states of matter, reaction types, stoichiometry, thermochemistry, intermolecular forces, and properties of the common elements and their ions in aqueous solution. Lecture plus four laboratory hours per week. This course fulfills the core-area in natural science in the Natural Science and Mathematical and Quantitative Reasoning requirement in the core curriculum. Offered fall and spring semesters.
Prerequisite: Math placement at 108 or above
NOTE: Students who receive credit for CHEM 111 may not receive credit for CHEM 100, 101, or 115.

**CHEM 112 General Chemistry II (4 credits) (CHEM 115)**
This course continues the study of chemistry begun in 111. Topics include thermodynamics, kinetics, equilibrium, acid-base chemistry, electrochemistry, and nuclear chemistry. Lecture plus four laboratory hours per week. This course fulfills the core-area in natural science in the Natural Science and Mathematical and Quantitative Reasoning requirement in the core curriculum. Offered spring semester and summer (when enrollment allows).
Prerequisite: A minimum grade of C- in CHEM 111
NOTE: Students who receive credit for CHEM 112 may not receive credit for CHEM 115.

**CHEM 115 Accelerated General Chemistry (4 credits) (CHEM 100, 101, 111, 112)**
A one semester general chemistry class that blends significant topics from CHEM 111 and 112 for very strong students interested in majoring in science or engineering. Approximately one-third of the course content is drawn from CHEM 111 with the balance coming from CHEM 112. Topics include atomic theory, stoichiometry, gas laws, phases of matter, atomic and molecular structure, bonding, kinetics, thermodynamics, equilibrium, electrochemistry, nuclear chemistry, and descriptive chemistry. Lecture plus four laboratory hours per week. This course fulfills the core-area in natural science in the Natural Science and Mathematical and Quantitative Reasoning requirement in the core curriculum. Offered fall semester.
Prerequisite: Math placement at the 113 level, high school chemistry, and satisfactory performance on the chemistry placement examination.
NOTE: Students who receive credit for CHEM 115 may not receive credit for CHEM 100, 101, 111, or 112.

**CHEM 201 Organic Chemistry I (4 credits)**
Study of the various families of organic compounds. Emphasis is placed on structure determination, reaction mechanisms, stereochemistry and spectroscopy in addition to a survey of various reaction types. An introduction to biochemical topics is included. Lecture plus four laboratory hours per week. Offered fall semester.
Prerequisite: A minimum grade of C- in CHEM 112 or 115

**CHEM 202 Organic Chemistry II (4 credits)**
Continuation of 201. Offered spring semester.
Prerequisite: A minimum grade of C- in CHEM 201

**CHEM 250 Organometallic Chemistry (2 credits)**
A study of the structure, bonding, and reactions of compounds that contain direct metal-carbon bonds. Emphasis is placed on the role these compounds play as stoichiometric and catalytic reagents in organic and inorganic synthesis. Additional topics include electronic and structural theory, reaction mechanisms, and the role of organometallics in biochemistry and material science. Offered alternate January terms.
Prerequisite: CHEM 201

**CHEM 295, 296 Topics (2 credits)**
**CHEM 297, 298 Topics (4 credits)**
The subject matter of these courses will vary from year to year, but will not duplicate existing courses. Descriptions of these courses are available in the Searchable Class Schedule on Murphy Online,
https://banner.stthomas.edu/pls/banner/prod/bwckschd.

**CHEM 300 Quantitative Analysis (4 credits)**
An introduction to quantitative chemical analysis. Topics include sample treatment, the statistical handling of data, equilibria governing acid/base chemistry and complex formation, and fundamentals underlying measurements using the following techniques: titrimetry (using acid/base, complexation and redox reactions), spectrophotometry (atomic absorption and emission spectroscopy and molecular absorption spectroscopy), and analytical separations (GC, HPLC, and capillary electrophoresis). Lecture plus four laboratory hours per week. This course fulfills the second-level Computer Competency requirement in the core curriculum. Offered fall and spring semesters.
Prerequisite: A minimum grade of C- in CHEM 112 or 115

**CHEM 320 Instrumental Analysis (4 credits)**
Principles and techniques of operation of modern chemical instrumentation not covered in CHEM 300. Topics include the capabilities, limitations and data interpretation of advanced optical spectroscopies (luminescence, Raman, etc.), voltammetry, potentiometry, differential scanning calorimetry, thermal gravimetric analysis and mass spectrometry. Fundamentals of signal processing, basic circuitry and optical components are also included. The laboratory consists of both structured exercises and a student designed project and report based on an industrial problem or on an analysis problem of interest to the student. Lecture plus four hours of lab each week. Offered spring semester.
Prerequisites: CHEM 202, 300

**CHEM 331 Chemical Thermodynamics and Reaction Dynamics (4 credits)**
Physical chemical introduction to the fundamentals of kinetic-molecular theory, statistical thermodynamics, classical thermodynamics, and chemical reaction dynamics. Emphasis on the in-depth study of chemical reaction equilibria, phase equilibria, and chemical reaction kinetics in gaseous, liquid and solid systems. Laboratory work involves modern computational methods in physical chemistry, as well as physicochemical measurements related to thermodynamics and reaction dynamics. Lecture plus six laboratory hours per week. This course fulfills the second level Computer Competency requirement in the core curriculum. Offered fall semester.
Prerequisites: CHEM 202, MATH 114 and PHYS 111

**CHEM 332 Quantum Chemistry and Molecular Spectroscopy (4 credits)**
Study of chemical systems from the point of view of molecular theory. Introduction to the fundamentals of quantum chemistry and atomic/molecular spectroscopy. Laboratory work involves computational methods in molecular quantum mechanics and spectroscopic measurements of atomic/molecular systems. Lecture plus six laboratory hours per week. This course fulfills the second level Computer Competency requirement in the core curriculum. Offered spring semester.
Prerequisites: CHEM 202, MATH 114 and PHYS 112

**CHEM 340 Organic Spectroscopy (2 credits)**
A more detailed study of various spectroscopic methods, especially as they are employed to determine structures of organic molecules. Coverage includes H-1, F-19, and C-13 NMR, mass spectrometry, ultraviolet and visible and infrared spectroscopies. Offered spring semester.
Prerequisite: A minimum grade of C- in CHEM 202

**CHEM 391 Research (1 credit)**
Work on a problem under the direction of the staff. Primarily literature work.
Prerequisite: Permission of the department chair

**CHEM 392 Research (1 credit)**
Work on a problem under the direction of the staff. Primarily laboratory work.
Prerequisite: CHEM 391

**CHEM 400 Advanced Inorganic Chemistry (4 credits)**
A study of the preparation, structure, bonding and reactions of inorganic compounds. Selected topics include group theory, periodicity, catalysis, bonding theories; main group, coordination, solid state and organometallic chemistry.

Lecture plus four laboratory hours per week. Offered fall semester.
Prerequisites: CHEM 202 and 332 or permission of the instructor

**CHEM 420 Bioanalytical and Forensic Chemistry (2 credits)**
The chemistry behind criminal investigations as well as some developments in analysis of biologically important molecules. Topics to be covered include enzyme and DNA analysis, mass spectrometry and spectral interpretation, the detection and identification of explosives and fire accelerants, methods of connecting the suspect to the scene of a crime (analysis of fingerprints, fibers, glass fragments, soil and gunshot residue), the analysis of drugs and poisons, and the detection of forgeries using ink, paint and materials analysis. The course is designed to have a lab component that uses both instrumental and "wet chemical" methods of analysis. Offered alternate January terms.
Prerequisite: CHEM 201

**CHEM 430 Polymer Chemistry (2 credits)**
An introduction to the science associated with polymers accomplished by discussing some of the fundamental aspects of polymer science and engineering. Three general subject areas will be addressed: 1) polymer synthesis and characterization, 2) polymer structure including melt, glassy, semicrystalline, rubbery, and solution states, and 3) selected physical properties (e.g. viscoelasticity, toughness, failure, permeability) and processing characteristics. Offered spring semester every other year.
Prerequisite: CHEM 202



**CHEM 440 Biochemistry I (4 credits)**
The first course in a two-semester sequence examining the chemistry underlying biological processes. The topics addressed include a review of the properties of aqueous solutions and buffers; the structure and function of proteins, carbohydrates and lipids; an introduction to the properties, reaction kinetics and catalytic mechanism of enzymes; membrane structure and function; qualitative and quantitative models of bioenergetics; and an introduction to metabolic regulation and control featuring carbohydrate metabolism as well as the citric acid cycle. Lecture plus four laboratory hours per week. Offered fall semester.
Prerequisite: A minimum grade of C- in CHEM 202

**CHEM 442 Biochemistry II (4 credits)**
The second course in a two-semester sequence examining the chemistry underlying biological processes. Topics include a continued investigation of bioenergetics focusing on oxidative phosphorylation and photophosphorylation; fatty acid metabolism; amino acid metabolism; nucleotide synthesis; mechanisms and regulation of gene expression; protein synthesis; and methods in genetic engineering. Lecture plus four laboratory hours per week. Offered spring semester.
Prerequisite: A minimum grade of C- in CHEM 440

**CHEM 475, 476 Experiential Learning (2 credits)**
**CHEM 477, 478 Experiential Learning (4 credits)**
See the description of these courses at the beginning of the "Curricula" section of this catalog.

**CHEM 481, 484 Student Seminar (1 credit)**
**CHEM 482, 483 Student Seminar (0 credit)**
This sequence of courses begins in the fall semester of the junior year and progresses for a total of four semesters. The first (CHEM 481) and last (CHEM 484) courses are each one credit and are graded on the usual letter grade scale. The interior two courses (CHEM 482, 483) are zero credit and are graded on a pass-fail basis (S/R). Seminars are presented by guest speakers, St. Thomas faculty, and St. Thomas students throughout all four courses. In CHEM 481, juniors are introduced to the chemical literature, literature search techniques including use of computer databases, and write a short paper based on literature research. In CHEM 483 seniors meet in small groups with faculty and discuss articles from the current literature. In CHEM 484, seniors research a topic from the chemical literature and present it in both written and oral formats. Information about career opportunities for students holding a chemistry degree is presented throughout the seminar sequence. Required of all chemistry majors. CHEM 481 and 483 are offered fall semester. CHEM 482 and 484 are offered spring semester.

**CHEM 487, 488 Topics (2 credits)**
**CHEM 489, 490 Topics (4 credits)**
The subject matter of these courses will vary from year to year, but will not duplicate existing courses. Descriptions of these courses are available in the Searchable Class Schedule on Murphy Online,
https://banner.stthomas.edu/pls/banner/prod/bwckschd.

**CHEM 491, 492 Research (2 credits)**
**CHEM 493, 494 Research (4 credits)**
See the description of these courses at the beginning of the "Curricula" section of this catalog.

**CHEM 495, 496 Individual Study (2 credits)**
**CHEM 497, 498 Individual Study (4 credits)**
See the description of these courses at the beginning of the "Curricula" section of this catalog.