

# UNDERGRADUATE CHEMISTRY HANDBOOK

(Summer 2010)



Student Name \_\_\_\_\_

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## TABLE OF CONTENTS

<b>Introduction</b>	i
<b>Minimum Grade Requirements</b>	ii
<b>Chemistry B.S. Checksheet</b>	1
Chemistry B.S. Recommended Schedule	3
<b>Chemistry B.A. Checksheet</b>	4
Chemistry B.A. Recommended Schedule	6
<b>Chemistry Minor Checksheet</b>	7
<b>Waypoints to Graduation and Semester Deadlines</b>	8
<b>Chemistry Advising</b>	
Advisor List	9
<b>Program Options</b>	
Teacher Certification	10
Pre-health	10
Suggested B.A. course sequence for Pre-professional Students	11
<b>Useful Information from the Undergraduate Catalog</b>	
Academic Eligibility	12
Registration, course loads, etc	12
Pass-fail grading option	12
Course withdrawals, etc	13
Transfer credit	13
Double majors, Second degrees, and Minors	14
Graduation	14
Curriculum for Liberal Education	14
<b>Honors program</b>	15
<b>Miscellaneous Student Information</b>	
Undergraduate research	15
Chemistry Club and Alpha Chi Sigma	16
AFTER GRADUATION?	16
University Counseling	16
Center for Academic Enrichment & Excellence	17
Virginia Tech Police Department	17
Safe Ride	
<b>Undergraduate Chemistry Courses</b>	18

## Introduction

Chemistry is central to the sciences, the understanding of the physical world, and the study of biological systems. Chemistry is the science of transformations and energetics of materials at the molecular level. Chemistry has applications from the nanoscale to the macroscopic. Chemists use their training and creativity to improve the quality of life by creating new drugs, inventing new materials, improving the efficiency of processes, developing new energy systems, and providing critical data for policy decisions. A chemistry degree provides a solid foundation to pursue a range of career directions spanning fundamental research, applied research tied closely to engineering or health professions, chemical education, and technical areas in business and law. Virginia Tech offers two course curricula leading to undergraduate degrees in Chemistry, the Bachelor's of Science (B.S.) and the Bachelor's of Arts (B.A.):

### THE B.S. CURRICULUM

The curriculum leading to the B.S. degree in chemistry prepares students for careers as professional chemists in industry or government or to continue their academic training in graduate study in chemistry or related fields. It is also suitable to prepare for pre-professional school or high school teaching. The B.S. degree meets the guidelines of the American Chemical Society (ACS) for an ACS-certified degree in chemistry.

### THE B.A. CURRICULUM

The B.A. curriculum allows greater flexibility to include more elective courses for students who wish to tailor a program to their individual goals, including pursuing a double major. It is also suitable for students interested in pursuing graduate study in an area related to chemistry, professional school, high school teaching with multiple endorsements, or business. In deciding to start either the B.A. or the B.S. degree, one major difference for freshman year is the different math courses in the two curricula. Due to the greater math requirements of the B.S., it is easier to start on the B.S. and switch to the B.A. rather than vice versa.

This handbook outlines the requirements to complete the Chemistry B.S. and B.A. degrees and provides answers to common questions that students have about choosing and completing a degree at Virginia Tech. There are two important notes to the information presented here: (1) the Virginia Tech Undergraduate Catalog is the official reference source on academic policies, and (2) this handbook includes the most current checksheets, however degree requirements can change and you should obtain the appropriate checksheet from the Chemistry Department website for your graduation term.

Thank you for choosing chemistry! For more information contact

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or visit the Chemistry Department's Undergraduate Programs website:

<http://www.chem.vt.edu/undergrad>

## **Minimum grade requirements for Progress Towards Degree (for Chemistry Majors and transfer students wishing to add a Chemistry Major)**

These minimum grade requirements went into effect Fall 2009.

First year chemistry majors are scheduled to take CHEM 1055-1056, *General Chemistry for Majors* lecture sequence, and the corresponding labs CHEM 1065-1066. All chemistry majors must earn a “C” (2.0) or better in CHEM 1055 in the fall to enroll in CHEM 1056 in the spring.

All chemistry majors take the *Principles of Organic Chemistry* lecture sequence, CHEM 2565-2566. Students must earn a “C” (2.0) or better in CHEM 1056 to take CHEM 2565. Chemistry majors must earn a “C” (2.0) or better in CHEM 2565 to take CHEM 2566.

Further, if a chemistry major fails to earn a “C” (2.0) or better in CHEM 1055 he or she must either retake this class (and earn the minimum grade) **or** take CHEM 1035-1036, *General Chemistry*, to remain in good standing for a chemistry degree.

- If the chemistry major elects to take CHEM 1035-1036, a minimum grade of “B” (3.0) is required in both in order to enroll in CHEM 2565 and progress towards the **B.S.** degree.
- If the chemistry major elects to take CHEM 1035-1036, a minimum grade of “C” (2.0) is required in both in order to enroll in CHEM 2565 and progress towards the **B.A.** degree.

Non-chemistry majors at Virginia Tech who have taken CHEM 1035 and CHEM 1036 and wish to transfer into chemistry and pursue a B.A. degree must have received a C (2.0) or better in each course. Non-chemistry majors at Virginia Tech who have taken CHEM 1035 and CHEM 1036 and wish to transfer into chemistry and pursue a B.S. degree must have received a B (3.0) or better in each course.



**College of Science  
Department of Chemistry  
Bachelor of Science Checksheet  
(for students graduating in Calendar Year 2013) <sup>1</sup>**

**PART 1: CURRICULUM FOR LIBERAL EDUCATION (CLE) REQUIREMENTS**

CLE requirements and approved courses are available online:

<http://www.cle.prov.vt.edu/guides/index.html>

(credit hours in parentheses)

- |             |   |   |
|-------------|---|---|
| <b>I.</b>   | credits + ViEWS)<br>ENGL 1105-1106 <sup>2</sup> Freshman English<br>& ViEWS requirement ( <i>Fulfilled by courses required for degree.</i> ) <sup>3</sup> | <b>Writing and Discourse</b> (Area 1: 6<br>(3) _____, (3) _____)    |
| <b>II.</b>  | <b>Ideas, Cultural Traditions, and Values</b> (Area 2: 6 credits required)<br>(Select from approved CLE courses)  | (3) _____, (3) _____  |
| <b>III.</b> | 6 credits required)<br>(Select from approved CLE courses)   | <b>Society and Human Behavior</b> (Area 3:<br>(3) _____, (3) _____) |
| <b>IV.</b>  | <b>Scientific Reasoning and Discovery</b> (Area 4) <sup>4</sup><br><i>Fulfilled by courses required for degree.</i>                                       |   |
| <b>V.</b>   | (Area 5) <sup>5</sup><br><i>Fulfilled by courses required for degree.</i>   | <b>Quantitative and Symbolic Reasoning</b>                          |
| <b>VI.</b>  | <b>Experience</b> (Area 6: 3 credits required)<br>(Select from approved CLE courses; must be a three-credit course.)                                      | <b>Creativity and Aesthetic</b><br>(3) _____                        |
| <b>VII.</b> | (Area 7: 3 credits required)<br>(Select from approved CLE courses)  | <b>Critical Issues in a Global Context</b><br>(3) _____             |

**PART 1: (CLE) credit hour requirement: 24 credits**

**PART 2: COLLEGE AND DEPARTMENT REQUIREMENTS**

- |            |   |   |
|------------|---|---|
| <b>I.</b>  |   | <b>Chemistry Courses</b> (46 credits)   |
|            | CHEM 1055-1056 <sup>1,2</sup> General Chemistry for Majors<br><u>MINIMUM GRADE REQUIREMENT:</u> Effective Fall 2009, Chemistry majors must earn a grade of "C" (2.0) or better in CHEM 1055 and in CHEM 1056.                   | (4) _____, (4) _____                    |
|            | CHEM 1065-1066 <sup>1,2</sup> General Chemistry for Majors lab  | (1) _____, (1) _____                    |
|            | CHEM 2154 <sup>2</sup> Analytical Chemistry for Majors  | (4) _____                               |
|            | CHEM 2164 <sup>2</sup> Analytical Chemistry for Majors lab  | (1) _____                               |
|            | CHEM 2424 Descriptive Inorganic Chemistry   | (3) _____                               |
|            | CHEM 2565 <sup>1,2</sup> -2566 <sup>2</sup> Principles of Organic Chemistry<br><u>MINIMUM GRADE REQUIREMENT:</u> Effective Fall 2009, Chemistry majors must earn a grade of "C" (2.0) or better in CHEM 2565 to take CHEM 2566. | (3) _____, (3) _____                    |
|            | CHEM 2555 <sup>2</sup> -2556 Organic Syn-Tech lab   | (2) _____, (2) _____                    |
|            | CHEM 3615-3616 Physical Chemistry   | (3) _____, (3) _____                    |
|            | CHEM 3625-3626 <sup>3</sup> Physical Chemistry lab  | (1) _____, (1) _____                    |
|            | CHEM 4014 <sup>3</sup> Survey of Chemical Literature  | (1) _____                               |
|            | CHEM 4114 Instrumental Analysis   | (3) _____                               |
|            | CHEM 4124 Instrumental Analysis Lab   | (1) _____                               |
|            | CHEM 4404 Physical Inorganic Chemistry  | (3) _____                               |
|            | CHEM 4414 Inorganic Synthesis & Techniques lab  | (2) _____                               |
| <b>II.</b> |   | <b>Mathematics Courses</b> (16 credits) |

MATH 1114 <sup>2</sup>	Elementary Linear Algebra	(2) _____	
MATH 1224 <sup>2</sup>	Vector Geometry	(2) _____	
MATH 1205-1206 <sup>2</sup>	Calculus	(3) _____, (3) _____	
MATH 2214	Introduction to Differential Equations	(3) _____	
MATH 2224 <sup>2</sup>	Multivariable Calculus	(3) _____	
<b>III. Physics Courses (8 credits)</b>			
PHYS 2305 <sup>1</sup> -2306	Foundations of Physics I & II (incl. lab)	(4) _____, (4) _____	
<b>IV. Restricted Electives (9 credits)</b>			
BCHM 3114 or 4115	Biochemistry elective	(3) _____	
STAT or CS course	Statistics or Computer Science elective	(3) _____	
	<i>NOT CS 1004</i>		
CHEM/BCHM/ BIOC/CHE 4xxx	CHEM/BCHM/BIOC/CHE elective <i>4000-level or higher</i>	(3) _____	
<b>V. FREE ELECTIVES (sufficient to achieve 120 credit graduation requirement or more)</b>			
( ) _____	( ) _____	( ) _____	( ) _____
( ) _____	( ) _____	( ) _____	( ) _____
( ) _____	( ) _____	( ) _____	( ) _____

**PART 2: College and department credit hour requirement:**

**96 credits**

**NOTES:**

- MINIMUM GRADE REQUIREMENT:** Effective Fall 2009, Chemistry majors must earn a grade of “C” (2.0) or better in CHEM 1055, 1056, and 2565. If a chemistry major fails to earn a “C” (2.0) or better in CHEM 1055 he or she must either retake this class (and earn the minimum grade) **or** take CHEM 1035-1036, *General Chemistry*, to remain in good standing for a chemistry degree.
  - If the chemistry major elects to take CHEM 1035-1036, a minimum grade of “B” (3.0) is required in both in order to enroll in CHEM 2565 and progress towards the **B.S.** degree.
  - If the chemistry major elects to take CHEM 1035-1036, a minimum grade of “C” (2.0) is required in both in order to enroll in CHEM 2565 and progress towards the **B.A.** degree.
- For “satisfactory progress towards degree,” these courses and their prerequisites must be completed by the time the student has attempted 72 hours.
- CHEM 3626 and CHEM 4014 satisfy the department’s ViEWS (Visual Expression, Writing and Speaking) communication requirement.
- PHYS 2305 and PHYS 2306 satisfy CLE Area 4.
- MATH 1205 and MATH 1206 satisfy CLE Area 5.

**Credit hours and GPA requirements:** Graduation requires completion of a minimum of 120 credit hours with a GPA of 2.0 or greater for all hours attempted. In addition, students must have an in-major GPA of 2.0 or greater. The in-major GPA is calculated from all chemistry courses except that not more than 6 hours of CHEM 2974, 4974, and 4994 will be included.

**Prerequisites:** This checksheet has no hidden prerequisites, although some of the courses listed are prerequisites for other courses. Please see your advisor or consult the Undergraduate Course Catalog for more information.

**Language study requirement:** The College of Science language requirement may be met by (1) completing 3 units of a single foreign or classical language in high school; (2) earning 6 semester hours of college-level foreign or classical language credit or American Sign Language; or (3) receiving credit-by-examination for a foreign or classical language or American Sign Language. (See the Undergraduate Catalog for more information.) Credits to satisfy the Language Study Requirement are in addition to the 120-credit graduation requirement for the Chemistry degree.

**Substitutions:** Students with chemistry credits due to transferring into the major, taking summer classes, or transferring credits from elsewhere may substitute the non-majors chemistry courses for the majors chemistry courses. Course substitutions must be approved by the Chemistry Department’s Director of Undergraduate Programs.

Since CHEM 2545-2546 does not satisfy the prerequisite for CHEM 2556 (due to training on specific instrumentation), two or more credits of CHEM 4994 may substitute for CHEM 2556 to meet the requirement of 400 lab hours beyond general chemistry for an ACS-approved degree.

**College of Science**  
 Department of Chemistry  
 Bachelor of Science (B.S.) in Chemistry  
 RECOMMENDED SCHEDULE

First Year		Fall	Spring
CHEM 1055, 1056	General Chemistry for Majors	4	4
CHEM 1065, 1066	General Chemistry for Majors Lab	1	1
ENGL 1105, 1106	Freshman English	3	3
MATH 1114	Elementary Linear Algebra	2	-
MATH 1224	Vector Geometry	-	2
MATH 1205, 1206	Calculus	3	3
	Electives	3	3
	Semester Total	16	16
Second Year			
CHEM 2154	Analytical Chemistry for Chem Majors	4	-
CHEM 2164	Analytical Chemistry for Chem Majors Lab	1	-
CHEM 2565, 2566	Principles of Organic Chemistry	3	3
CHEM 2555	Organic Synthesis & Techniques Lab	-	2
CHEM 4014	Survey of the Chemical Literature	-	1
CHEM 2424	Descriptive Inorganic Chemistry	-	3
MATH 2214	Introduction to Differential Equations	-	3
MATH 2224	Multivariable Calculus	3	-
PHYS 2305, 2306	Foundations of Physics	4	4
	Semester Total	15	16
Third Year			
CHEM 2556	Organic Synthesis & Techniques Lab	2	-
CHEM 3615, 3616	Physical Chemistry	3	3
CHEM 3625	Physical Chemistry Lab	-	1
BCHM 3114 or 4115	biochemistry elective	3	-
STAT or CS	Statistics or Computer Science (not CS 1004)	-	3
	Electives	6	8
	Semester Total	14	15
Fourth Year			
CHEM 3626	Physical Chemistry Lab	1	-
CHEM 4114	Instrumental Analysis	3	-
CHEM 4124	Instrumental Analysis Lab	1	-
CHEM 4404	Physical Inorganic Chemistry	3	-
CHEM 4414	Inorganic Synthesis & Techniques Lab	-	2
CHEM 4xxx	CHEM/BIOC/CHE elective, 4000-level or higher	-	3
	Electives	6	9
	Semester Total	14	14

**College of Science  
Department of Chemistry  
Bachelor of Arts Checksheet  
(for students graduating in Calendar Year 2013) <sup>1</sup>**

**PART 1: CURRICULUM FOR LIBERAL EDUCATION (CLE) REQUIREMENTS**

(CLE requirements and approved courses are available online:

<http://www.cle.prov.vt.edu/guides/index.html>)

(credit hours in parentheses)

- |             |  |  |
|-------------|--|--|
| <b>I.</b>   | credits + ViEWS)<br>ENGL 1105-1106 <sup>2</sup> Freshman English<br>& ViEWS requirement <sup>3</sup>                 | <b>Writing and Discourse</b> (Area 1: 6<br>(3) _____, (3) _____    |
| <b>II.</b>  | <b>Ideas, Cultural Traditions, and Values</b> (Area 2: 6 credits required)<br>(Select from approved CLE courses)     | (3) _____, (3) _____   |
| <b>III.</b> | 6 credits required)<br>(Select from approved CLE courses)  | <b>Society and Human Behavior</b> (Area 3:<br>(3) _____, (3) _____ |
| <b>IV.</b>  | <b>Scientific Reasoning and Discovery</b> (Area 4) <sup>4</sup><br><i>Fulfilled by courses required for degree.</i>  |  |
| <b>V.</b>   | (Area 5) <sup>5</sup><br><i>Fulfilled by courses required for degree.</i>  | <b>Quantitative and Symbolic Reasoning</b>                         |
| <b>VI.</b>  | <b>Experience</b> (Area 6: 3 credits required)<br>(Select from approved CLE courses; must be a three-credit course.) | <b>Creativity and Aesthetic</b><br>(3) _____                       |
| <b>VII.</b> | (Area 7: 3 credits required)<br>(Select from approved CLE courses)   | <b>Critical Issues in a Global Context</b><br>(3) _____            |

**PART 1: (CLE) credit hour requirement:**

**24 credits**

**PART 2: COLLEGE AND DEPARTMENT REQUIREMENTS**

- |           |  |  |
|-----------|--|--|
| <b>I.</b> | CHEM 1055-1056 <sup>1,2</sup> General Chemistry for Majors<br><b>MINIMUM GRADE REQUIREMENT: Effective Fall 2009, Chemistry majors must earn a grade of "C" (2.0) or better in CHEM 1055 and CHEM 1056.</b><br>CHEM 1065-1066 <sup>2</sup> General Chemistry for Majors lab<br>CHEM 2154 <sup>2</sup> Analytical Chemistry for Majors<br>CHEM 2164 <sup>2</sup> Analytical Chemistry for Majors lab<br>CHEM 2424 Descriptive Inorganic Chemistry<br>CHEM 2565-2566 <sup>1,2</sup> Principles of Organic Chemistry<br><b>MINIMUM GRADE REQUIREMENT: Effective Fall 2009, Chemistry majors must earn a grade of "C" (2.0) or better in CHEM 2565 to take CHEM 2566.</b><br>CHEM 2545-2546 <sup>2</sup> Organic Chemistry lab<br>CHEM 4615-4616 Physical Chemistry for Life Sciences<br>CHEM 3625 Physical Chemistry lab<br>CHEM 4014 <sup>3</sup> Survey of Chemical Literature | <b>Chemistry Courses</b> (34 credits)<br>(4) _____, (4) _____<br>(1) _____, (1) _____<br>(4) _____<br>(1) _____<br>(3) _____<br>(3) _____, (3) _____<br>(1) _____, (1) _____<br>(3) _____, (3) _____<br>(1) _____<br>(1) _____ |
|-----------|--|--|

- |            |   |
|------------|---|
| <b>II.</b> | <b>Mathematics Courses</b> (12 credits) |
|------------|---|

MATH 1015-1016<sup>2,6</sup> Elementary Calculus I  
MATH 2015<sup>2,5,7</sup>-2016<sup>2,5,8</sup> Elementary Calculus II

(3) \_\_\_\_\_, (3) \_\_\_\_\_  
(3) \_\_\_\_\_, (3) \_\_\_\_\_

**III. Physics Courses (8 credits)**

PHYS 2205<sup>2</sup> - 2206<sup>9</sup> General Physics  
PHYS 2215<sup>2</sup> - 2216<sup>10</sup> General Physics Lab

(3) \_\_\_\_\_, (3) \_\_\_\_\_  
(1) \_\_\_\_\_, (1) \_\_\_\_\_

**IV. Restricted Electives (11 credits)**

STAT or CS course	Statistics or Computer Science elective <i>NOT CS 1004</i>	(3) _____
3xxx-4xxx	CHEM/BCHM/BIOC/CHE electives <i>3000-level or higher</i>	(3) _____, (3) _____
CHEM ViEWS <sup>2</sup>	Additional ViEWS requirement	(2-3) _____

**V. FREE ELECTIVES (sufficient to achieve 120 credit graduation requirement or more)**

( ) _____	( ) _____	( ) _____	( ) _____
( ) _____	( ) _____	( ) _____	( ) _____
( ) _____	( ) _____	( ) _____	( ) _____
( ) _____	( ) _____	( ) _____	( ) _____

**PART 2: College and department credit hour requirement: 96 credits**

NOTES:

- MINIMUM GRADE REQUIREMENT:** Effective Fall 2009, Chemistry majors must earn a grade of “C” (2.0) or better in CHEM 1055, 1056, and 2565. If a chemistry major fails to earn a “C” (2.0) or better in CHEM 1055 he or she must either retake this class (and earn the minimum grade) **or** take CHEM 1035-1036, *General Chemistry*, to remain in good standing for a chemistry degree.
  - If the chemistry major elects to take CHEM 1035-1036, a minimum grade of “B” (3.0) is required in both in order to enroll in CHEM 2565 and progress towards the **B.S.** degree.
  - If the chemistry major elects to take CHEM 1035-1036, a minimum grade of “C” (2.0) is required in both in order to enroll in CHEM 2565 and progress towards the **B.A.** degree.
- For “satisfactory progress towards degree,” these courses and their prerequisites must be completed by the time the student has attempted 72 hours.
- CHEM 4014 satisfies part of the University’s ViEWS (Visual Expression, Writing and Speaking) requirement. **Please note that one additional ViEWS course is required.** B.A. majors who wish to complete their ViEWS requirements in Chemistry may enroll in the second semester of Physical Chemistry lab (CHEM 3626) or take three credits of Undergraduate Research with an oral presentation at the Chemistry Undergraduate Symposium.
- PHYS 2206 and PHYS 2216 satisfy CLE Area 4.
- MATH 2015 and MATH 2016 satisfy CLE Area 5.
- MATH 1205 may be substituted for MATH 1015 and MATH 1016.
- MATH 1206 may be substituted for MATH 2015.
- MATH 2214 (MATH 1114 and MATH 1206 OR 2015 prerequisite)  
OR MATH 2224 (MATH 1224 and MATH 1206 OR 2015 prerequisite)  
may be substituted for MATH 2016.
- PHYS 2305 (MATH 1205 prerequisite) may be substituted for PHYS 2205 and PHYS 2215.
- PHYS 2306 (MATH 1206 prerequisite) may be substituted for PHYS 2206 and PHYS 2216.

**Credit hours and GPA requirements:** Graduation requires completion of a minimum of 120 credit hours with a GPA of 2.0 or greater for all hours attempted. In addition, students must have an in-major GPA of 2.0 or greater. The in-major GPA is calculated from all chemistry courses except that not more than 6 hours of CHEM 2974, 4974, and 4994 will be included.

**Prerequisites:** This checksheet has no hidden prerequisites, although some of the courses listed are prerequisites for other courses. Please see your advisor or consult the Undergraduate Course Catalog for more information.

**Language study requirement:** The College of Science language requirement may be met by (1) completing 3 units of a single foreign or classical language in high school; (2) earning 6 semester hours of college-level foreign or classical language credit or American Sign Language; or (3) receiving credit-by-examination for a foreign or classical language or American Sign Language. (See the Undergraduate Catalog for more information.) Credits to satisfy the Language Study Requirement are in addition to the 120-credit graduation requirement for the Chemistry degree.

**Substitutions:** Students with chemistry credits due to transferring into the major, taking summer classes, or transferring credits from elsewhere may substitute the non-majors chemistry courses for the majors chemistry

courses. Course substitutions must be approved by the Chemistry Department's Director of Undergraduate Programs.

**College of Science**  
 Department of Chemistry  
 Bachelor of Arts (B.A.) in Chemistry  
 RECOMMENDED SCHEDULE

First Year		Fall	Spring
CHEM 1055, 1056	General Chemistry for Majors	4	4
CHEM 1065, 1066	General Chemistry for Majors Lab	1	1
ENGL 1105, 1106	Freshman English	3	3
MATH 1015, 1016	Elementary Calculus I	3	3
	Electives	3	4
	Semester Total	14	15
Second Year			
CHEM 2154	Analytical Chemistry for Chem Majors	4	-
CHEM 2164	Analytical Chemistry for Chem Majors Lab	1	-
CHEM 2565, 2566	Principles of Organic Chemistry	3	3
CHEM 2545, 2546	Organic Chemistry Lab	1	1
CHEM 4014	Survey of the Chemical Literature	-	1
CHEM 2424	Descriptive Inorganic Chemistry	-	3
MATH 2015, 2016	Elementary Calculus II	3	3
PHYS 2205, 2206	General Physics	3	3
PHYS 2215, 2216	General Physics Lab	1	1
	Semester Total	16	15
Third Year			
CHEM 4615, 4616	Physical Chemistry for Life Sciences	3	3
CHEM 3625	Physical Chemistry Lab	-	1
STAT or CS	Statistics or Computer Science (not CS 1004)	3	-
	Electives	9	11
	Semester Total	15	15
Fourth Year			
CHEM 4xxx, 4xxx	CHEM/BIOC/CHE Electives, 3000-level or higher	3	3
	Electives	12	12
	Semester Total	15	15

**College of Science**  
**Department of Chemistry**  
**CHEMISTRY MINOR CHECKSHEET**  
**For students graduating in calendar year 2012**

**I. Required Courses (19 hours)**

CHEM 1035-1036 General Chemistry	(3) ____	(3) ____
CHEM 1045-1046 General Chemistry Labs	(1) ____	(1) ____
CHEM 2535-2536 Organic Chemistry	(3) ____	(3) ____
CHEM 2545-2546 Organic Chemistry Labs	(1) ____	(1) ____
CHEM 4615 Physical Chemistry for Life Sciences	(3) ____	

*(Additional prerequisites: MATH 2015, PHYS 2206)*

**II. Elective course (3 hours)** (3) \_\_\_\_

Choose one course from this list:

- CHEM 2114 Analytical Chemistry
- or** CHEM 2424 Descriptive Inorganic Chemistry
- or** CHEM 4514 Green Chemistry
- or** CHEM 4534 Organic Chemistry of Polymers
- or** CHEM 4554 Drug Chemistry
- or** CHEM 4616 Physical Chemistry for Life Sciences  
*(Additional prerequisite: MATH 2016)*
- or** CHEM 4994 Undergraduate Research  
*(Requires permission of faculty research advisor and undergraduate research eligibility requirements)*

**III. Total Credits Required**

A minimum of 22 credit hours in chemistry courses must be completed.

**IV. Minimum GPA**

The student's overall GPA for chemistry courses must be a 2.0 or higher.

**Notes:**

Acceptable substitutions are as follows:

Course	Substitution
CHEM 1035-1036	CHEM 1055-1056 General Chemistry for Majors
CHEM 1045-1046	CHEM 1065-1066 General Chemistry Lab for Majors
CHEM 2114	CHEM 2154 Analytical Chemistry for Majors
CHEM 2535-2536	CHEM 2565-2566 Principles of Organic Chemistry
CHEM 4615	CHEM 3615 (Pre: CHEM 1036 OR 1056; PHYS 2306; and MATH 1205, 1206, & 2224)
CHEM 4616	CHEM 3616 (Pre: CHEM 3615, MATH 2214)

## IMPORTANT WAYPOINTS TO GRADUATION

### Freshman year

- attend Orientation, choose math sequence
- attend advising sessions (Fall, Spring) and meet your academic advisor (Spring)

### Sophomore year

- choose B.A. or B.S. organic lab sequence (also try to survive - crunch year for chemists!)

### Beginning of Junior Year

- Download degree checksheet for your graduation year
- Apply for Degree on Hokie SPA
- Request DARS Report on Hokie SPA and review with your advisor

### End of Junior Year

- add any minors or second majors before being within 30 credits of graduation
- Begin making hotel arrangements for out-of-town guests to attend graduation
- honk if you pass p-chem ☺

### Beginning of Senior Year

- Request a new DARS Report on Hokie SPA and review with your advisor

### Senior Year (graduation semester)

- Request a new DARS Report on Hokie SPA and review with your advisor

### Senior Year (2 months before Graduation)

- Review [http://www.registrar.vt.edu/graduation/ug\\_commcement.php](http://www.registrar.vt.edu/graduation/ug_commcement.php) for commencement dates, times and locations
- Visit Bookstore to purchase cap and gown, announcements, etc.

## IMPORTANT EVENTS EACH SEMESTER

End of week 1	last day to add classes
End of week 6	last day to drop classes
Tuesday of week 9	course request opens for the next semester
Tuesday of week 10	course request closes for the next semester
Monday of week 14	Drop/Add opens for the next semester
End of week 14	last day to apply late withdrawal policy
Wednesday of week 15	end of classes
Thursday of week 15	reading day
Friday of week 15	final exams begin

!!! Check the calendar on the Registrar's website (<http://www.registrar.vt.edu>) for exact dates each semester.

## Advising

### ADVISORS

As future colleagues, the Chemistry Faculty wants and expects to know every chemistry major personally. You should, as you move through the program, make an effort to meet and know your professors; they are always available for help and guidance. A complete and current faculty listing is found on the department website. In addition, in their second semester at Virginia Tech, all undergraduate chemistry majors are assigned to a faculty member who serves as their permanent academic advisor. Students may schedule appointments directly with their advisors whenever questions or issues arise. Additionally, it is the student's responsibility to contact their advisor during course request for each upcoming semester. For "emergency" advice when the advisor cannot be located, students should feel free to contact any other advisor from the list below:

Dr. Patricia Amateis	007 Davidson	231-6629	pamateis@vt.edu
Dr. Michael Berg	221 Davidson	231-6837	bergm@vt.edu
Dr. Karen Brewer	1105 Hahn Hall South	231-6579	brewer@vt.edu
Dr. Daniel Crawford	1110 Hahn Hall South	231-7760	crawdad@vt.edu
Ms. Jeannine Eddleton	009 Davidson	231-8228	jeddleto@vt.edu
Dr. Alan Esker	1107 Hahn Hall South	231-4601	aesker@vt.edu
Dr. Felicia Etzkorn	3105 Hahn Hall South	231-2235	fetzcorn@vt.edu
Dr. Brian Hanson	103/408 Davidson	231-7206	hanson@vt.edu
Dr. Gary Long	230 Davidson	231-7575	glong@vt.edu
Dr. Robert Moore	1103 Hahn Hall South	231-0641	rbmoore3@vt.edu
Dr. Carla Slebodnick	2028 ILSB (CRC)	231-1848	slebod@vt.edu
Dr. James Tanko	3109 Hahn Hall South	231-6687	jtanko@vt.edu
Dr. Brian Tissue	322 Davidson	231-3786	tissue@vt.edu
Dr. Gordon Yee	2103 Hahn Hall South	231-3090	gyee@vt.edu

In addition to your assigned academic advisor, the Department provides advisors for special programs:

Freshman Advising	Dr. Patricia Amateis and Dr. Gordon Yee
Transfer Student Advising	Dr. Patricia Amateis
Career Advisor*	Dr. Gordon Yee
Corps of Cadets Advisor	Dr. Robert Moore
Honors Advisor	Dr. Brian Hanson
Pre-Med, Dental, and Veterinary	Dr. Michael Berg
Pre-Pharmacy Programs	Dr. Gary Long
Teacher Certification	Ms. Jeannine Eddleton

\*All chemistry majors should interact at least once a year with Dr. Yee. However, it is especially critical that rising juniors and seniors discuss their goals and aspirations early in the Fall Semester. Successfully finding the right position after graduation requires proper planning and a coordinated campaign.

A final note on advising: Advice is just that - advice to you to help you make decisions. Your advisor will provide advice on what he or she thinks will serve you best. Our advisors have been through what you are going through so listen to them and then make decisions that are best for you. You will find that life is a journey full of expected and unexpected curves with many different paths - all different and none of them right or wrong.

## PROGRAM OPTIONS FOR CHEMISTRY MAJORS

### CHEMISTRY TEACHER CERTIFICATION

The teacher certification advisor for chemistry majors is Mrs. Jeannine Eddleton. Mrs. Eddleton's office is in 9 Davidson Hall, her email address is [jeddleto@vt.edu](mailto:jeddleto@vt.edu); and her phone number is (540) 231-8228.

Students wishing to become high school chemistry teachers should pursue a B.A. degree in chemistry and then enter the fifth-year secondary science education licensure program offered by the School of Education:

<http://www.soe.vt.edu/scied/>

### PRE-HEALTH ADVISING

Pre-health advising at Virginia Tech is expanding its services to students and moving to a new location.

Formerly housed in the office of University Honors in Hillcrest Hall, and for many years referred to as the pre-med and pre-dental program, pre-health advising not only has a new name, but also new leadership. The Department of Career Services, a department within the Division of Student Affairs, located in the Smith Career Center, is now home to pre-health advising. Dr. Judith Wubah is the new director of the Pre-Health Advising office.

The *pre-pharmacy advisor* for chemistry majors is Dr. Gary Long.

The *pre-med, pre-dental, and pre-vet advisor* for chemistry majors is Dr. Mike Berg.

Students who wish to go to medical or dental school will meet minimum admission requirements for most schools by adding freshman biology to either (B.A. or B.S.) Chemistry degree program. However, most students take additional biology and biochemistry courses. For an orderly progression through these courses, it is important that pre-med and pre-dental students take biology in their freshman year.

The next page shows a suggested program of study for chemistry students who plan to go to medical school. A pre-dentistry program of study would be very similar.

## CHEMISTRY B.A. for PRE-MEDICAL Students

## SUGGESTED COURSE SEQUENCE

First Year		Fall	Spring
CHEM 1055, 1056	General Chemistry for Chem Majors	4	4
CHEM 1065, 1066	General Chemistry for Chem Majors Lab	1	1
BIOL 1105, 1106	Principles of Biology	3	3
BIOL 1115, 1116	Principles of Biology Lab	1	1
ENGL 1105, 1106	Freshman English	3	3
MATH 1015, 1016	Elementary Calculus I	3	3
	Semester Total	15	15
Second Year			
CHEM 2565, 2566	Principles of Organic Chemistry	3	3
CHEM 2545, 2546	Organic Chemistry Lab	1	1
CHEM 4014 <sup>†</sup>	Survey of Chemical Literature	-	1
BIOL 2604	General Microbiology	3	-
BIOL 2004	Genetics	-	3
MATH 2015, 2016	Elementary Calculus II	3	3
PHYS 2205, 2206	General Physics	3	3
PHYS 2215, 2216	General Physics Lab	1	1
	Electives <sup>‡</sup>	3	-
	Semester Total	17	15
Third Year			
CHEM 2154	Analytical Chemistry for Chem Majors	4	-
CHEM 2164	Analytical Chemistry for Chem Majors Lab	1	-
CHEM 2424	Descriptive Inorganic Chemistry	-	3
BCHM 4115, 4116	General Biochemistry	4	3
STAT 3615	Biological Statistics	-	3
	Electives <sup>‡</sup>	6	6
	Semester Total	15	15
Fourth Year			
CHEM 4615, 4616	Physical Chemistry for Life Sciences	3	3
CHEM 3625	Physical Chemistry Lab	-	1
	Electives <sup>‡</sup>	12	9
	Semester Total	15	13

Students desiring a second major in biochemistry will need to take BIOL 2614 (1 cr.) and BCHM 2144 (1 cr.) in the sophomore year, and BCHM 4124 (6 cr.) in their senior year. Refer to the Biochemistry Dept website for updated information (<http://www.biochem.vt.edu/undergraduate.php>).

Other electives should be chosen after consultation with the Pre-health advising office. Students interested in pharmacy school can follow this sequence being sure to take other required electives, e.g., microeconomics and public speaking, per admission requirements of the pharmacy schools of interest.

## Useful Information from the Undergraduate Catalog

The following information is a general summary of many academic policies. **Refer to the complete text in the Undergraduate Course Catalog (<http://www.undergradcatalog.registrar.vt.edu/>) for full details.**

### ACADEMIC ELIGIBILITY POLICY

A GPA of 2.0 (a C average) overall and in-major is required for graduation. Any time your overall GPA falls below 2.0 you are placed on academic probation. A student on probation may take no more than 16 credits per semester. Probation is lifted when the cumulative GPA rises to 2.0. See the Undergraduate Catalog for full requirements and conditions leading to academic suspension.

### REGISTRATION FOR CLASSES

Course Request (pre-registration) is an eight-day period in the middle of each semester during which students enrolled currently may select classes for the following semester. During the spring, students register for both the summer school (if they plan to attend) and for the next fall. Plan your schedule, consult with your advisor, and go online to Hokie SPA and register.

### COURSE LOADS

A student is classified as "full-time" if enrolled for 12 credit hours or more. A normal course load is 15-17 hours. Overloads (more than 19 hours per semester, 9 each summer session) require permission of your academic Dean's office. Unless such permission has been obtained in advance, you will not be able to add more than 19 credits of courses in Hokie SPA during course request or during Drop/Add.

### LATE ADDS

Adding a course to your schedule after the deadline requires permission of your Academic Dean.

### CLASS LEVEL

A student must have received credit for at least 30 hours to be classified as a sophomore, at least 60 hours to be classified as a junior, and at least 90 hours to be classified as a senior.

### ENROLLMENT IN GRADUATE COURSES

With permission of the instructor, chemistry majors may enroll in 5000-level chemistry courses. Chemistry majors wishing to take 5000-level courses in other departments must have the approval of the instructor and the Dean of the Graduate School.

### PASS-FAIL GRADE OPTIONS

Students may take certain courses on a pass-fail basis, according to the following regulations:

- 1. No college core requirements or departmental requirements may be taken under the pass-fail option.**
2. Minimum credit hours already passed on graded courses must equal 30 with a minimum GPA = 2.50. (Does not apply for courses offered only on a pass-fail basis.)
3. Maximum number of pass-fail credits allowed = 10% of the requirements for graduation taken at Virginia Tech. For example, if a student takes 120 credits at Virginia Tech, 12 hours may be taken Pass-Fail. If a student takes only 90 credit hours at Virginia Tech (with 30 transfer credits), then only 9 (10% of 90) credits may be taken Pass-Fail.
4. For courses taken pass-fail, P or F is recorded on the student's transcript and credit is given if the grade is P. If the course is failed, the "F" is considered as an "F" received under the "A-F" grading system and is included in calculation of the GPA.
5. Pass-fail courses are normally non-transferable to other institutions.
6. No more than 2 courses may be taken pass-fail in any semester unless courses are offered only pass-fail.

## COURSE WITHDRAWAL POLICY

Students may drop courses prior to the drop deadline and the course is removed from your transcript. The drop deadline is announced in each semester's Timetable. A maximum of six hours (6) may be dropped beyond the normal drop deadline date during a student's academic career at Virginia Tech, subject to the following stipulations:

1. Students must formally request to drop a course by the Friday before the last day of classes in that semester.
2. Courses from which a student withdraws under the terms of this policy will appear on their transcript with a W. The W signifies that this policy was invoked; the reasons for its use are the (private) responsibility of the student.
3. A student's decision to invoke this policy is irrevocable and unappealable.
4. Withdrawals may not be employed to reduce or obviate any penalty otherwise accruing to students under the University Honor System.
5. Students may request withdrawal from any course, irrespective of the grade earned up to the point of the request.
6. To withdraw from a course, you must fill out a Course Withdrawal Form available from the College of Science administrative office or from <http://www.science.vt.edu/student/forms/cw.pdf>. The form must be signed by you, your advisor, and your academic dean.

## REPEATED AND DUPLICATED COURSES

A course that partially or wholly duplicates another course also does not count toward graduation. Duplication of two courses does not necessarily mean that they are equivalent, rather it means that there is sufficient material overlap that credit is not allowed for both. No credit will be given toward graduation for duplicated courses nor may duplicate courses be used for GPA enhancement, unless the grade in the course already taken is a C- or less. Students may repeat courses in which they received grades of C- or below. Both grades stay on the record and figure into the overall and in-major GPA, but the course hours count only once toward graduation. Transcripts will display all hours attempted whether or not they count toward graduation.

## TRANSFER CREDIT

Students transferring to Virginia Tech from a community college may transfer as many as 60 credits. Those who transfer from a four-year college have no such limitation. However, all students graduating from Virginia Tech must complete at least 27 hours in residence. A student must take at least 27 of their last 45 hours at Virginia Tech. Also, chemistry majors and minors must take at least 25% of the required chemistry courses at Virginia Tech.

More information is available online at the University Registrar's website: <http://www.registrar.vt.edu>. Transfer students should also review the information in the online Transfer Guide: (<http://www.registrar.vt.edu/tranguide/>).

Students frequently wish to take summer school courses at other institutions for transfer back to Virginia Tech. The student should contact the college or university they wish to attend to determine what courses will be offered. An "Authorization to Take Courses Elsewhere" form should be obtained in the College of Science's administrative office or from <http://www.science.vt.edu/student/forms/index.html> and completed (indicating the courses to be taken and the Virginia Tech courses for which credit is requested). The form must be returned to the Dean's office at least three weeks before matriculation at the other institution. Students who wait until the last part of the Spring semester to file this form may experience some delay. The transcript evaluator will determine whether the desired courses will transfer as expected, and approved copies are sent to the student and the advisor. After the courses are completed, the student must request that an official transcript be sent to the University Registrar at Virginia Tech. The evaluation will be processed as described above.

1. Students on academic suspension or disciplinary suspension may not transfer courses taken during the period of suspension even if an "Authorization" is issued before Spring grades are known.
2. Submission of an "Authorization" form does not commit the student to taking all or even any of the courses indicated. Filing the form does provide the student with the safeguard of knowing exactly how the proposed courses will transfer.
3. A student may take summer school courses without "authorization"; however, this could lead to unwanted surprises when the transcript is evaluated.
4. Students in any sort of academic difficulty should consider carefully before taking summer courses elsewhere and seek advice since such action may alter their eligibility level without improving their academic record.
5. Credits will not transfer if the grade received is C- or lower. Courses taken pass/fail will not transfer.

#### DOUBLE MAJORS and SECOND DEGREES

Students who complete the requirements for two majors within the same academic term are considered Double Majors. Students receive a diploma for their primary major (degree) and a double major certificate for your secondary major (double major).

Students may complete the requirements for a Second Degree in a different academic term. Students pursuing a Second Degree must complete an additional 30 credits over the minimum required for their first degree. Students will receive a separate diploma for each degree.

You should indicate on your Application for Degree on Hokie SPA if your secondary major should be a double major or a second degree under the section "What degree is this?" (Please note that if you will be completing your second degree in a later term than the first degree you will select "first degree for both majors.")

#### MINORS

Any department that offers a major may offer a minor. If you desire a minor in a particular subject, contact the appropriate department for their requirements or ask your advisor. Note that Majors and Minors are supposed to be added before senior year.

#### GRADUATION

You should apply for your Degree on Hokie Spa during your junior year. You may then generate a Degree Audit Report System (DARS) report in Hokie Spa to review your record to see what requirements remain to be completed for graduation. Applying for your degree early ensures that you will have time to take courses that you may have overlooked, and it allows you and your advisor to correct the Registrar's analysis if errors are present. Finally, you should be advised that the Registrar's graduation analysis is not a binding contract. Do not assume that you are excused from a required course on the basis of error in DARS; the Registrar will eventually find the mistake and you will not graduate.

#### CURRICULUM FOR LIBERAL EDUCATION (CLE) & UNIVERSITY AND COLLEGE OF SCIENCE REQUIREMENTS

- 1.No more than 60 hours in the major may be counted towards the total number of hours required for graduation.
- 2.Successful completion of English 1105 and 1106, or 1204H. Students who receive Advanced Standing (with credit) for 1105 take only 1106.
- 3.Proficiency in a foreign language equivalent to one year of university instruction. This requirement can be met in several ways:
  - 3.1. Completing the third year (Level III) of a language in high school.
  - 3.2. Completing two years each of two different foreign languages in high school (for College of

- Science majors).
- 3.3. Completing the 1106 course in Chinese, French, German, Greek, Italian, Japanese, Latin, Portuguese, Russian, or Spanish, including any prerequisites.  
NOTE: Students who have not completed foreign language requirements in high school may not count these hours toward the 120 required for graduation.
  - 3.4. Passing an oral examination in a language not taught at Virginia Tech.
  - 3.5. Documenting that English is not your primary language (see Department of Foreign Languages & Literatures for obtaining documentation).
  4. Six (6) hours of humanities (Area 2).
  5. Six (6) hours of social sciences (Area 3).
  6. Three (3) hours of fine arts (Area 6). (The College of Science at Virginia Tech requires three credits for Area 6; some colleges within the university have different requirements.)
  7. Three (3) hours: Critical Issues in a Global Context (Area 7). Some Area 7 courses may also count for Areas 2 or 3.
  8. No course may be used to fulfill more than one core area, except for Area 7 courses.
  9. Virginia Tech's Curriculum for Liberal Education yearly guides are available online: <http://www.cle.prov.vt.edu/>.

### **The Honors Program** (*information from [www.univhonors.vt.edu](http://www.univhonors.vt.edu)*)

The goal of University Honors is to provide the student enhanced access to a great faculty and the tools to create an education second to no other among the nation's elite.

Virginia Tech's Honors Program enhances students' education by offering direct and personal contacts with top faculty; intensive academic advising from individuals who are familiar with the numerous choices associated with the university; Honors independent study and research options; priority registration (applies after first semester); and excellent placement of graduates into nationally ranked graduate schools and professional sites.

Entering freshmen are invited to apply to University Honors if they have a cumulative GPA of 3.70 (as reported on their high school transcript) and a minimum SAT score of 1350 (critical reading and mathematics) or a minimum ACT composite score of 30.

Transfer Students: Students who have completed one or more semesters at Virginia Tech or another college may participate in the program if they have a cumulative GPA of 3.60 or above and provided they have at least four (4) semesters remaining before they will graduate from Virginia Tech.

A student may choose from six distinct diploma options in University Honors: Commonwealth Scholar, Scholar in Health Studies, Honors Scholar, in Honors, Honors Baccalaureate, and the Combined Bachelor's/Master's Program.

Students who wish to contact the Honors Program office for more information should call (540)231-4591 to schedule an appointment.

### **UNDERGRADUATE RESEARCH (CHEM 4994)**

Chemistry majors are encouraged to undertake a research project in collaboration with at least one faculty member. Credit for this activity is obtained by enrolling in CHEM 4994 for those semesters (including summers) in which the work is to be performed. Chemistry faculty can suggest either short-term (one semester) or long-term projects; in every case, undergraduate research projects are designed to

meet the individual interests and needs of the student. An interested student should consult with a prospective research mentor at least several weeks prior to the semester to do the research.

#### ALPHA CHI SIGMA & CHEMISTRY CLUB

There are two student groups affiliated with the Chemistry Department at Virginia Tech: Alpha Chi Sigma, the co-ed professional chemistry fraternity; and the Chemistry Club, a student affiliate chapter of the American Chemical Society. All chemistry majors are encouraged to join one and/or both of these groups. Activities include meetings, socials, tutoring, and hosting "illusion shows" and an end-of-the-year picnic for the department. For further information, please visit

<http://www.chem.vt.edu/undergrad/undergrad-clubs.html>

#### AFTER GRADUATION?

After receiving the B.S. or B.A. degree in chemistry, some students continue their education in professional or graduate school, and some take an entry-level job in chemistry or a related discipline.

**Professional School Opportunities.** Chemistry graduates may choose to pursue careers in dentistry, law, medicine, optometry, pharmacy, veterinary medicine, etc. Your academic advisor can direct you to numerous sources of information concerning professional school.

**Graduate School.** Many companies prefer to hire scientists with advanced degrees.

B.S. and B.A. chemists are qualified to enter graduate school and pursue the M.S. or Ph.D. degree in a surprisingly large number of areas, some of which we have listed below:

chemistry	biochemistry	chemical engineering
textiles	paper chemistry	environmental engineering
food science	toxicology	medicinal chemistry
pharmacology	pharmacy	materials engineering
microbiology	virology	forensic chemistry
oceanography	clinical chemistry	secondary education

Your academic advisor should be able to advise you concerning graduate school, particularly in chemistry. If you are interested in an area unfamiliar to your advisor, s/he should be able to direct you to someone knowledgeable. Students wishing to go to graduate school should plan to take the Graduate Record Exam (GRE) in the fall of their senior year, and should complete their applications in mid-January.

**Employment.** Finding a job requires work, perseverance, and a little luck, so you should plan to spend considerable time and effort in your search. If you sit back and wait for employers to come to you, you will not find a job! There are three sources of help for students interested in finding employment immediately after graduation: your academic advisor, the departmental career advisor, and the Office of Career Services, <http://www.career.vt.edu/>. This office provides an Information Center with materials such as directories, employer literature and video tapes, salary information, etc. They offer services such as mock interviews, resumé critique sessions, group meetings and seminars, and on-campus interviewing opportunities.

#### UNIVERSITY COUNSELING CENTER ([www.ucc.vt.edu](http://www.ucc.vt.edu))

The Cook Counseling Center offers short-term individual, couples, and group counseling for a variety of concerns. Students come in for counseling to help them with issues such as stress, depression, anxiety, loneliness, sexual concerns, academic motivation, and relationship problems.

The Cook Counseling Center counselors are available to talk to you during the day from 8:00 am to 5:00 at 540-231-6557.

If you need emergency counseling outside normal business hours assistance is available by calling 540-231-6444.

**CENTER FOR ACADEMIC ENRICHMENT & EXCELLENCE ([www.caee.vt.edu](http://www.caee.vt.edu))**

The Center for Academic Enrichment and Excellence (CAEE) offers free academic support, such as tutoring and a wide variety of seminars and information sessions (including seminars on time management, honing test-taking and note-taking skills, and how to stay focused through the semester) to undergraduate students at Virginia Tech.

**VIRGINIA TECH POLICE DEPARTMENT ([www.police.vt.edu](http://www.police.vt.edu))**

The Virginia Tech Police Department is nationally accredited by the Commission on Accreditation for Law Enforcement Agencies Incorporated. Our police department strives to enhance the safety and quality of life for students, faculty, staff and visitors through effective law enforcement and proactive crime prevention in partnership with the university community. The department currently employs fifty sworn officers, ten dispatchers, eight security guards, and numerous support/wage personnel.

Several programs are offered by the department, free of charge, to Virginia Tech students. Programs include the Student's Police Academy, Self-Defense/Rape Aggression Defense System course, and VT C-CERT (Campus Community Emergency Response Team) training. Please visit the department's website ([www.police.vt.edu](http://www.police.vt.edu)) for more information.

**SAFE RIDE**

The police department also sponsors a nighttime campus safety escort service known as Safe Ride. Safe Ride operates from dusk until dawn and provides transportation or a walking escort upon request. To use this service, call (540) 231-SAFE.

## **Undergraduate Courses (CHEM)**

### **1015-1016: INTRODUCTION TO CHEMISTRY**

For students enrolled in curricula other than science or engineering. Chemical principles applied to material, environmental, and life sciences. (Duplicates 1035-1036.) (3H,3C)

### **1025-1026: INTRODUCTION TO CHEMISTRY LABORATORY**

Accompanies 1015-1016, where lab work is required in a student's curriculum. Must be taken concurrently and in phase with lecture sequence, 1015-1016. In both semesters, experiments illustrate principles covered in lecture. (Duplicates 1045-1046.) Co: 1015 for 1025; 1016 for 1026. (3L,1C)

### **1035-1036: GENERAL CHEMISTRY**

Principles of the science, character of the elements and their more important compounds, solution of chemical problems, and important applications. (Duplicates 1015-1016.) (3H,3C)

### **1035H,1036H: GENERAL CHEMISTRY**

More in-depth treatment of the principles of the science, character of the elements and their more important compounds, solution of chemical problems, and important applications. (Duplicates 1015-1016) (3H,3C)

### **1045-1046: GENERAL CHEMISTRY LAB**

Accompanies 1035-1036. Selected experiments illustrate principles taught in lecture. (Duplicates 1025-1026). Co: 1035 for 1045; 1036 for 1046. (3L,1C)

### **1055-1056: GENERAL CHEMISTRY FOR CHEMISTRY MAJORS**

In depth treatment of chemical bonding, thermodynamics, chemical equilibrium, reaction kinetics, descriptive chemistry of the elements, acid-base chemistry, chemistry of gases, liquids and solids, and other topics. This class is restricted to chemistry majors. Co: 1065 for 1055; 1066, 1066 for 1056. (4H,4C)

### **1055H-1056H: HONORS GENERAL CHEM FOR MAJORS**

More in-depth treatment of chemical bonding, thermodynamics, chemical equilibrium, reaction kinetics, descriptive chemistry of the elements, acid-base chemistry, chemistry of gases, liquids and solids, and other topics. This class is restricted to chemistry majors.

Co: 1065 for 1055H; 1066, 1066 for 1056H. (4H,4C)

### **1065-1066: GENERAL CHEMISTRY FOR CHEMISTRY MAJORS LAB**

Accompanies 1055-1056. Selected experiments illustrate principles taught in lecture. This class is restricted to chemistry majors. Co: 1055 for 1065; 1056 for 1066. (3L,1C)

### **2114: ANALYTICAL CHEMISTRY**

A first course in analytical chemistry. Topics covered include volumetric and gravimetric analysis, and elementary spectroscopy. Pre: 1036 or 1056. Co: 2124. (3H,3C)

### **2124: ANALYTICAL CHEMISTRY LABORATORY TECHNIQUES AND PRACTICE**

Practical introduction to wet methods of quantitative chemical analysis based on fundamental chemical principles. CHEM 2124 may be substituted for CHEM 3124. Pre: (1046 or 1066), 2114. Co: 2114. (3L,1C)

### **2154: ANALYTICAL CHEMISTRY FOR CHEMISTRY MAJORS**

A one-semester course in analytical chemistry emphasizing the principles of equilibrium with examples from acid-base, complexation, solubility, and redox chemistry. The course also introduces the principles of spectroscopic, electrochemical, and chromatographic instrumentation. Pre: 1036 or 1036H or 1056 or 1056H. Co: 2164. 4H,4C)

### **2164: ANALYTICAL CHEMISTRY FOR CHEMISTRY MAJORS LAB**

A one-semester laboratory course in analytical chemistry that provides practical training in wet chemical methods, atomic and molecular spectroscopy, electrochemistry, and separations. Pre: 1046 or 1066. Co: 2154. (3L,1C)

### **2424: DESCRIPTIVE INORGANIC CHEMISTRY**

Application of fundamental principles in a systematic study of bonding and reactivity of the elements and their compounds. Pre: 1036 or 1056. (3H,3C)

2514: SURVEY OF ORGANIC CHEMISTRY

Short course in fundamentals of organic chemistry with emphasis on nomenclature, isomerism, and properties of organic compounds. Compounds of importance to biology and biochemistry stressed. (Prior credit for 2535 precludes credit for this course.) One year of Chemistry required. (3H,3C)

2535-2536: ORGANIC CHEMISTRY

Structure, stereochemistry, reactions, and synthesis of organic compounds. Pre: 1036 or 1056 for 2535; 2535 or 2565 for 2536. (3H,3C)

2545-2546: ORGANIC CHEMISTRY LABORATORY

The laboratory accompanies lectures in organic chemistry 2535 and 2536. Pre: 1046 or 1066 for 2545; 2545, (2536 or 2566) for 2546. Co: 2535 or 2565 for 2545; 2536 for 2546. (3L,1C)

2555-2556: ORGANIC SYNTHESIS AND TECHNIQUES LAB

Synthesis and characterization of organic compounds using modern laboratory techniques. II Pre: 2566 for 2555; 2555 for 2556. (6L,2C)

2565-2566: PRINCIPLES OF ORGANIC CHEMISTRY

Organic chemistry for chemistry majors. Structure and reactions of organic compounds, with emphasis on fundamental principles, theories, synthesis, and reaction mechanisms. The subject matter partially duplicates that of 2535-2536; no credit will be given for the duplicated courses. Pre: 1036 or 1056 for 2565; 2565 for 2566. (3H,3C)

2565H-2566H: PRINCIPLES ORG CHEM

More in-depth treatment of organic chemistry for chemistry majors. Structure and reactions of organic compounds, with emphasis on fundamental principles, theories, synthesis, and reaction mechanisms. The subject matter partially duplicates that of 2535-2536; no credit will be given for the duplicated courses. (3H,3C)

2964: FIELD STUDY

Pass/Fail only. Variable credit course.

2974: INDEPENDENT STUDY

Variable credit course.

2984: SPECIAL STUDY

Variable credit course.

3615-3616: PHYSICAL CHEMISTRY

Principles of thermodynamics, kinetics, and quantum mechanics applied to chemical equilibria, reactivity, and structure. Partially duplicates 4615, cannot receive credit for both 3615 and 4615. I,II,III. Pre: (1036 or 1056), PHYS 2306, MATH 2224 for 3615; 3615, 1036, MATH 2214, (PHYS 2306 or PHYS 2176) for 3616. (3H,3C)

3615H-3616H: HONORS PHYSICAL CHEMISTRY

More in-depth study of principles of thermodynamics, kinetics, and quantum mechanics as applied to chemical equilibria, reactivity, and structure. Partially duplicates 4615, cannot receive credit for both 3615H and 4615. 3615H requires additional work; consult the instructor. I,II,III Pre: 1036, (PHYS 2306 or PHYS 2176) for 3615H; 3615, 1036, MATH 2214, (PHYS 2306 or PHYS 2176) for 3616H. (3H,3C)

3625-3626: PHYSICAL CHEMISTRY LABORATORY

Laboratory study of selected physico-chemical principles and methods. Data acquisition, data analysis, and report writing are stressed. I,II Pre: 3615 or 4615 for 3625; 3616, 3625 for 3626. (3L,1C)

4014: SURVEY OF CHEMICAL LITERATURE

Use of the chemical literature as an aid to professional activities. I,II (1H,1C)

4074 (MSE 4544): LABORATORY IN POLYMER SCIENCE

Experimental techniques used in the synthesis of various linear polymers, copolymers, and crosslinked networks. Determination of polymer molecular weights and molecular weight distribution. Methods used in the thermal,

mechanical, and morphological characterization of polymeric systems. Graduate students in chemistry, P/F only.  
Pre: 3616, 4534. (1H,3L,2C)

#### 4114: INSTRUMENTAL ANALYSIS

Principles of instrumental methods including data analysis, phase equilibrium, spectroscopy, and electrochemistry. Applications of modern instrumentation to chemical analyses using chromatography, electrophoresis, atomic and molecular spectroscopy, potentiometry, and voltammetry. Note: Graduate students will not be expected to take the corequisite lab 4124. Pre: 3616. Co: 4124. (3H,3C)

#### 4114H: HONORS INSTRUMENTAL ANALYSIS

More in-depth treatment of principles of instrumental methods including data analysis, phase equilibrium, spectroscopy, and electrochemistry. Applications of modern instrumentation to chemical analyses using chromatography, electrophoresis, atomic and molecular spectroscopy, potentiometry, and voltammetry. Note: Graduate students will not be expected to take the corequisite lab 4124. Pre: 3616. Co: 4124. (3H,3C)

#### 4124: INSTRUMENTAL ANALYSIS LABORATORY

Hands-on experience with modern instrumental methods of analysis. Experiments use spectroscopy, electrochemistry, and separations. Co: 4114. (3L,1C)

#### 4404: PHYSICAL INORGANIC CHEMISTRY

A study of spectroscopic, bonding, and structural properties of inorganic compounds. I Co: 3616. (3H,3C)

#### 4414: INORGANIC CHEMISTRY LAB

Synthesis and characterization of inorganic compounds using modern laboratory techniques. II  
Pre: 4404. Co: 4424, 3616. (6L,2C)

#### 4514: GREEN CHEMISTRY

Green chemistry applies the principles of *prevention* of toxic and hazardous waste, and energy efficiency to real world chemical products and processes. Emphasis is on case studies, problem solving, and life cycle analysis. Pre: 2536 or 2566 (3H,3C).

#### 4524: IDENTIFICATION OF ORGANIC COMPOUNDS

Structure determination of organic compounds by spectroscopic methods, with an emphasis on mass spectrometry and nuclear magnetic resonance. Course will emphasize problem-solving skills. I. Pre: (2536 or 2566), (3616 or 4616). (3H,3C)

#### 4534: ORGANIC CHEMISTRY OF POLYMERS

Structure, synthesis, and basic characteristics of the major classes of polymerization reactions including step-growth (condensation) and chain growth (addition), free radical, and ionic mechanisms. Pre: 2536 or 2566. (3H,3C)

#### 4554: DRUG CHEMISTRY

Structure, synthesis, and physiological effects of major classes of pharmaceutical agents including CNS depressants and stimulants, analgesics, anesthetics, cardiovascular agents, chemotherapeutic drugs, and oral contraceptives. II  
Pre: 2536 or 2566. (3H,3C)

#### 4615-4616: PHYSICAL CHEMISTRY FOR THE LIFE SCIENCES

Principles of thermodynamics, chemical kinetics, and chemical bonding for students in the life sciences. 4615: Laws and applications of thermodynamics. 4616: Chemical kinetics and chemical bonding including spectroscopy. Partly duplicates 3615, cannot receive credit for 3615 and 4615. Pre: One year of chemistry, physics, and calculus. (3H,3C)

#### 4634 (MSE 4534): POLYMER AND SURFACE CHEMISTRY

Physical chemical fundamentals of polymers and surfaces including adhesives and sealants. II Pre: 3615 or 4615. (3H,3C)

#### 4654: ADHESIVE AND SEALANT SCIENCE

Introduction to the fundamental and practical aspects of adhesives and sealants. Emphasis on synthesis of polymeric adhesive and sealant molecules, determination of physical properties of adhesives and sealants, chemical and physical characteristics of adherend surfaces, and mechanical behavior and durability of bonded systems – including

metals, composites, polymers, and wood. I Pre: (3615 or 4615). (3H,3C)

4734 (CSES 4734) (ENSC 4734): ENVIRONMENTAL SOIL CHEMISTRY

Chemistry of inorganic and organic soil components with emphasis on environmental significance of soil solution-solid phase equilibria, sorption phenomena, ion exchange processes, reaction kinetics, redox reactions, and acidity and salinity processes. Pre: CSES 3114, CSES 3124, CHEM 2514 or CHEM 2535, CHEM 3114, MATH 2015. (3H,3C) I.

4754 (CSES 4754) (ENSC 4754): INSTRUMENTAL ANALYSIS FOR AGRICULTURAL AND ENVIRONMENTAL SCIENCES

Theory and principles of common analytical instruments and their applications to agriculture and environmental science research. Topics include atomic absorption and emission spectroscopy, spectrophotometric methods (UV, visible, luminescence, and automation), chromatography, ion-selective electrodes, and microwave digestion.

Infrared spectroscopy, atomic ratio and molecular mass spectroscopy, nuclear magnetic resonance will also be included. Provides hands-on experience with modern analytical instruments. Prerequisites or graduate standing required. II Pre: (3114, 3124) or (CSES 3114, CSES 3124). (3H,3L,4C)

4964: FIELD STUDY

Pass/Fail only. Variable credit course.

4974: INDEPENDENT STUDY

Variable credit course.

4984: SPECIAL STUDY

Variable credit course. X-grade allowed.

4994: UNDERGRADUATE RESEARCH

Variable credit course.