Annual Assessment Plan - Chemistry

Mission of the Major:

The major in chemistry provides students the opportunity and the guidance to build for themselves a foundation in the fundamental area of chemistry, the study of matter. Students engage in active learning as they apply the scientific method towards understanding the natural world. Students think critically when evaluating data as well as issues related to chemistry in society, and they learn to write and speak effectively about science and scientific issues. Students are prepared for a variety of careers as well as advanced study in graduate school.

Program objectives:

1. Provide students the opportunity and the guidance to learn the fundamental principles of chemistry.
2. Engage students in practicing the process of science – planning, executing, and evaluating.
3. Train students to communicate scientific work in a clear, coherent manner in both written and oral form.
4. Help students to understand the importance of diversity in the practice of science through collaborative learning where different perspectives are valued and evaluated.
5. Challenge students to think critically and quantitatively in evaluating data and to apply that skill to issues arising in the world around them, including ethical conflicts surrounding particular scientific theories, technologies, or applications.

1. Alignment with the Wells College Academic Program Goals:

Alignment of Chemistry goals with the Wells Academic Program Goals

	Chemistry Goal				
Wells APG	1	2	3	4	5
1					✓
2	✓	✓			
3			✓		
4				✓	
5					
6				✓	
7				✓	
8	✓	✓		✓	✓

Alignment of BCS Goals, Program Objectives and Learning Outcomes

<u>Goal 1:</u> Provide students the opportunity and the guidance to learn the fundamental principles of chemistry.

<u>Program Objective 1</u>: ***Knowledge*****.** Students will acquire a working knowledge of basic principles and critical information in the chemical sciences.

Learning Outcome: Students' working knowledge of basic principles is assessed through exams, projects, case studies, problem sets and laboratory reports.

<u>Goal 2:</u> Engage students in practicing the process of science – planning, executing, and evaluating.

<u>Program Objective 2</u>: ***Critical Thinking***. Students will develop creative and critical thinking as they apply scientific reasoning toward understanding the natural world.

Learning Outcome: Students participate in inquiry-based lab activities, engage in case studies, analyze problem sets, and conduct directed and independent research projects, culminating in a senior thesis.

<u>Goal 3</u>: Train students to communicate scientific work in a clear, coherent manner in both written and oral form.

<u>Program Objective 3</u>: ***Skills***. Students will be active participants in learning the skills necessary for work in the fields of biology and chemistry.

Learning Outcomes: As Chemistry majors students learn
a) basic laboratory and field techniques, including appropriate qualitative/quantitative analysis.
b) to work in collaboration with others
c) to apply the scientific method to investigate the natural world
d) to use, evaluate, and appropriately cite the scientific literature
e) to communicate the results of scientific investigation (oral and/or written)
f) to recognize that many problems require cross-disciplinary approaches

<u>Goal 4</u>: Help students to understand the importance of diversity in the practice of science through collaborative learning where different perspectives are valued and evaluated.

<u>Program Objective 4</u>: ***Interconnectedness and Diversity***. Students will learn to recognize and appreciate the diversity of the natural world and the interconnectedness of disciplinary approaches towards studying it.

Learning Outcome: Students work in groups, allowing them to appreciate the importance of different perspectives and ideas to solving scientific problems.

<u>Goal 5:</u> Challenge students to think critically in evaluating data and to apply that skill to issues arising in the world around them, including ethical conflicts surrounding particular scientific theories, technologies, or applications.

<u>Program Objective 5</u>: ***Social relevance***. Students will develop an understanding of issues related to biology and chemistry in society.

Learning Outcome: Students consider the applications of science in society through case studies and real world scenarios that explore different social, political and ethical viewpoints.

<u>Means of Assessment of Outcomes</u>

Student artifacts will be continually collected throughout the academic year by the faculty member teaching the targeted courses. Each faculty member will evaluate if the students learned what was expected, based on each assignment. Percentages of how well the student answered/completed the activity will be calculated, and students will be considered proficient if 70% of the students demonstrated a passing grade on the assessed activity. This proficiency simply allows the faculty to assess student learning based on the completed activity, and is not tied to the final grade in the course, which may contain other determinates such as attendance and participation in class.

<u>How Assessment Data will be utilized</u>

<u>Specific Course Objectives and Assessment Measures for Required Courses</u>

The alignments with the overall Chemistry program objectives is a focus for the 2015-2016 school year.

CHEM 107L - General Chemistry

1. Think about/understand nature at the atomic and molecular level. (1,2,3a,3b,3c,3f)

See, for example, answer key to Exam #1 (28 September, 2006), questions 3 & 6
See, for example, answer key to Final Exam (December 11, 2006), questions 3, 4 &7

2. Understand and use the mathematics of chemistry. (1,2,3a,3b,3c,3f)

See, for example, answer key to Exam #1 (28 September, 2006), questions 1, 2, 4 & 5
See, for example, answer key to Final Exam (December 11, 2006), questions 1, 5 & 6

3. Understand the role of energy (heat and electromagnetic radiation) in determining the properties of atoms and molecules. (1,2,3a,3b,3c,3f)

See, for example, answer key to Final Exam (December 11, 2006), questions 1, 2 &7

4. Effectively perform laboratory experiments and then clearly communicate the goals and results of these experiments to an outside audience. (1,2,3a-f,5)

See, for example, "Writing for General Chemistry Laboratories"; handout shows what is expected of students.
See, for example, "Slake, Smelt & Slake, Ltd."; example of letter from client, plus lab instructions
See, for example, "GenChemCo Industries" letters; first letter shows a well-written student letter with my comments; second letter is example of a less-well-written student letter (no comments are given on this one as this letter is used during peer-editing exercise).

CHEM 108L - Chemical Analysis

1. Continue to work on the goals from Chem 107L (1,2, 3a-f,5)
2. Understand the dynamic and predictive properties of chemistry. (1,2,3a,3b,3c,3f)

See, for example, Chem 108L Exam #1 (8 March 2007), questions 1, 2, 3, 4 & 5

CHEM 213L - Organic Chemistry I

Chemistry 213L is the first semester of a two-semester lecture and laboratory class. The lecture portion of the class teaches students the fundamental concepts in organic chemistry. In the laboratory section students practice important techniques used in the organic chemistry lab. A pre-requisite for the course is general chemistry (Chem108L), and students in the class are typically in their sophomore year. This is a core class in the BCS major and is taken by students in all three major concentrations.

1. *Recognize how the structure of carbon based molecules can aid in predicting reactivity, including acid/base and nucleophile/electrophile chemistry.(1,3b,3c)*
   - These are assessed on the in-class exams and quizzes. I have given a specific example from one of the exams. Questions 5 and 6 test the students' knowledge of acids/bases as well as nucleophiles.

- Relevant artifacts:
    - Chem213L final exam - Questions 5 and 6
    - Chem213L in-class exam #3 - Questions 8, 9, and 10

2. *Evaluate how organic chemistry plays a role in our lives and how it is all around us. (1,2,3c,3f,4,5)*
    - I typically use case-studies and in-class exercises that the students work on in groups. The exercises are not typically collected, but the worksheets the students are given illustrate how this objective is met.
    - Relevant artifacts:
        - Rubbers and Raincoats in-class exercise*
        - A Case-study: Thalidomide: The pros and cons*
3. *Become familiar with the techniques used by an organic chemist in the lab and learn how to keep a good lab notebook. (1,2,3a,3d,3f)*
    - Keeping a good lab notebook is essential for scientists and the students' ability to write in one is assessed by grading them. Each laboratory exercise teaches the students a new technique in organic chemistry.
    - Relevant artifacts:
        - Chem213L Lab Notebook sheet and grading rubric
        - Week 1 – Introduction to Techniques in the Organic Chemistry Lab (technique: melting point) and example lab notebook
        - Week 2 – Fractional Distillation (technique: distillation) and example lab notebook*
        - Week 3 – Extraction and Crystallization of Benzoic Acid and Triphenylmethane (techniques: extraction, crystallization) and example lab notebook*
        - Week 4 and 5 – Extraction of Caffeine from Tea (techniques: extraction, sublimation, thin layer chromatography) and example lab notebook*
4. *Identify trends in mechanisms and reactivity to reduce the amount of memorization needed (1,2,3b).*
    - There are a number of reactions that must be learned in organic chemistry. To aid the students in recognizing trends, they must complete a reaction notebook. This exercise highlights important trends in reactivity as well as reaction mechanisms.
    - Relevant artifacts:
        - List of topics/information needed in your notebook
        - Chem213L Student Reaction Notebook
5. *Work together to solve a problem that has not been previously encountered and present the information to the class. (3a,3b,3c,3e)*
    - In their final lab project, students are given a new reaction that they have not previously seen in lab. They are to use the skills developed previously in lab as well as the knowledge gained in class to work through the problem. The information must be presented to the class.
    - Relevant artifacts included:
        - Chem213L Final Lab Project handout
        - Chem213L student grading rubric and presentation
        - Chem213L Acid catalyzed hydration of 1-hexene and student presentation
        - Chem213L Oxymercuration/reduction of 1-hexene and student lab notebook
        - Chem213L Free Radical Polymerization Reactions and student lab notebook

6. *Work through a series of organic transformations in the lab and in class (a multi-step reaction sequence). (1,2,3a,3c,3d)*
   - These are assessed both in the lab and in-class on the exams, quizzes and in-class exercises.
   - Relevant artifacts:
     - Chem213L – in-class exercises*
     - Chem213L – Synthesis of Aspirin from Oil of Wintergreen*
7. *Apply knowledge of reactions learned in class to laboratory exercises. (1, 3a-c)*
   - This is actually done in a number of the labs, but I will give a specific example.
   - Relevant artifacts:
     - Chem213L – Acid catalyzed hydration of 1-hexene and student lab notebook

CHEM 214L - Organic Chemistry II

Chemistry 214L is the second semester of a two-semester lecture and laboratory class. The lecture portion of the class teaches students the fundamental concepts in organic chemistry. In the laboratory section students practice important techniques used in the organic chemistry lab and learn how to search the primary scientific literature. A pre-requisite for the course is the first semester of organic chemistry (Chem213L), and students in the class are typically in their sophomore year. This is a core class in the BCS major and is taken by students in all three major concentrations.

1. *Recognize how the structure of carbon based molecules can aid in predicting reactivity, including acid/base and nucleophile/electrophile chemistry.(1,3b,3c)*
   - These are assessed on the in-class exams and quizzes. I have given a specific example from one of the exams.
   - Relevant artifacts:
     - Chem214L Final exam – question 1
2. *Evaluate how organic chemistry plays a role in our lives and how it is all around us. (1,2,3c,3f,4,5)*
   - Here I show how handouts are used to relate information to students as well as how exams and labs are used to test the ability of the students' ability to work through problems relevant to their lives.
   - Relevant artifacts:
     - Chem214L Final exam - Question 6
     - Chem214L – Multi-step synthesis of N-methyl prozac and student lab notebook*
     - Chem214L – Useful chemistry… making soap and student lab notebook*
3. *Become familiar with the techniques used by an organic chemist in the lab and learn how to keep a good lab notebook. (1,2,3a,3d,3f)*
   - In order to illustrate some of the important spectrophotometric techniques used in organic chemistry, I have the supplement my lecture with in-class exercises that are completed as the lecture progresses.
   - Relevant artifacts:
     - Chem214L – ^{1}H-NMR worksheets*
4. *Identify trends in mechanisms and reactivity to reduce the amount of memorization needed (1,2,3b).*

- There are a number of reactions that must be learned in organic chemistry. To aid the students in recognizing trends, they must complete a reaction notebook. This exercise highlights important trends in reactivity as well as reaction mechanisms.
- Relevant artifacts:
    - Chem214L Student Reaction Notebook

5. *Work together to solve a problem that has not been previously encountered and present the information to the class. (3a,3b,3c,3e)*
    - In their final lab project, students are given a new reaction that they have not previously seen in lab. They are to use the skills developed previously in lab as well as the knowledge gained in class to work through the problem. The information must be presented to the class. They must also identify a viable alternative synthesis to the one they will be carrying out using the primary scientific literature.
    - Relevant artifacts included:
        - Chem214L Final Project - Presentation handout and grading rubric
        - Chem214L Student rubric and presentation (3-Step Preparation of Polystyrene from Ethylbenzene)
6. *Work through a series of organic transformations in the lab and in class (a multi-step reaction sequence). (1,2,3a,3c,3d)*
    - These are assessed both in the lab and in-class on the exams, quizzes and in-class exercises.
    - Relevant artifacts:
        - Chem214L Final exam - Question 4
        - 2-Step Semi-microscale Preparation of a Cinnamate Ester Analog instruction sheet and student lab notebook
7. *Apply knowledge of reactions learned in class to laboratory exercises. (1, 3a-c)*
    - This is actually done in a number of the labs, but I will give a specific example of how the NMR lectures and worksheets are integrated into the labs.
    - Relevant artifacts:
        - Addition of I_2 to 4-pentenoic acid – with a twist! and student lab notebook*
8. *Identify synthetic routes to complex molecules using reactions encountered in class. (1,2)*
    - Assessing the students' ability to do this is done using exams, quizzes and in-class exercises. A few examples are given below:
        - Exam Question 10
        - Chapter 15 in-class exercise – Diels-Alder Reactions
        - Chapter 10 in-class exercise – Retrosynthesis
        - Electrophilic Aromatic Substitution in-class exercise
9. *Choose a problem to study in the lab and design methods using the primary scientific literature to solve the problem utilizing the scientific method. (1,2,3a-f)*
    - The students are first given a worksheet describing how to examine the scientific literature. Their ability to search and use the primary literature is done through the writing of a proposal, where they must use and properly cite references.
    - Relevant artifacts:
        - Chem214L library worksheet
        - Chem214L final project overview
        - Chem214L final project synthetic proposal
        - Chem214L – example of a final project (grading rubric and proposal) – Preparation of Polystyrene from Ethylbenzene