Proposed Learning Goals and Outcomes: Chemistry Major

Our departmental evaluation of the degree to which students are achieving our learning outcomes, which is intended primarily as a tool for us to assess the effectiveness of our program, will take place primarily during their involvement in CHEM 0389: Senior Seminar in Chemistry. In that course, each student will assemble a portfolio documenting their achievements during their college career. We anticipate that the portfolio will include a section related to each of the goals identified below, with each section being introduced by a narrative that describes the materials presented, links them to specific outcomes, and assesses the student's achievement of each outcome. While we expect that most students will be able to provide appropriate supporting evidence from their coursework, in some cases (e.g. if the student did poorly on assignments related to particular outcomes) it would be appropriate for them to include additional essays summarizing their understanding of the material related to a particular outcome. For each outcome, the table below also includes a description of the standard that will be used in determining whether or not students have met that outcome.

Goal #1: Students will have a solid understanding of the basic principles of chemistry and introductory physics.

Learning Outcome	Method of Assessment	Standard for "Meets"	Courses
1.01 Students will have demonstrated the ability to explain the structure of matter (including molecules, atoms, and nuclei), and to distinguish between solids, liquids, gases, and solutions.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work reflect an understanding of atomic and molecular structure, and the forces that determine whether a substance exists as a solid, liquid or gas.	CHEM 0109 CHEM 0201, 0203 CHEM 0307 PHSC 0127
1.02 Students will have demonstrated the ability to describe some of the chemical and physical properties, and trends in those properties, of elements based on their position in the periodic table.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work reflect an understanding of the organization of the periodic table by various classifications and the similarities or trends in chemical and physical properties within those classifications.	CHEM 0109, 0111 PHSC 0127
1.03 Students will have demonstrated the ability to interpret chemical equations and to make stoichiometric calculations.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative reflects an understanding of the nature of chemical equations. Submitted work demonstrates the ability to write and balance chemical equations and make basic stoichiometric calculations relating reactants to products.	CHEM 0109 CHEM 0201, 0203

Proposed Learning Goals and Outcomes: Chemistry Major

1.04 Students will have demonstrated the ability to understand the mechanisms used to predict the products of organic chemical reactions.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work demonstrate that students can predict the outcomes of at least four classes of organic transformations (nucleophilic substitutions, electrophilic additions, etc.). At least two examples include a clear indication of the stereochemical outcomes of the reactions.	CHEM 0201, 0203
1.05 Students will have demonstrated the ability to explain acid-base chemistry, including the use of appropriate net ionic equations, and to perform acid-base calculations.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work reflect the ability to identify acids and bases, write chemical equations that describe their acid-base chemistry, perform simple acid-base calculations, and describe the factors that affect acid or base strength.	CHEM 0109, 0111 CHEM 0201
1.06 Students will have demonstrated the ability to describe oxidation-reduction reactions using appropriate chemical equations, to identify oxidation and reduction, and to apply those concepts to electrochemical cells.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work reflect an understanding of balancing oxidation-reduction chemical equations, identifying the oxidant and reductant, and designing simple electrochemical cells.	CHEM 0109, 0111 CHEM 0311 CHEM 0313
1.07 Students will have demonstrated the ability to explain the basic laws of thermodynamics and to apply those laws to chemical reactions.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work reflect an understanding of enthalpy, entropy, and Gibbs free energy and how they relate to the spontaneity of a reaction. The narrative or submitted work also demonstrates the ability to compare molecules and to determine which is more stable.	CHEM 0109, 0111 CHEM 0201, 0203 CHEM 0305 CHEM 0311 CHEM 0313 PHSC 0125

Proposed Learning Goals and Outcomes: Chemistry Major

1.08 Students will have demonstrated the ability to describe the chemical principles, methods and instrumentation used in chemical analysis.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work reflect an understanding of the chemical principles underlying volumetric, gravimetric, electrochemical, spectroscopic, and chromatographic methods of analysis.	CHEM 0109, 0111 CHEM 0203 CHEM 0311
1.09 Students will have demonstrated the ability to describe the factors that control the rates of chemical reactions.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work reflect an understanding of how the concentrations of reactants and products, temperature, and presence of a catalyst control the rate of a chemical reaction.	CHEM 0111 CHEM 0305 CHEM 0313
1.10 Students will have demonstrated the ability to explain the properties or reactivity of important biomolecules based on the structure of those molecules.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative reflects an understanding of the structure, properties and reactivity of biomolecules. Submitted work includes three instances where the student has explained how the structure of a molecule allows it to react in a specific way; for example, the bifunctional nature of amino acids allows amino acids to form bio-polymers.	CHEM 0313

Proposed Learning Goals and Outcomes: Chemistry Major

1.11 Students will have demonstrated the ability to explain Newton's laws of motion and to apply those laws to situations involving a variety of kinds of forces, including frictional, centripetal, gravitational, electrostatic and magnetic.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work provide examples of the application of each of Newton's laws of motion and show a familiarity with the concepts of speed, velocity, and acceleration. Student work includes examples of the use of free-body diagrams to show the forces acting on an object, and at least one example involving each of the following forces: frictional, centripetal, gravitational, electrostatic and magnetic forces.	CHEM 0305 PHSC 0125, 0127
1.12 Students will have demonstrated the ability to explain the nature of conservation laws in physics and chemistry (e.g. energy, momentum, atoms), and to apply those ideas in a variety of situations.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work provide examples that illustrate the laws of conservation of momentum and energy, including familiarity with the concepts of work, kinetic energy, gravitational potential energy, and electrical potential energy.	CHEM 0109 CHEM 0305 PHSC 0125, 0127
1.13 Students will have demonstrated the ability to explain basic principles of electricity and magnetism, and to apply those ideas to simple electrical circuits and devices.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work demonstrate an understanding of the parameters for simple electrical circuits (voltage, current, resistance, power) and of Ohm's Law and its application to both series and parallel circuits	CHEM 0111 CHEM 0311 PHSC 0127

Proposed Learning Goals and Outcomes: Chemistry Major

1.14 Students will have demonstrated the ability to describe wave phenomena, including an explanation of the properties of sound and light.	Students will submit responses to exam questions, homework problems or class activities where they have utilized this knowledge.	Narrative and submitted work demonstrate a clear understanding of the different types of waves (transverse, longitudinal), the properties of waves (velocity, frequency, wavelength, amplitude, period) and some important wave behaviors (reflection, refraction, interference, Doppler effect).	CHEM 0109 CHEM 0307 PHSC 0125, 0127

Proposed Learning Goals and Outcomes: Chemistry Major

Goal #2: Students will develop effective laboratory skills and will understand safety issues related to laboratory work.

Learning Outcome	Method of Assessment	Standard for "Meets"	Course(s)
2.01 Students will have demonstrated the ability to perform a variety of measurements, using a variety of instruments and an awareness of the uncertainties inherent in any measurement.	Students will submit laboratory reports or notebooks for which they made appropriate measurements.	Narrative and submitted work include instances where the student performed at least six different kinds of measurements, and demonstrates an understanding of the errors associated with those measurements.	CHEM 0109, 0111 CHEM 0201, 0203 CHEM 0307 CHEM 0311 CHEM 0350 PHSC 0125, 0127
2.02 Students will have demonstrated the ability to perform a variety of basic procedures in the chemistry lab, including weighing samples, titration, …	Students will submit laboratory reports or notebooks showing that they have performed such procedures correctly.	Narrative and submitted work demonstrate an understanding of several procedures, including determining sample mass, titration, and determining pH.	CHEM 0109, 0111 CHEM 0201, 0203 CHEM 0307 CHEM 0311
2.03 Students will have demonstrated the ability to keep accurate and detailed records of what was done during experiments.	Students will submit laboratory reports or notebooks with such records.	Narrative reflects an understanding of the record-keeping needed for laboratory work. Submitted work includes at least one laboratory report, for a moderately involved experiment, that demonstrates these abilities.	CHEM 0109, 0111 CHEM 0201, 0203 CHEM 0307 CHEM 0311 CHEM 0350 PHSC 0125, 0127
2.04 Students will have demonstrated the ability to practice the basic principles of safety in the laboratory, including the use of material safety data sheets.	Students will submit laboratory notebooks where they noted pertinent safety information, and will submit answers to a safety test.	Narrative and submitted work demonstrate a familiarity with MSDSs, and include a safety test on which all questions were either answered correctly or were addressed in a separate essay.	CHEM 0109, 0111 CHEM 0201, 0203 CHEM 0307 CHEM 0350 CHEM 0311

Proposed Learning Goals and Outcomes: Chemistry Major

Goal #3: Students will understand the methodology and processes of science.

Learning Outcome	Method of Assessment	Standard for "Meets"	Course(s)
3.01 Students will have demonstrated the ability to use the methodology of science, including the processes of observation, forming hypotheses, making predictions based on hypotheses, testing of those predictions, and evaluation of the results.	Students will submit laboratory reports where they have engaged in the various processes of science.	Narrative and submitted work reflect a clear understanding of the methodology of science and submitted work includes laboratory reports that provide at least one example for each of the processes where the student successfully engaged in that process.	CHEM 0109, 0111 CHEM 0201 CHEM 0350 PHSC 0125
3.02 Students will have demonstrated the ability to distinguish between hypotheses and scientific theories, and will be able to explain some of the evidence that underpins major theories of chemistry.	Students will submit answers to exam questions or papers demonstrating their knowledge of major chemical theories.	Narrative and submitted work demonstrate an understanding of the nature of scientific theories, and includes discussion of the evidence that underpins at least two such chemical theories (e.g. atomic nature of matter, kinetic theory of gases)	CHEM 0109, 0111 PHSC 0125, 0127

Proposed Learning Goals and Outcomes: Chemistry Major

Goal #4: Students will be able to relate their scientific knowledge to both the natural and technological worlds around them, and will be able to apply those understandings to develop informed opinions about societal issues with a scientific component.

Learning Outcome	Method of Assessment	Standard for "Meets"	Course(s)
4.01 Students will have demonstrated the ability to provide specific examples of situations where scientific principles can explain particular events in the natural world.	Students will submit responses to exam questions or homework problems that demonstrate their ability to make such explanations.	Narrative and submitted work demonstrate an understanding of at least three natural phenomena based on principles of chemistry and/or physics.	CHEM 0109, 0111 GNSC 0330 PHSC 0125, 0127
4.02 Students will have demonstrated the ability to provide specific examples of the application of scientific principles to technology.	Students will submit responses to exam questions or homework problems that demonstrate their knowledge of such applications.	Narrative and submitted work demonstrate an understanding of at least three technological applications of basic principles of chemistry and/or physics.	CHEM 0109, 0111 CHEM 0311 GNSC 0330 PHSC 0125, 0127
4.03 Students will have demonstrated the ability to analyze the chemistry associated with issues like global warming, radioactivity, and acid rain.	Students will submit responses to homework problems, exam questions or papers where they have made such analyses.	Narrative and submitted work identify at least two social/environmental issues with a scientific component, and demonstrate an understanding of the basic chemistry that is involved.	CHEM 0109, 0111 CHEM 0201, 0203 GNSC 0330

Proposed Learning Goals and Outcomes: Chemistry Major

Goal #5: Students will be able to make effective use of mathematical reasoning to solve scientific problems.

Learning Outcome	Method of Assessment	Standard for "Meets"	Course(s)
5.01 Students will have demonstrated the ability to utilize graphs to analyze and understand the phenomenon being investigated	Students will submit homework problems, laboratory reports or exam questions where they have demonstrated these skills.	Narrative and submitted work include at least two examples of situations where the student has demonstrated the ability to utilize graphical representations of data, including an interpretation of the slope of a best-fit line.	CHEM 0109, 0111 CHEM 0305, 0307 CHEM 0311 CHEM 0313 PHSC 0125, 0127
5.02 Students will have demonstrated the ability to use dimensional analysis to determine the appropriate units for an unknown quantity.	Students will submit exam questions, laboratory reports, and/or homework problems where they have demonstrated this skill.	Narrative and submitted work include at least two examples of problems where the student was able to work out the units for an unknown quantity.	CHEM 0109, 0111 CHEM 0305, 0307 CHEM 0311 PHSC 0125, 0127
5.03 Students will have demonstrated the ability to solve algebraic equations for an unknown quantity and to calculate that quantity given appropriate information.	Students will submit exam questions and/or homework problems where they have demonstrated these skills.	Narrative and submitted work include at least five examples (involving five different equations) of situations where the student has demonstrated these skills.	CHEM 0109, 0111 CHEM 0305, 0307 CHEM 0311 PHSC 0125, 0127
5.04 Students will have demonstrated the ability to apply basic ideas from differential and integral calculus to solve chemistry and physics problems, including those involving reaction rates and thermodynamics.	Students will submit exam questions and/or homework problems where they have demonstrated these skills.	Narrative and submitted work include at least three examples (involving three different applications of calculus) of situations where the student demonstrated these skills.	CHEM 0109, 0111 CHEM 0305, 0307 CHEM 0311 PHSC 0125, 0127

Proposed Learning Goals and Outcomes: Chemistry Major

Goal #6: Students will develop effective written skills.

Learning Outcome	Method of Assessment	Standard for "Meets"	Course(s)
6.01 Students will have demonstrated the ability to accurately record the details of what was performed and the results that were observed during an experiment.	Students will submit copies of laboratory notes demonstrating these qualities, along with comments/grades from their instructor.	Narrative reflects an understanding of the need for careful observation and record-keeping during experiments. Submitted work includes at least two examples of laboratory notes demonstrating these competencies.	CHEM 0201, 0203 CHEM 0307 CHEM 0311 PHSC 0125, 0127
6.02 Students will have demonstrated the ability to write brief, formal experimental reports describing their work in the laboratory.	Students will submit copies of laboratory reports demonstrating these qualities, along with comments/grades from their instructor.	Narrative reflects an understanding of the key features of formal laboratory reports. Submitted work includes at least one high-quality formal laboratory report.	CHEM 0201, 0203 CHEM 0307 CHEM 0311 PHSC 0125, 0127

The grid below summarizes how the major coursework contributes to the individual goals described above for students in the CHEMISTRY MAJOR:

	General Chemistry I	General Chemistry II	Organic Chemistry I	Organic Chemistry II	Advanced Inorganic	Physical Chemistry I	Physical Chemistry II	Instrumental Analysis	Biochemistry	Theor/Exp Research	Physics I	Physics II	Current Topics Seminar	Science, Tech, Society
1. Basic principles	X	X	X	X		X	X	X	X		X	X		
2. Laboratory skills	X	X	X	X			X	X		X	X	X		
3. Methodology of science	X	X	X							X	X	X		
4. Apply to social issues	X	X		X				X			X	X	X	X
5. Mathematical reasoning	X	X				X	X	X	X		X	X		
6. Written communication			X	X			X	X			X	X		