

**SLOs and Criteria for the General Education Science Requirement
for Courses with CHEM or GEOL Prefixes**

Course	Gen Ed Science Criteria		
	1	2	3
CHEM 101 Consumer Chemistry	X	X	X
CHEM 111 Introductory Chemistry Lab	X	X	X
CHEM 112 Introductory Organic and Biological Chemistry Lab	X	X	X
CHEM 113 Introductory Chemistry	X	X	X
CHEM 114 Introductory Organic and Biological Chemistry	X	X	X
CHEM 131 General Chemistry I Lab	X	X	X
CHEM 132 General Chemistry II Lab	X	X	X
CHEM 133 General Chemistry I	X	X	X
CHEM 134 General Chemistry II	X	X	X
CHEM 203 General Science for Elementary Teachers	X	X	X
GEOL 111 Introduction to Geology	X	X	X

1. Promotes Quantitative Literacy Through Analysis of Empirical Evidence

Science advances through observation or experiment, carefully designed to eliminate bias and test hypotheses.

2. Results Applied Within a Larger Framework

Science consists not only of the accumulation of isolated data and hypotheses, but of interpreting any new information within a larger body of scientific knowledge.

3. Promotes Critical Thinking Through Evaluation

Science evolves as a process of evaluating evidence, articulating arguments, justifying conclusions, and identifying and presenting multiple perspectives.

CONSUMER CHEMISTRY LEARNING OUTCOME SET	Gen Ed Science Criteria		
CHEM 101 Consumer Chemistry	1	2	3
Learning Objective 1. Science Relevance			
1.1 Students will find satisfaction in engaging in real-world issues that require knowledge of chemistry. <i>Example:</i> With confidence, students examine news articles on energy crises and energy conservation measures and interpret the accuracy of such reports.		X	
1.2 Students will perceive value in the understanding of chemistry as a result of relevance to their lives.		X	
1.3 Students will become motivated as life-long learners of chemistry (and of science).		X	
Learning Objective 2. Science Literacy			
2.1 Students will learn the chemical principles that underlie the real-world and pressing issues of our world today. <i>Example:</i> Students explain the methods used to gather past evidence for global warming.	X		
2.2 Students will be able to locate scientific information needed for a better understanding of these issues. <i>Example:</i> Interpret values of the color-coded Air Quality Index and know how to assess local air quality data from the EPA.	X		
2.3 Students will develop the critical thinking skills needed to analyze the many dimensions of these issues. <i>Example:</i> Compare and contrast indoor and outdoor air, in terms of which pollutants are likely to be present and their relative amounts.			X
2.4 Students will develop the ability to assess risks and benefits of different scenarios. <i>Example:</i> Evaluate the risks and benefits associated with petroleum, coal, and natural gas as fossil fuel energy sources.			X

Learning Objective 3. Science Application

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| 3.1 Students will develop the skills (analytic and critical judgment) needed to use scientific information to make informed decisions. | X |
| 3.2 Students will be able to respond with reasoned and informed intelligence to issues in local communities, regionally, nationally, and in larger global communities. | X |

Learning Objective 4. Science and Sustainability

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| 4.1 Students will evaluate chemical processes using the concepts of green chemistry. | X |
| <i>Example:</i> Students evaluate articles on green chemistry alternatives to stratospheric ozone-depleting compounds and recognize the effect that market forces have on the success of these innovations. | |
| 4.2 Students will connect their knowledge of sustainability from other courses to content in their chemistry course. | X |
| 4.3 Students will understand the urgency of working towards using natural resources in sustainable ways. | X |
| 4.4 Students will take actions based on this understanding, taking up the challenge of safeguarding the interests of coming generations. | X |
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INTRODUCTORY CHEMISTRY LEARNING OUTCOME SET	Gen Ed Science Criteria		
CHEM 113/111 Introductory Chemistry Lecture and Lab	1	2	3
Learning Objective 1. Foundational Chemical Knowledge			
Students demonstrate foundational knowledge of fundamental principles of chemistry including the structure of matter, stoichiometry, periodicity, bonding and reactivity.			
Outcome 1.1 Structure of Matter Students demonstrate knowledge of atomic and molecular structure.	X	X	X
Outcome 1.2 Stoichiometry Students demonstrate knowledge of chemical stoichiometry.	X	X	X
Outcome 1.3 Periodicity Students demonstrate knowledge of chemical periodicity.	X	X	X
Outcome 1.4 Bonding Students demonstrate knowledge of chemical bonding.	X	X	X
Outcome 1.5 Reactivity Students demonstrate knowledge of chemical reactivity.	X	X	X
Outcome 1.6 Chemical Equilibrium Students demonstrate knowledge of chemical equilibrium.	X	X	X
Learning Objective 2. Quantitative Literacy through Analysis of Empirical Evidence			
Students demonstrate the ability to analyze quantitative empirical data and reach conclusions based on that data.			
Outcome 2.1 Data Analysis Students demonstrate the ability to analyze data in various forms, especially graphical data, and evaluate the appropriateness of data to answer a particular question.	X	X	X
Outcome 2.2 Evaluation of Hypotheses Students demonstrate the ability to identify what evidence might be required to assess a given hypothesis, how to revise such a hypothesis in light of empirical results, and to decide what additional observations might be needed.	X	X	X

Outcome 2.3 Inductive Method and Experimental Procedures Students demonstrate the ability to integrate inductive methods and experimental procedures, including use of laboratory practices and methods applicable to the development of analytic procedures that reinforce the students' mathematical competence.	X	X	X
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Learning Objective 3. Integration and Application of Chemical Knowledge

Students demonstrate the ability to interpret and apply new information within a larger body of scientific knowledge.

Outcome 3.1 Chemistry and Society Students demonstrate the ability to connect scientific knowledge with other aspects of modern society, especially technological, historical, or ethical issues that rest on a body of scientific understanding.	X	X	X
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Outcome 3.2 Formulating and Testing Theories Students demonstrate the ability to evaluate relationships, both between chemistry and other disciplines and within chemistry itself, by using the natural sciences as a basis for building and testing theories.	X	X	X
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Outcome 3.3 Application of Scientific Thinking Students demonstrate the ability to apply scientific thinking to questions outside the natural sciences, where a scientific viewpoint may be essential to understanding an issue or dilemma and proposing practical solutions to such problems.	X	X	X
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Learning Objective 4. Critical Thinking through Evaluation

Students demonstrate the ability to evaluate evidence, articulate arguments, justify conclusions, and present multiple perspectives.

Outcome 4.1 Evaluation of Scientific Explanations Students demonstrate the ability to evaluate a proposed scientific explanation, critique its practice of science, and decide whether scientific reasoning is appropriate for the particular question involved.	X	X	X
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Outcome 4.2 Evaluation and Modification of Scientific Theories Students demonstrate the ability to evaluate major theories involved in chemistry and to assess the extent to which empirical evidence may modify those theories.	X	X	X
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INTRODUCTORY CHEMISTRY LEARNING OUTCOME SET	Gen Ed Science Criteria		
CHEM 114/112 Introductory Organic and Biological Chemistry Lecture and Lab	1	2	3
Learning Objective 1. Foundational Organic Chemical Knowledge			
Students demonstrate foundational knowledge of fundamental principles of organic chemistry including the structure, nomenclature, properties, and reactions of the common classes of organic compounds.			
Outcome 1.1 Structure of Organic Compounds Students demonstrate knowledge of structures of the common classes of organic compounds.	X	X	X
Outcome 1.2 Nomenclature of Organic Compounds Students demonstrate knowledge of nomenclature of the common classes of organic compounds.	X	X	X
Outcome 1.3 Properties of Organic Compounds Students demonstrate knowledge of properties of the common classes of organic compounds.	X	X	X
Outcome 1.4 Reactions of Organic Compounds Students demonstrate knowledge of reactions of the common classes of organic compounds.	X	X	X
Learning Objective 2. Foundational Biological Chemical Knowledge			
Students demonstrate foundational knowledge of fundamental principles of biological chemistry including the structural aspects, nomenclature, properties, and reactions of proteins, carbohydrates, lipids, and nucleic acids.			
Outcome 2.1 Structure Aspects of Biological Compounds Students demonstrate knowledge of structures of proteins, carbohydrates, lipids, and nucleic acids.	X	X	X
Outcome 2.2 Nomenclature of Biological Compounds Students demonstrate knowledge of nomenclature of proteins, carbohydrates, lipids, and nucleic acids.	X	X	X
Outcome 2.3 Properties of Biological Compounds Students demonstrate knowledge of properties of proteins, carbohydrates, lipids, and nucleic acids.	X	X	X

Outcome 2.4 Reactions of Biological Compounds Students demonstrate knowledge of reactions of proteins, carbohydrates, lipids, and nucleic acids.	X	X	X
Learning Objective 3. Quantitative Literacy through Analysis of Empirical Evidence Students demonstrate the ability to analyze quantitative empirical data and reach conclusions based on that data.			
Outcome 3.1 Data Analysis Students demonstrate the ability to analyze data in various forms, especially graphical data, and evaluate the appropriateness of data to answer a particular question.	X	X	X
Outcome 3.2 Evaluation of Hypotheses Students demonstrate the ability to identify what evidence might be required to assess a given hypothesis, how to revise such a hypothesis in light of empirical results, and to decide what additional observations might be needed.	X	X	X
Outcome 3.3 Inductive Method and Experimental Procedures Students demonstrate the ability to integrate inductive methods and experimental procedures, including use of laboratory practices and methods applicable to the development of analytic procedures that reinforce the students' mathematical competence.	X	X	X
Learning Objective 4. Integration and Application of Chemical Knowledge Students demonstrate the ability to interpret and apply new information within a larger body of scientific knowledge.			
Outcome 4.1 Chemistry and Society Students demonstrate the ability to connect scientific knowledge with other aspects of modern society, especially technological, historical, or ethical issues that rest on a body of scientific understanding.	X	X	X
Outcome 4.2 Formulating and Testing Theories Students demonstrate the ability to evaluate relationships, both between chemistry and other disciplines and within chemistry itself, by using the natural sciences as a basis for building and testing theories.	X	X	X

Outcome 4.3 Application of Scientific Thinking Students demonstrate the ability to apply scientific thinking to questions outside the natural sciences, where a scientific viewpoint may be essential to understanding an issue or dilemma and proposing practical solutions to such problems.	X	X	X
Learning Objective 5. Critical Thinking through Evaluation Students demonstrate the ability to evaluate evidence, articulate arguments, justify conclusions, and present multiple perspectives.			
Outcome 5.1 Evaluation of Scientific Explanations Students demonstrate the ability to evaluate a proposed scientific explanation, critique its practice of science, and decide whether scientific reasoning is appropriate for the particular question involved.	X	X	X
Outcome 5.2 Evaluation and Modification of Scientific Theories Students demonstrate the ability to evaluate major theories involved in chemistry and to assess the extent to which empirical evidence may modify those theories.	X	X	X

GENERAL CHEMISTRY LEARNING OUTCOME SET	Gen Ed Science Criteria		
CHEM 133/131 General Chemistry I Lecture and Lab	1	2	3
Learning Objective 1. Foundational Chemical Knowledge			
Students demonstrate foundational knowledge of fundamental principles of chemistry including the structure of matter, stoichiometry, periodicity, bonding and reactivity.			
Outcome 1.1 Structure of Matter Students demonstrate knowledge of atomic and molecular structure.	X	X	X
Outcome 1.2 Stoichiometry Students demonstrate knowledge of chemical stoichiometry.	X	X	X
Outcome 1.3 Periodicity Students demonstrate knowledge of chemical periodicity.	X	X	X
Outcome 1.4 Bonding Students demonstrate knowledge of chemical bonding.	X	X	X
Outcome 1.5 Reactivity Students demonstrate knowledge of chemical reactivity.	X	X	X
Learning Objective 2. Quantitative Literacy through Analysis of Empirical Evidence			
Students demonstrate the ability to analyze quantitative empirical data and reach conclusions based on that data.			
Outcome 2.1 Data Analysis Students demonstrate the ability to analyze data in various forms, especially graphical data, and evaluate the appropriateness of data to answer a particular question.	X	X	X
Outcome 2.2 Evaluation of Hypotheses Students demonstrate the ability to identify what evidence might be required to assess a given hypothesis, how to revise such a hypothesis in light of empirical results, and to decide what additional observations might be needed.	X	X	X

Outcome 2.3 Inductive Method and Experimental Procedures Students demonstrate the ability to integrate inductive methods and experimental procedures, including use of laboratory practices and methods applicable to the development of analytic procedures that reinforce the students' mathematical competence.	X	X	X
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Learning Objective 3. Integration and Application of Chemical Knowledge

Students demonstrate the ability to interpret and apply new information within a larger body of scientific knowledge.

Outcome 3.1 Chemistry and Society Students demonstrate the ability to connect scientific knowledge with other aspects of modern society, especially technological, historical, or ethical issues that rest on a body of scientific understanding.	X	X	X
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Outcome 3.2 Formulating and Testing Theories Students demonstrate the ability to evaluate relationships, both between chemistry and other disciplines and within chemistry itself, by using the natural sciences as a basis for building and testing theories.	X	X	X
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Outcome 3.3 Application of Scientific Thinking Students demonstrate the ability to apply scientific thinking to questions outside the natural sciences, where a scientific viewpoint may be essential to understanding an issue or dilemma and proposing practical solutions to such problems.	X	X	X
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Learning Objective 4. Critical Thinking through Evaluation

Students demonstrate the ability to evaluate evidence, articulate arguments, justify conclusions, and present multiple perspectives.

Outcome 4.1 Evaluation of Scientific Explanations Students demonstrate the ability to evaluate a proposed scientific explanation, critique its practice of science, and decide whether scientific reasoning is appropriate for the particular question involved.	X	X	X
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Outcome 4.2 Evaluation and Modification of Scientific Theories Students demonstrate the ability to evaluate major theories involved in chemistry and to assess the extent to which empirical evidence may modify those theories.	X	X	X
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GENERAL CHEMISTRY LEARNING OUTCOME SET	Gen Ed Science Criteria		
CHEM 134/132 General Chemistry II Lecture and Lab	1	2	3
Learning Objective 1. Foundational Chemical Knowledge			
Students demonstrate foundational knowledge of fundamental principles of chemistry including thermodynamics, equilibrium, and electrochemistry.			
Outcome 1.1 Thermodynamics Students demonstrate knowledge of basic thermodynamics.	X	X	X
Outcome 1.2 Equilibrium Students demonstrate knowledge of chemical equilibrium.	X	X	X
Outcome 1.3 Electrochemistry Students demonstrate knowledge of electrochemistry.	X	X	X
Learning Objective 2. Quantitative Literacy through Analysis of Empirical Evidence			
Students demonstrate the ability to analyze quantitative empirical data and reach conclusions based on that data.			
Outcome 2.1 Data Analysis Students demonstrate the ability to analyze data in various forms, especially graphical data, and evaluate the appropriateness of data to answer a particular question.	X	X	X
Outcome 2.2 Evaluation of Hypotheses Students demonstrate the ability to identify what evidence might be required to assess a given hypothesis, how to revise such a hypothesis in light of empirical results, and to decide what additional observations might be needed.	X	X	X
Outcome 2.3 Inductive Method and Experimental Procedures Students demonstrate the ability to integrate inductive methods and experimental procedures, including use of laboratory practices and methods applicable to the development of analytic procedures that reinforce the students' mathematical competence.	X	X	X

Learning Objective 3. Integration and Application of Chemical Knowledge

Students demonstrate the ability to interpret and apply new information within a larger body of scientific knowledge.

Outcome 3.1 Chemistry and Society

Students demonstrate the ability to connect scientific knowledge with other aspects of modern society, especially technological, historical, or ethical issues that rest on a body of scientific understanding.

X X X

Outcome 3.2 Formulating and Testing Theories

Students demonstrate the ability to evaluate relationships, both between chemistry and other disciplines and within chemistry itself, by using the natural sciences as a basis for building and testing theories.

X X X

Outcome 3.3 Application of Scientific Thinking

Students demonstrate the ability to apply scientific thinking to questions outside the natural sciences, where a scientific viewpoint may be essential to understanding an issue or dilemma and proposing practical solutions to such problems.

X X X

Learning Objective 4. Critical Thinking through Evaluation

Students demonstrate the ability to evaluate evidence, articulate arguments, justify conclusions, and present multiple perspectives.

Outcome 4.1 Evaluation of Scientific Explanations

Students demonstrate the ability to evaluate a proposed scientific explanation, critique its practice of science, and decide whether scientific reasoning is appropriate for the particular question involved.

X X X

Outcome 4.2 Evaluation and Modification of Scientific Theories

Students demonstrate the ability to evaluate major theories involved in chemistry and to assess the extent to which empirical evidence may modify those theories.

X X X

GENERAL SCIENCE FOR ELEMENTARY TEACHERS LEARNING OUTCOME SET	Gen Ed Science Criteria		
CHEM 203 General Science for Elementary Teachers	1	2	3
1. The student will acquire fundamental knowledge in the subject matter areas covered in elementary school science.	X	X	X
2. The student will participate in "hands-on" science activities that can be used in the elementary school classroom.	X	X	X
3. The student will learn how to use small groups in science activities to develop science-processing skills.	X		X
4. The student will be able to locate and use a variety of resources to teach science in the elementary school.		X	
5. The students will be able to apply the scientific process in discovering the solution to certain scientific problems.	X		X
6. The student will gain experience in teaching science through "guided discovery" techniques.	X	X	X
7. The student will gain a greater appreciation of God's creation – the physical world.		X	
INTRODUCTION TO GEOLOGY LEARNING OUTCOME SET	Gen Ed Science Criteria		
GEOL 111 Introduction to Geology	1	2	3
See Attached.	X	X	X

Learning Objectives for Students in Geology 111

1. The student will understand the importance of scientific literacy with specific examples drawn from the field of geology. This scientific literacy results in scientific decisions-making by answering questions about the natural world. The student will then be able to properly evaluate scientific information and endorse life styles and political decisions that support Earth-friendly policies. The student will then be able to link science with other aspects of contemporary society with specific focus on technological, historical, or ethical issue that rests on a body of scientific understanding.
2. The student is expected to demonstrate an understanding of natural processes as well as human influenced processes. The natural processes include hazards such as flooding, earthquakes, and volcanoes. Some human –influenced processes include soil erosion and water pollution.
3. The student is expected to know the Earth's interior is differentiated chemically, physically, and thermally. He is expected to evaluate heat transfer through the Earth's subsystems by radiation, convection, and conduction and include its role in plate tectonics and volcanism. He is expected to examine the chemical, physical, and thermal structure of Earth's crust, mantle, and core. He is expected to explain how scientists use geophysical methods such as seismic wave analysis, gravity, and magnetism to interpret Earth's structure.
4. The student will know that plate tectonics is the global mechanism for major geologic processes and that heat transfer is the driving force. He is expected to investigate new conceptual interpretation of data and geophysical technologies that lead to current theory of plate tectonics. He is expected to describe how heat and rock composition affect density within Earth's interior and how density influences the development and motion of Earth's tectonic plates. He will be able to distinguish the location, type and relative motion of convergent, divergent and transform plate boundaries using evidence from the distribution of earthquakes and volcanoes. He will be able to evaluate the role of plate tectonics with respect to long-term global changes in Earth's subsystems such as

continental buildup, glaciations, sea level fluctuations, mass extinctions, and climate change.

5. The student will know that the geosphere continuously changes over a range of time scales involving dynamic and complex interactions among Earth's subsystems. The student is expected to compare the roles of erosion and deposition through the actions, water, wind, ice, gravity and igneous activity by lava in constantly reshaping Earth's surface. He will be able to explain how plate tectonics accounts for geologic surface processes and features, including folds, faults, sedimentary basic formation, mountain building and continental accretion. He will be able analyze changes in continental configurations such as Pangaea and their impact on the biosphere, atmosphere, and hydrosphere through time. He will be able to interpret Earth surface features using a variety of methods such as satellite imagery, aerial photography, and topographic and geologic maps using appropriate technology. He will be able to evaluate the impact of changes in Earth's subsystems on humans such as earthquakes, tsunamis, volcanic eruptions, and flooding and the impact of humans on Earth's subsystems such as population growth, fossil fuel burning, and use of fresh water.
6. The student will know that Earth contains energy, water, mineral and rock resources and that use of these resources impacts Earth's subsystems.
7. The student will know that the fluid Earth is composed of hydrosphere and cryosphere systems that interact on various time scales the biosphere and geosphere. The student is expected to quantify the components and fluxes within the hydrosphere such as changes in polar ice caps and glaciers and groundwater levels in response to precipitation events or excessive pumping.
8. The student will know that interactions among Earth's five subsystems influence climate and resource availability, which affect Earth habitability. The student is expected to quantify the dynamics of surface and groundwater movement such as recharge, discharge, storage, residence time and sustainability.
9. The student will know that the Earth's surface is constantly changing and consists of useful resources. The student is expected to explore the

processes that led to the formation of sedimentary rocks and fossil fuels. He is expected to recognize how landforms such as deltas, canyons and sand dunes are the results of Earth's surface by wind, water and ice.

10. The student will know that matter has physical properties that can be used for classification. The student is expected to test the physical properties of minerals, including hardness, color, luster and streak.
11. The student will understand the structure of Earth, the rock cycle, and plate tectonics. The student is expected to classify rocks as metamorphic, igneous, or sedimentary by the processes of their formation. He is expected to identify the major tectonic plates, including Eurasian, African, Indo-Australian, Pacific, North American, and South American.