

CHEM S100 Introduction to Chemical Science

Upon successful completion of this course, students will be able to:

1. Use scientific notation, significant figures and dimensional analysis in basic chemical calculations.
2. Describe matter in terms of pure substances, mixtures and physical state on a sub-microscopic and macroscopic level.
3. Describe chemical and physical changes undertaken by matter.
4. Describe mixtures with basic concentration units.
5. Discuss the aspects of mass balance in physical and chemical processes.
6. Complete and balance chemical equations.
7. Discuss the interrelationships between atomic and molecular masses, the mole, Avogadro's number and stoichiometric coefficients.
8. Relate atomic structure, electronic structure and chemical reactivity to various features of the periodic table.
9. Use chemical nomenclature and diagrammatic representations to discuss elements, ions and compounds.
10. Differentiate chemical compounds in terms of bonding.
11. Describe the energy changes that accompany chemical reactions and identify how those changes influence the extent of a chemical reaction.
12. Identify intermolecular forces and how they influence the state of matter.
13. Describe gaseous samples of matter in submicroscopic (e.g. Kinetic Molecular Theory) and macroscopic (e.g. Ideal Gas Laws) terms.
14. Describe the basic chemical features of acid and base molecules and discuss how those features affect aqueous solutions.
15. Differentiate between the extent of chemical reactions (i.e. equilibrium) and the rate of chemical reactions.
16. Balance nuclear reactions in terms of particle conservation and describe the associated energy changes.
17. Discuss the applications of nuclear chemistry to power generation and the medical industry.

CHEM S103 Introduction to General Chemistry

Upon successful completion of this course, students will be able to:

1. Describe and apply the scientific method.
2. Demonstrate critical thinking skills through qualitative and quantitative analyses tasks.
3. Use dimensional analysis with proper attention to units and significant figures.
4. Describe chemical and physical properties of matter.
5. Explain the basic model of the atom and understand nuclear decay and radioactivity.
6. Describe theories of chemical bonding and the forces that influence molecular shapes.

7. Determine names and formulas of binary molecular compounds, ionic compounds, and acids and be able to identify types of chemical bonds.
8. Complete standard elementary stoichiometry-based calculations.
9. Balance chemical equations, identify basic types of chemical reactions, and predict the outcomes of these reactions.
10. Explain and calculate energy exchanges in chemical reactions.
11. Use the concept of the mole in quantitative chemical calculations.
12. Calculate and utilize solution concentration units such as molarity and percent concentrations.
13. Explain intermolecular forces and their role in influencing physical and chemical properties of substances.
14. Discuss the gas laws and their applications in quantitative problems.

CHEM S104 Survey of Organic and Biological Chemistry

Upon successful completion of this course, students will be able to:

1. Articulate and correctly communicate concepts of organic and biochemistry using the vocabulary of these fields.
2. Employ formal definitions and properties of organic functional groups to predict both chemical and physical properties of an organic molecule.
3. Apply the concepts of structure and function to predict properties of biomolecules.
4. Use correct vocabulary relating to the common and IUPAC names of simple organic and biochemical compounds.
5. Write chemical equations that describe organic and biochemical reactions.
6. Discuss the basic relationships between physical properties and molecular structure of organic and biochemical compounds.
7. Explain the principles of the chemistry of lipids, carbohydrates, proteins, and enzymes.

CHEM S105 General Chemistry I

Upon successful completion of this course, students will be able to:

1. Describe the nature of matter from a sub-microscopic and macroscopic perspective.
2. Identify and describe physical and chemical properties of matter.
3. Utilize dimensional analysis to solve analytical problems based on physical and chemical change.
4. Name and graphically represent atoms, ions and compounds.
5. Describe the atomic and electronic structure of atoms and ions and relate that structure to position in the Periodic Table as well as physical and chemical properties.
6. Distinguish ionic and covalent compounds in terms of physical and chemical properties including electron distribution between bonded atoms.
7. Describe the basic electronic structure of molecules in terms of Valence Bond Theory and Molecular Orbital Theory.

8. Determine the geometry of and electron distribution (i.e. polarity) in simple compounds.
9. Discuss chemical reactions on an electronic, atomic/molecular and molar basis.
10. Complete and balance simple chemical reactions in the gas or liquid phase or as aqueous solutions.
11. Calculate solution concentrations of various species in relevant concentration units.
12. Characterize reactions in terms of equilibrium position.
13. Describe the energy changes associated with chemical reactions and how those changes influence the equilibrium position of the reaction.
14. Utilize gas laws to describe the response of gaseous samples to physical or chemical changes.
15. Describe standard chemical laboratory safety protocols.
16. List and demonstrate safe and effective methods to use standard laboratory glassware and equipment.
17. Articulate and defend the relevant purpose, procedure, results and conclusions of laboratory exercises.
18. Demonstrate in writing the relevant calculations carried out in completing laboratory exercises.

CHEM S105R General Chemistry I Recitation

Upon successful completion of this course, students will be able to:

1. Use basic chemical concepts to organize chemical and physical data
2. Identify the information and equations relevant to the solution of a particular chemistry problem.
3. Apply chemical principles to generate solutions to chemistry-based problems.

CHEM S106 General Chemistry II

Upon successful completion of this course, students will be able to:

1. Identify and discuss how atomic and molecular structural features influence the physical states of matter and changes between the physical states of matter.
2. Determine rates of chemical reactions and the variables that affect chemical reaction rates.
3. Assess experimental data for mechanistic features of a chemical reaction.
4. Identify the constituents of a system at chemical equilibrium and discuss the variables that influence the equilibrium composition.
5. Discuss the chemical features of acids and bases.
6. Apply equilibrium concepts to, and complete equilibrium calculations for acid/base and precipitation reactions.
7. Define energy, entropy, free energy and the changes that occur in these variables as a chemical reaction approaches and establishes chemical equilibrium.

8. Discuss how thermochemical variables reflect spontaneous and non-spontaneous processes.
9. Describe the thermochemical features of electrochemical systems and their accompanying energy exchanges.
10. Articulate the basic concepts (e.g. particle conservation, energy changes) of nuclear chemistry along with the associated implications and applications for power generation and medicine.
11. Use IUPAC organic chemistry nomenclature to identify and describe functional groups and complete small molecule reactions.
12. Discuss the electronic nature of transition metals and relate those features to physical and chemical properties of transition metal elements and compounds.
13. Discuss the electronic nature of the main group elements and relate those features to chemical reactions typical to these elements.
14. Describe standard chemical laboratory safety protocols.
15. List and demonstrate safe and effective methods to use standard laboratory glassware and equipment.
16. Articulate and defend the relevant purpose, procedure, and certainty of results and conclusions of laboratory exercises.
17. Demonstrate in writing the relevant calculations carried out in completing laboratory exercises.

CHEM S106R General Chemistry II Recitation

Upon successful completion of this course, students will be able to:

1. Use basic chemical concepts to organize chemical and physical data
2. Identify the information and equations relevant to the solution of a particular chemistry problem.
3. Apply chemical principles to generate solutions to chemistry-based problems.

CHEM S341 Organic Chemistry

At the end of this course a student who has done well in this class should be able to:

1. Provide systematic names for most small organic molecules.
2. Draw a chemical structure from a systematic or common name of a molecule.
3. Draw various types of isomers of organic compounds.
4. Recognize and name common organic functional groups.
5. Predict products of a reaction given the reactants and reaction conditions.
6. Devise a synthetic pathway given reactants and products.
7. Use curved arrows to represent reaction mechanisms.
8. Explain the conditions under which SN1, SN2, E1 and E2 reactions will predominate.
9. Describe the physical and chemical properties associated with each organic functional group.

10. Answer correctly at least 75% of the questions on a standard ACS organic chemistry exam for first year organic chemistry students.
11. Correctly use and care for all lab-ware and instruments common to an undergraduate organic chemistry laboratory.
12. Understand an MSDS for any compound.
13. Follow all safety rules, actions, protocols with respect to lab behavior, chemical handling and response in an emergency.
14. Use UV, IR, NMR and mass spectrometry data to deduce the structure of an organic compound.
15. Use the internet to retrieve information about various properties and reactions of organic compounds.
16. Recognize incorrectly drawn organic structures.
17. Solve simple 'roadmap' problems.
18. Keep an accurate and complete record of experiments in a standard laboratory notebook.
19. Hand in all assignments on time.

CHEM S342 Biochemistry

Upon successful completion of this course, students will be able to:

1. Explain the logic behind the building block theory of biochemistry.
2. Solve problems involving pH and buffer systems using the Henderson-Hasselbalch equation.
3. Provide the structures, properties and names of the 20 protein amino acids.
4. Explain aspects of protein structure, including 1^o, 2^o, 3^o and 4^o structures.
5. List the functions in which proteins are involved.
6. Draw a reaction diagram and explain how catalysts work.
7. Use equations for Gibb's free energy to predict reaction spontaneity.
8. Show how coupling of reactions can make a metabolic pathway spontaneous.
9. Determine the kinetic parameters of a Michaels-Menten enzyme.
10. Run kinetic experiments involving enzyme inhibitors and determining the type of inhibition.
11. Describe several ways in which protein activity is regulated.
12. Draw and explain the saturation/binding curves for both myoglobin and hemoglobin under various conditions of pH, [CO₂], pO₂, [CO], anemia, maturation, and physiological regulators.
13. Show how cooperativity is a hallmark of oligomeric proteins and explain the difference between concerted and sequential binding.
14. Draw and recognize correct chemical structures for biological carbohydrates, lipids, nucleotides and nucleic acids.
15. Draw a model biological membrane and explain the role of each of the components.

16. Explain the overall concept of metabolism with respect to small molecules, ATP, NADPH, inputs and outputs.
17. Provide the pathways and/or mechanisms for various shuttle pathways for example malate/aspartate shuttle.
18. Reproduce the reactions for various metabolic pathways including the reaction types, names of enzymes, structures and names of all intermediate metabolites, regulation and purpose of each pathway. Specific pathways are: Glycolysis; TCA cycle; Electron Transport Chain and Oxidative Phosphorylation; Gluconeogenesis; Glyoxylate pathway; Pentos Phosphate Pathway; Glycogen synthesis and breakdown, including hormone effects; Fatty Acid Oxidation and Ketone Bodies; Photosynthesis and the Calvin-Benson cycle; DNA replication; RNA transcription; and Protein synthesis (translation).
19. Score at least 75% on a standard ACS exam for a one semester biochemistry course.
20. Correctly use and care for all lab-ware and instruments common to an undergraduate biochemistry laboratory.
21. Understand an MSDS for any compound.
22. Follow all safety rules, actions, protocols with respect to lab behavior, chemical handling and response in an emergency.
23. Use the internet to retrieve information about various properties and reactions relevant to biochemistry.
24. Keep an accurate and complete record of experiments in a standard laboratory notebook.
25. Hand in all assignments on time.
26. Prepare a professional report on laboratory experiments.

CHEM S349 Survey of Environmental Chemistry

Upon successful completion of this course, students will be able to:

1. Describe and quantify the mass and energy exchanges between the atmosphere, the hydrosphere/lithosphere and the biosphere
2. Identify and characterize temporary versus permanent environmental reservoirs
3. Identify and quantify processes that influence mass and energy exchanges between sinks and reservoirs
4. Recognize the analytical chemical methods relevant to the study of particular environmental parameters
5. Evaluate the influence of environmental conditions on the behavior of chemicals in the environment
6. Discuss the environmental impact of chemical contaminants in terms of fundamental chemical principles including equilibrium, oxidation-reduction, kinetics, solubility, acid-base chemistry, and thermodynamics
7. Assess the validity of analytical results based on associated statistical data
8. Describe the effect of contaminants on the environment and its inhabitants, including humans
9. Recognize the impacts of environmental regulations and governmental policies on a local, regional and worldwide scale

10. Integrate environmental chemical concepts into problem solving schemes, laboratory exercises and research projects

CHEM S350 Environmental Chemistry

Upon successful completion of this course, students will be able to:

1. Describe and quantify the mass and energy exchanges between the atmosphere, the hydrosphere/lithosphere and the biosphere.
2. Identify and characterize temporary versus permanent environmental reservoirs.
3. Identify and quantify processes that influence mass and energy exchanges between sinks and reservoirs.
4. Identify the analytical chemical methods relevant to the study of particular environmental parameters.
5. Describe the theoretical and operational principles of analytical and chemical techniques used to measure environmental chemical parameters and features.
6. Evaluate the influence of environmental conditions on the behavior of chemicals in the environment.
7. Discuss the environmental impact of chemical contaminants in terms of fundamental chemical principles including equilibrium, oxidation-reduction, kinetics, solubility, acid-base chemistry, and thermodynamics.
8. Use statistical methods to establish the validity of analytical results.
9. Describe the effect of contaminants on the environment and its inhabitants, including humans.
10. List and discuss the impacts of environmental regulations and governmental policies on a local, regional and worldwide scale.
11. Integrate environmental chemical concepts into problem solving schemes, laboratory exercises and research projects.
12. Articulate environmental chemical concepts through oral and written communication.