National Evaluation Series

Test Framework

Chemistry (821)

December 2024

Multiple Choice

Subarea	Range of Objectives	Approximate Percentage of Test Score
I. Matter and Its Interactions: Periodic Properties	0001–0002	12%
II. Matter and Its Interactions: Chemical Structure and Reactions	0003–0007	22%
III. Matter and Its Interactions: Substances, Mixtures, and Solutions	0008–0009	12%
IV. Motion and Stability: Forces and Interactions	0010–0012	15%
V. Energy in Chemical Systems	0013–0016	19%
Total	0001–0016	**80%**

Open Response

Subarea	Range of Objectives	Approximate Percentage of Test Score
VI. Integration of Knowledge and Understanding		
Key Scientific Concepts	0017	10%
Application of Science and Engineering Practices	0018	10%
Total	0017–0018	**20%**

MATTER AND ITS INTERACTIONS: PERIODIC PROPERTIES

0001: Apply knowledge of atomic and subatomic structure and the principles of quantum theory.

- Apply knowledge of historical atomic models to evaluate the development, strengths, and limitations of the models in representing atomic structure.
- Demonstrate knowledge of the properties of nuclides (i.e., mass, charge, and nuclide ratio), the composition of isotopes, and the difference between average atomic mass and mass number.
- Apply knowledge of the principles of quantum mechanics to atomic structure (e.g., electron configuration, ionization energy, electron affinity).
- Apply knowledge of the relationships between electrons, energy levels, photons, the electromagnetic spectrum, and atomic spectra to interpret the electron configurations of atoms and ions.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0001, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0002: Apply knowledge of periodic properties and the organization of the periodic table.

- Apply knowledge of the organization of the periodic table and classification of elements to predict physical and chemical properties of a given element.
- Apply knowledge of periodic trends (e.g., atomic radius, ionic radius, electronegativity).
- Apply knowledge of valence electron configuration to predict ionic charges, oxidation states, and bonding patterns.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0002, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

MATTER AND ITS INTERACTIONS: CHEMICAL STRUCTURE AND REACTIONS

0003: Apply knowledge of the nomenclature and structure of inorganic and organic compounds.

- Apply the IUPAC rules of nomenclature to name simple ionic and molecular compounds from their formulas and write structural formulas from the IUPAC names of substances.
- Demonstrate knowledge of functional groups and isomers and their associated properties.
- Identify the chemical composition and basic structure of organic compounds (e.g., hydrocarbons, alcohols, esters, common biomolecules).
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0003, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0004: Apply knowledge of chemical bonding and the relationship between bond type and the properties of substances.

- Apply knowledge of atomic structure to the formation of bonds between atoms.
- Demonstrate knowledge of the characteristics of various types of chemical bonding.
- Apply knowledge of factors that affect bond strength (e.g., electronegativity, electron affinity) to predict the nature of chemical bonding and bond type.
- Apply knowledge of bonding to draw and analyze Lewis structures of simple chemical species.
- Apply knowledge of VSEPR to predict molecular geometry and molecular polarity of simple chemical species.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0004, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0005: Apply knowledge of physical and chemical properties and physical and chemical changes.

- Demonstrate knowledge of the particulate nature of matter and the characteristics of elements, compounds, and mixtures (e.g., solutions, colloidal dispersions, noncolloidal suspensions).
- Distinguish between physical and chemical properties and between physical and chemical changes in matter.
- Apply knowledge of physical and chemical properties to identify common substances.
- Apply knowledge of intermolecular forces to explain physical properties and phase changes.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0005, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0006: Apply knowledge of the types and characteristics of chemical reactions.

- Apply knowledge of common types of chemical reactions (i.e., synthesis, decomposition, single replacement, double replacement, and combustion) and predict the products of these reactions.
- Classify chemical reactions based on driving forces (e.g., precipitation, gas or water formation, electron transfer).
- Apply knowledge of chemical reactions to identify common chemical processes in the home, industry, the environment, and health and medicine.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0006, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0007: Apply knowledge of the quantitative relationships expressed in chemical equations.

- Balance equations for chemical reactions.
- Demonstrate knowledge of the mole concept and its use in chemical calculations.
- Solve stoichiometric problems, including problems with limiting reagents.
- Calculate the percent yield for chemical reactions.
- Apply knowledge of the principles of titration (e.g., acid-base, oxidation-reduction).
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0007, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

MATTER AND ITS INTERACTIONS: SUBSTANCES, MIXTURES, AND SOLUTIONS

0008: Apply knowledge of the mass relationships in chemical substances.

- Solve problems related to molecular mass and formula mass.
- Solve problems related to percent composition of substances.
- Determine empirical and molecular formulas.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0008, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0009: Analyze the properties of solutions.

- Solve problems related to solution concentrations.
- Demonstrate a qualitative and quantitative understanding of the colligative properties of solutions (e.g., freezing point depression, boiling point elevation).
- Interpret solubility curves.
- Determine the hydronium ion concentration and the pH and pOH for acid, base, and salt solutions.
- Solve problems related to acid-base dissociation and neutralization in aqueous solutions.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0009, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

MOTION AND STABILITY: FORCES AND INTERACTIONS

0010: Apply knowledge of the kinetic molecular theory, the nature of phase changes, and the gas laws.

- Demonstrate knowledge of the arrangements, movements, and interactions of particles in solids, liquids, and gases.
- Apply knowledge of the basic principles of the kinetic molecular theory to explain phase changes and analyze phase diagrams.
- Analyze heating and cooling curves qualitatively and quantitatively.
- Apply knowledge of the properties of ideal and real gases and solve problems related to gas law relationships for ideal gases.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0010, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0011: Apply knowledge of the connection between molecular structure and forces between particles.

- Apply knowledge of the characteristics of different types of intermolecular forces (i.e., dispersion, dipole-dipole, hydrogen bonding, and ion-dipole).
- Predict the forces present between molecules, atoms, and ions.
- Analyze factors that affect solubility (e.g., polarity, molecular shape, particle size).
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0011, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0012: Apply knowledge of the principles of chemical equilibrium.

- Demonstrate an understanding of the dynamic nature of equilibrium and how it relates to concentration, pressure, volume, and temperature, as well as the presence of a catalyst.
- Apply knowledge of Le Chatelier's principle to chemical systems.
- Solve equilibrium problems and predict how the equilibrium constant relates to the extent of a reaction.
- Predict the direction in which a reaction will proceed to reach equilibrium by comparing the equilibrium constant with a reaction quotient.
- Demonstrate knowledge of the principles and applications of equilibrium systems (e.g., buffers, Haber process).
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0012, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

ENERGY IN CHEMICAL SYSTEMS

0013: Apply knowledge of the factors that affect reaction rates and methods of measuring reaction rates.

- Identify factors that influence reaction rates (e.g., surface area, agitation, temperature, concentration).
- Relate experimental data to reaction rates and rate laws.
- Demonstrate knowledge of reaction mechanisms and rate laws for simple reactions.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0013, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0014: Apply knowledge of the principles of thermodynamics and calorimetry.

- Demonstrate knowledge of the three laws of thermodynamics, including their application in chemical systems.
- Demonstrate knowledge of the different forms of energy and the conversion from one form to another.
- Demonstrate knowledge of the difference between heat and temperature.
- Solve problems related to specific heat.
- Apply knowledge of calorimetry to analyze the results of calorimetry experiments.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0014, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0015: Apply knowledge of the energy relationships in chemical bonding and chemical reactions.

- Analyze energy changes due to forming or breaking chemical bonds.
- Solve problems related to enthalpy changes during chemical reactions.
- Predict the spontaneity of a given reaction based on the Gibbs energy change and analyze the effect of enthalpy change, entropy change, or temperature on spontaneity.
- Demonstrate an understanding of the relationship between the equilibrium constant and Gibbs energy.
- Interpret potential energy diagrams of chemical reactions.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0015, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

0016: Apply knowledge of oxidation-reduction reactions to electrochemistry.

- Apply knowledge of oxidation-reduction reactions to predict whether a given reaction will occur based on standard reduction potentials.
- Analyze the components (e.g., anode, cathode) and operating principles of voltaic and electrolytic cells.
- Calculate potentials of electrochemical cells.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to Objective 0016, such as asking questions and defining problems, developing and using models, planning and safely conducting investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and communicating and evaluating data and conclusions.

INTEGRATION OF KNOWLEDGE AND UNDERSTANDING

0017: Prepare an organized, developed analysis of a key topic in chemistry related to Matter and Its Interactions: Periodic Properties or Motion and Stability: Forces and Interactions.

- Describe the key scientific concepts that relate to a given topic.
- Use representative graphs, formulas, and/or diagrams with proper labels to model the presented topic.
- Discuss how a specific science and engineering practice (e.g., developing and using models, constructing explanations, designing solutions) could be used to help a diverse group of students understand phenomena related to the given topic.

0018: Prepare an organized, developed analysis of a key topic in chemistry related to Matter and Its Interactions: Chemical Structure and Reactions; Matter and Its Interactions: Substances, Mixtures, and Solutions; or Energy in Chemical Systems that emphasizes the application of science and engineering practices in a classroom setting.

- Form a testable scientific claim that addresses a given topic.
- Outline a specific scientific procedure to investigate the proposed claim, including identifying variables and controls.
- Describe any appropriate safety considerations and practices for this procedure.
- Describe a possible result provided by collected data and provide reasoning of how the collected data provide evidence that supports or refutes the tested claim.
- Discuss how a specific science and engineering practice (e.g., developing and using models, planning and carrying out investigations) could be used to help a diverse group of students make sense of phenomena related to the given topic.