Subarea I: Nature of Science

Competencies 1–3
13% (Multiple Choice)
15% (Constructed Response)

Competency 1

Apply knowledge of scientific practices.

- Analyze processes by which new scientific knowledge is generated and the ethical issues related to the practice of scientific research.
- Apply knowledge of the principles and procedures for designing and carrying out scientific investigations.
- Apply knowledge of the methods and criteria for collecting, organizing, analyzing, presenting, and communicating scientific data.
- Analyze the design of a scientific experiment or investigation and interpret data using basic statistical methods.
- Apply procedures for the proper, safe, and legal use of equipment, materials, and chemicals in the chemistry classroom.
- Identify methods for maintaining safety in the chemistry classroom and recognize appropriate responses to safety incidents.

Competency 2

Analyze the historical progression of scientific knowledge and the role of science in contemporary society.

- Analyze the significance of key events, theories, experiments, and individuals in the history of chemistry.
- Analyze social, economic, and ethical issues associated with technological and scientific developments.
- Analyze industrial processes, chemical processes in the home, and related safety issues.
- Assess the risks and benefits of nuclear materials and nuclear processes.
- Analyze how the release of chemicals affects the atmosphere, aquatic environments, and terrestrial environments.
- Analyze practices for preventing environmental damage resulting from the release of chemicals into the environment.

Competency 3

Apply knowledge of the crosscutting concepts in the sciences.

- Demonstrate knowledge of major contemporary theories, laws, models, and concepts in engineering, physics, biology, and Earth and space science.
- Apply chemical theory to various sciences and disciplines outside of chemistry.
- Apply literacy skills to the interpretation and synthesis of scientific information from a range of sources.
- Analyze patterns and causal relationships in natural phenomena.
- Apply the concepts of scale, proportion, and quantity to the analysis of scientific phenomena and engineered systems.
- Use models to explain and predict scientific phenomena and to evaluate engineered solutions.
- Analyze natural and engineered systems and track the cycling of energy within them.
- Analyze the relationship between structure and function in natural and engineered systems.
- Analyze the stability of physical systems and the forces affecting stability.

Subarea II: Structure of Matter

Competencies 4–6

15% (Multiple Choice)

Competency 4

Analyze the atomic structure of matter.

- Analyze historical and contemporary models of atomic structure and the supporting evidence for these models.
- Relate interactions among electrons, protons, and neutrons to their properties (e.g., mass, charge).
- Analyze the relationships among electron energy levels, photons, and atomic spectra.
- Analyze the electron configurations of atoms and ions.

Competency 5

Apply knowledge of the periodic table.

- Analyze the organization of the periodic table in terms of atomic number and properties of the elements.
- Analyze trends within periods and groups in the periodic table.
- Predict physical and chemical properties of given elements on the basis of their positions in the periodic table.
- Use the periodic table to gain information about given elements (e.g., relative reactivity).

Competency 6

Apply knowledge of chemical nomenclature and chemical structure.

- Apply the International Union of Pure and Applied Chemistry (IUPAC) rules of nomenclature to the naming of inorganic and organic compounds.
- Analyze the characteristics of ionic solids, network solids, and metallic solids.
- Analyze the chemical composition and basic structure of inorganic compounds.
- Recognize common organic compounds, including saturated, unsaturated, and aromatic hydrocarbons; nucleic acids; amino acids; carbohydrates; and lipids.
- Differentiate among structural, geometric, and optical isomers.

Subarea III: Propertiesof Matter

Competencies 7–9

11% (Multiple Choice)

Competency 7

Apply knowledge of the properties of matter.

- Differentiate among elements, compounds, and mixtures.
- Distinguish between physical and chemical changes in matter.
- Use physical and chemical properties to identify an unknown substance.
- Analyze the methods by which chemical and physical properties of matter are determined.

Competency 8

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

- Apply knowledge of the basic principles of kinetic molecular theory.
- Compare arrangements and movements of particles in the four states of matter.
- Analyze heating and cooling curves and phase diagrams.
- Apply knowledge of the relationships between temperature, pressure, and volume in gases.
- Solve problems involving the gas laws.

Competency 9

Apply knowledge of nuclear processes.

- Compare the characteristics of the different types of emanations from radioactive materials.
- Analyze the processes of natural radioactivity and artificial transmutation.
- Solve problems involving the half-life of radioactive materials.
- Relate nuclear mass defect to nuclear binding energy.
- Analyze the processes of fission and fusion.

Subarea IV: Energy in Chemical Processes

Competencies 10–12
13% (Multiple Choice)

Competency 10

Apply knowledge of the principles of thermodynamics and calorimetry.

- Analyze the three laws of thermodynamics and their application to chemical systems.
- Analyze the results of calorimetry experiments.
- Differentiate between heat and temperature.

Competency 11

Analyze energy changes in chemical bonding, chemical reactions, and physical processes.

- Analyze energy changes due to the formation or breaking of chemical bonds.
- Solve problems involving energy changes during chemical reactions.
- Interpret potential energy diagrams of chemical reactions.
- Predict the spontaneity of given chemical reactions.
- Analyze energy changes involved in phase transitions, dissolving solutes in solvents, and diluting solutions.

Competency 12

Apply knowledge of chemical bonding and intermolecular forces.

- Compare the characteristics of various types of chemical bonds.
- Analyze chemical bonding in terms of electron behavior and the factors that affect bond strength.
- Predict and interpret Lewis structures.
- Use the valence-shell electron-pair repulsion (VSEPR) model and valence-bond theory to predict molecular geometry and molecular polarity.
- Analyze the characteristics of various types of intermolecular forces.
- Predict the type of interaction between molecules of a given structure.
- Relate the properties of substances to their atomic bonds and intermolecular forces.

Subarea V: Chemical Reactions

Competencies 13–17

17% (Multiple Choice)

Competency 13

Apply knowledge of the nature of chemical reactions.

- Classify different types of inorganic chemical reactions.
- Predict the outcomes of chemical reactions.
- Demonstrate knowledge of collision theory and the factors that influence reaction rate.
- Analyze rate problems and experimental rate data.
- Relate reaction mechanisms to rate laws.

Competency 14

Apply knowledge of the principles of chemical equilibrium.

- Analyze the effects of concentration, pressure, temperature, and catalysts on chemical equilibrium.
- Apply Le Chatelier's principle to chemical systems.
- Solve problems involving equilibrium constants.
- Solve problems involving solubility product constants.

Competency 15

Analyze the theories, principles, and applications of acid-base chemistry.

- Analyze acids and bases according to operational and conceptual definitions.
- Analyze the principles and applications of acid-base titration.
- Calculate the hydronium ion concentration, hydroxide ion concentration, and pH and pOH for acid, base, and salt solutions.
- Compare the relative strengths of given acids using knowledge of periodic relationships.

Competency 16

Analyze oxidation-reduction reactions and electrochemical processes.

- Analyze processes that occur during oxidation-reduction reactions.
- Determine oxidation numbers and balance oxidation-reduction reactions.
- Analyze the components and operating principles of electrochemical cells and electrolytic cells.
- Predict whether a given oxidation-reduction reaction will occur using standard reduction potentials.

Competency 17

Analyze organic reactions.

- Analyze common types of organic reactions (e.g., combustion, addition, substitution, polymerization, oxidation, esterification).
- Analyze the rates of reactions involving organic compounds on the basis of bond types and strengths.
- Apply knowledge of fundamental biochemical processes (e.g., photosynthesis, cellular respiration, fermentation).

Subarea VI: Solutions and Quantitative Relationships

Competencies 18–20

16% (Multiple Choice)

Competency 18

Apply knowledge of solutions and suspensions.

- Compare the characteristics of different types of solutions and suspensions.
- Analyze factors affecting solubility (e.g., temperature, pressure, molecular structure).
- Analyze the colligative properties of solutions.
- Solve problems involving concentrations of solutions.

Competency 19

Apply knowledge of the mole concept.

- Relate the mole to Avogadro's number.
- Solve problems involving molar mass, molecular and formula masses, and percent composition.
- Determine empirical and molecular formulas.

Competency 20

Apply knowledge of stoichiometry.

- Interpret chemical notation.
- Balance chemical equations.
- Analyze net ionic equations.
- Solve stoichiometric problems involving moles, mass, volume, and energy.