Missouri Educator Gateway Assessments

FIELD 076: CHEMISTRY
TEST FRAMEWORK

April 2020

	Content Domain	Range of Competencies	Approximate Percentage of Test Score
I.	Matter and Its Interactions—Composition and Bonding	0001–0002	14%
II.	Matter and Its Interactions—Structure and Periodicity	0003–0004	14%
III.	Energy	0005–0008	20%
IV.	Solutions and Gases and Their Associated Properties	0009–0011	14.5%
V.	Physics	0012	12.5%
VI.	Biology	0013	12.5%
VII.	Earth Science	0014	12.5%

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MATTER AND ITS INTERACTIONS—COMPOSITION AND BONDING

0001 Analyze the properties of matter.

For example:

1.1 Analyze various historical and contemporary models of atomic structure and the supporting evidence for these models.

1.2 Demonstrate knowledge of the properties of and interactions between electrons, protons, and neutrons.

1.3 Analyze the electromagnetic spectrum with respect to the relationship between energy levels, photons, and atomic spectra.

1.4 Analyze electron configurations, orbital diagrams, and Lewis dot symbols of elements.

1.5 Analyze the characteristics and properties of elements, compounds, and mixtures.

1.6 Apply knowledge of chemical and physical properties and changes of matter and the methods used to determine them.

1.7 Apply knowledge of nuclear changes to the characteristics of matter and radioactive materials.

1.8 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to properties of matter (e.g., separation of substances, density, flame tests).

1.9 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to the properties of matter (e.g., analyzing the scale difference between radioisotope dating using carbon versus radioisotope dating of rock, explaining how spectra are used to determine the age of stars) and make connections between science, engineering, and daily life (e.g., identifying differences between flat-screen technology and cathode ray tubes, describing how chemical properties can be used in forensics studies).

0002 Analyze chemical bonding and matter interactions and properties.

For example:

2.1 Compare the characteristics of different types of chemical bonds (i.e., ionic, covalent, metallic).

2.2 Analyze chemical bonding in terms of electron behavior and the factors that affect bond strength.

2.3 Use Lewis structures to represent chemical bonding in compounds.

2.4 Analyze the characteristics of various types of intermolecular forces (e.g., dipole-dipole, dispersion, hydrogen bonding) and the forces between molecules of a given structure.

2.5 Relate the properties of substances to their intramolecular and intermolecular forces.

2.6 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to properties of matter (e.g., boiling points and melting points, conductivity tests, solubility tests).

2.7 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to chemical bonding and matter interactions and properties (e.g., recognizing how different classes of compounds exhibit similar characteristics; showing how observational evidence can be used to make models of concepts and interactions that are not viewable) and make connections between science, engineering, and daily life (e.g., explaining how alloys can be used in different construction applications, understanding why salts are used to deice roadways and sidewalks).

MATTER AND ITS INTERACTIONS—STRUCTURE AND PERIODICITY

0003 Apply knowledge of the structure and naming of chemical substances and periodic properties of the elements.

For example:

3.1 Apply the basic rules of nomenclature for common acids, binary molecular, ionic, and simple organic compounds (e.g., International Union of Pure and Applied Chemistry [IUPAC]).

3.2 Demonstrate knowledge of the organization of the periodic table and its usefulness in predicting the physical and chemical properties and relative reactivity of given elements.

3.3 Analyze the characteristics of inorganic structures, including ionic solids, network solids, and metallic solids.

3.4 Predict the geometry of molecules and polyatomic ions using the valence-shell electron-pair repulsion (VSEPR) model.

3.5 Analyze the chemical composition and basic structure of organic compounds.

3.6 Recognize the characteristics of structural, geometric, and optical isomers.

3.7 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to structure and periodicity (e.g., halide reactivity, metal activity series, building VSEPR models).

3.8 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to the structure and naming of chemical substances and periodic properties of the elements (e.g., explaining the properties of biological macromolecules, outlining key steps in the explanation and application of periodic laws) and make connections between science, engineering, and daily life (e.g., recognizing functional groups in classes of organic compounds that have an engineering use, understanding why common names often replace IUPAC names).

0004 Apply knowledge of the mole and mass relationships in chemical changes.

For example:

4.1 Demonstrate knowledge of the mole concept and its use in chemical quantities.

4.2 Solve problems involving mole calculations (e.g., molar mass, number of particles, volumes of gases), percent-composition, and empirical and molecular formulas.

4.3 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to mole and mass relationships (e.g., counting by weighing, determining percent compositions and empirical formulas).

4.4 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to the mole and mass relationships in chemical changes (e.g., explaining how moles are like dozens, recognizing that formulas represent absolute proportions) and make connections between science, engineering, and daily life (e.g., comparing the empirical and molecular formulas for various carbohydrates, determining the mass of active and inactive ingredients in common medications).

ENERGY

0005 Analyze energy transfers in chemical and physical processes.

For example:

5.1 Analyze the three laws of thermodynamics and their applications to chemical and biochemical systems (e.g., cellular energetics, enzymes and catalysts, energy transfer in an ecosystem).

5.2 Differentiate among forms of energy.

5.3 Distinguish between heat and temperature.

5.4 Analyze energy transfers due to the formation or breaking of chemical bonds.

5.5 Analyze energy transfers during chemical reactions, phase transitions, dissolving solutes in solvents, and diluting solutions.

5.6 Calculate and interpret the values of specific heat and the results of calorimetry experiments.

5.7 Analyze entropy changes and Gibbs free energy in chemical reactions and predict the spontaneity of given chemical reactions.

5.8 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to energy transfer (e.g., calorimetry, Hess's law, energy diagrams).

5.9 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to energy changes in chemical and physical processes (e.g., explaining the cause-and-effect relationship of bond strength and reaction enthalpy, proposing solutions to reaction systems that do not proceed spontaneously) and make connections between science, engineering, and daily life (e.g., explaining heat and cold pack reactions, describing how calorimetry is used to determine energy content in foods).

0006 Analyze the types of chemical reactions and their causes.

For example:

6.1 Analyze the five general types of chemical reactions (i.e., combination/synthesis, decomposition, single displacement, double displacement, combustion).

6.2 Distinguish among fundamental organic and biochemical reactions (e.g., addition, substitution, photosynthesis).

6.3 Apply the law of conservation of mass to the balancing of chemical equations.

6.4 Solve reaction stoichiometry problems involving moles, mass, volume, and energy, including determining the limiting reactant and percent yield.

6.5 Interpret collision theory and factors that influence reaction rates.

6.6 Analyze rate problems and experimental rate data.

6.7 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to chemical reactions (e.g., determine reaction types, compare theoretical and actual yield, analyze factors that affect reaction rate).

6.8 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to types of chemical reactions and their causes (e.g., relating the experimental determination of rate laws to other mathematical models, applying concepts of green chemistry in manufacturing, recognizing stoichiometric ratios for a given class of elements) and make connections between science, engineering, and daily life (e.g., explaining the chemical process of creating saturated fats, explaining how reaction rates can influence the absorption of nutrients in soil).

0007 Apply knowledge of oxidation and reduction reactions and electrochemical cells.

For example:

7.1 Demonstrate knowledge of oxidation, reduction, oxidation numbers, and the balancing of oxidation-reduction equations.

7.2 Analyze the components and operating principles of electrochemical cells and electrolytic cells.

7.3 Solve problems involving electrochemical cells.

7.4 Demonstrate knowledge of the applications of electrochemistry.

7.5 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to oxidation and reduction reactions and electrochemical cells (e.g., constructing a battery, electroplating).

7.6 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to oxidation and reduction reactions and electrochemical cells (e.g., explaining how the composition of an electrode will affect the current in an electrochemical cell, explaining applications of electroplating) and make connections between science, engineering, and daily life (e.g., describing why a sacrificial anode is used to prevent corrosion on some metal structures, relating the voltage of a battery to the materials used to construct the battery).

0008 Apply knowledge of chemical equilibrium.

For example:

8.1 Apply knowledge of the concept of chemical equilibrium and the factors that influence chemical equilibrium.

8.2 Apply Le Chatelier's principle to chemical systems.

8.3 Solve problems involving equilibrium constants.

8.4 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, and graphing methods) related to chemical equilibrium (e.g., determine the equilibrium constant for a reaction, manipulate factors that affect forward and reverse reactions).

8.5 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to chemical equilibrium (e.g., explaining how an exothermic reaction might have favorable results when run at low temperature, predicting the changes in equilibrium in a car battery as electrical systems are turned on and off) and make connections between science, engineering, and daily life (e.g., recognizing the equilibrium condition of fog formation, describing how a reaction that is producing a product can be described as stable).

SOLUTIONS AND GASES AND THEIR ASSOCIATED PROPERTIES

0009 Demonstrate knowledge of the kinetic molecular theory, the nature of phase changes, and the gas laws.

For example:

9.1 Demonstrate knowledge of the basic principles of the kinetic molecular theory and the distinguishing characteristics of different states of matter.

9.2 Analyze heating and cooling curves and phase diagrams.

9.3 Demonstrate knowledge of the relationships between volume, temperature, amount, and pressure of gases.

9.4 Solve problems involving the gas laws.

9.5 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to the kinetic molecular theory (e.g., gas law stations, build time and temperature graphs for phase transitions).

9.6 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to kinetic molecular theory, phase changes, and the gas laws (e.g., describing how the kinetic molecular theory differs from the characteristics of a real gas, identifying the flow of energy as a block of dry ice sublimates) and make connections between science, engineering, and daily life (e.g., describing the condition that would make cloud seeding successful, exploring the basic functioning of a hot air balloon).

0010 Demonstrate knowledge of the acid and base nature of substances.

For example:

10.1 Analyze acids and bases according to how they behave and how they are defined (e.g., Arrhenius, Brønsted-Lowry, Lewis).

10.2 Demonstrate knowledge of the relationship between molecular structure and acid strength, the relative strengths of acids and bases, and dissociation constants associated with each.

10.3 Determine the hydronium ion concentration, hydroxide ion concentration, pH, and pOH for strong and weak acids and bases and hydrolysis of salts.

10.4 Analyze buffer solutions qualitatively and quantitatively.

10.5 Demonstrate knowledge of the principles and applications of acid-base titrations, including neutralization reactions.

10.6 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to acids and bases (e.g., determining appropriate indicators, measuring the concentration of an acid or base using titration).

10.7 Apply knowledge of scientific practice, crosscutting concepts, and engineering practices to the acid and base nature of substances (e.g., describing the implications of the logarithmic nature of the pH scale, recognizing that buffer systems tend toward stability) and make connections between science, engineering, and daily life (e.g., explaining why some medications are made in buffered form, recognizing that some products like batteries must use potentially dangerous acids).

0011 Analyze the properties of solutions and other aqueous mixtures.

For example:

11.1 Demonstrate knowledge of different types of mixtures, including solutions, colloids, and suspensions.

11.2 Solve problems involving concentrations and dilutions of solutions.

11.3 Analyze factors that affect solubility and solubility curves (i.e., solid-liquid, gas-liquid).

11.4 Demonstrate knowledge of solubility rules to derive net ionic equations.

11.5 Analyze the colligative properties of solutions.

11.6 Apply knowledge of laboratory practices and techniques for data collection, analysis, and reporting (e.g., observation and measurement, quantitative and qualitative data, graphing methods) related to mixtures (e.g., chromatography, serial dilutions, creating solubility curves, formation of a precipitate).

11.7 Apply knowledge of scientific practices, crosscutting concepts, and engineering practices to properties of solutions and other aqueous mixtures (e.g., describing an observed solubility trend for gases, recognizing the limits of freezing point depression and boiling point elevation, analyzing trends for solubility rules for metal hydroxides) and make connections between science, engineering, and daily life (e.g., describing how particulate filters on power plants help reduce smog formation, explaining why treating wastewater with chemicals to bond impurities to larger molecules increases purity of final product).

PHYSICS

0012 Apply knowledge of physics concepts.

For example:

12.1 Apply concepts of mechanical forces and interactions to describe the motion of an object (e.g., position, velocity, and acceleration; Newton's laws; momentum and collisions; the universal law of gravitation).

12.2 Apply concepts of electric and electromagnetic forces in a variety of situations (e.g., Coulomb's law, Ohm's law, circuits, electromagnets).

12.3 Apply knowledge of energy and the conservation of energy, including kinetic energy, potential energy, and thermal energy, and conversions among them (e.g., evaluate real-world devices that convert energy from one form to another).

12.4 Apply knowledge of relationships between frequency, wavelength, and speed of a wave; wave reflection, refraction, and superposition; principles of optics; and applications of waves in technologies for information transfer.

BIOLOGY

0013 Apply knowledge of biology concepts.

For example:

13.1 Apply knowledge of the structure of prokaryotic and eukaryotic cells; the function of membranes and organelles; and the processes of photosynthesis and cellular respiration.

13.2 Analyze how bacteria, plants, and animals obtain, store, and use energy, nutrients, and water to maintain homeostasis, including through the use of the levels of biological organization in multicellular organisms.

13.3 Demonstrate knowledge of cellular division and the cell cycle.

13.4 Apply knowledge of the synthesis, structure, and function of nucleic acids; factors controlling gene expression; the processes involved in protein synthesis; and basic methods and applications of genetic engineering (e.g., restriction enzymes, DNA sequencing, recombinant DNA).

13.5 Analyze the patterns and processes of inheritance, including asexual and sexual reproduction.

13.6 Demonstrate knowledge of population genetics and the primary mechanisms of evolution, natural selection, and speciation.

13.7 Analyze how biotic and abiotic factors affect carrying capacity and biodiversity of an ecosystem, population curves, the types of relationships that exist between organisms in communities, and factors that produce change in communities.

13.8 Analyze energy flow and biogeochemical cycling in ecosystems and the trophic roles of organisms in different ecosystems (e.g., food chain, food web).

EARTH SCIENCE

0014 Apply knowledge of Earth science concepts.

For example:

14.1 Demonstrate knowledge of the origin of the universe and the characteristics and life cycles of stars, galaxies, and other objects in the universe.

14.2 Apply knowledge of the characteristics and motions of objects within the solar system and the interactions of the Earth-moon-sun system.

14.3 Demonstrate knowledge of the geologic timescale and dating methods; the structure of Earth's interior and methods used to study it; the evidence for, and causes of, plate tectonics; the rock cycle; and the processes of weathering, erosion, and deposition.

14.4 Apply knowledge of the properties of water, movement of water through the hydrologic cycle, and characteristics of different water reservoirs.

14.5 Demonstrate knowledge of factors of the composition, evolution, and structure of the atmosphere; the processes of energy transfer in the atmosphere; factors that affect weather, climate, and climate change; and the use of weather models, maps, and weather-related technology.

14.6 Demonstrate knowledge of factors that influence the movement of matter through geochemical cycles; types, characteristics, distribution, and management of renewable and nonrenewable resources; and the advantages and disadvantages of different sources of energy.

14.7 Demonstrate knowledge of natural hazards and catastrophic events and their impacts on human populations, the effects of human activities on each of Earth's systems, and strategies for mitigating these effects.