



Preparation Manual Science 7–12 (236)

Overview and Exam Framework

Reference Materials

Sample Selected-Response Questions

Sample Selected-Response Answers and Rationales

Preparation Manual

Section 3: Overview and Exam Framework Science 7–12 (236)

Exam Overview

Exam Name	Science 7–12
Exam Code	236
Time	5 hours
Number of Questions	140 selected-response questions
Format	Computer-administered test (CAT)

The TExES Science 7–12 (236) exam is designed to assess whether an examinee has the requisite knowledge and skills that an entry-level educator in this field in Texas public schools must possess. The 140 selected-response questions are based on the Science 7–12 exam framework and cover grades 7–12. The exam may contain questions that do not count toward the score. Your final scaled score will be based only on scored questions.

The Standards

Standard I

The science teacher manages classroom, field and laboratory activities to ensure the safety of all students and the ethical care and treatment of organisms and specimens.

Standard II

The science teacher understands the correct use of tools, materials, equipment and technologies.

Standard III

The science teacher understands the process of scientific inquiry and its role in science instruction.

Standard IV

The science teacher has theoretical and practical knowledge about teaching science and about how students learn science.

Standard V

The science teacher knows the varied and appropriate assessments and assessment practices to monitor science learning.

Standard VI

The science teacher understands the history and nature of science.

Standard VII

The science teacher understands how science affects the daily lives of students and how science interacts with and influences personal and societal decisions.

Standard VIII

The science teacher knows and understands the science content appropriate to teach the statewide curriculum (Texas Essential Knowledge and Skills [TEKS]) in physical science.

Standard IX

The science teacher knows and understands the science content appropriate to teach the statewide curriculum (Texas Essential Knowledge and Skills [TEKS]) in life science.

Standard X

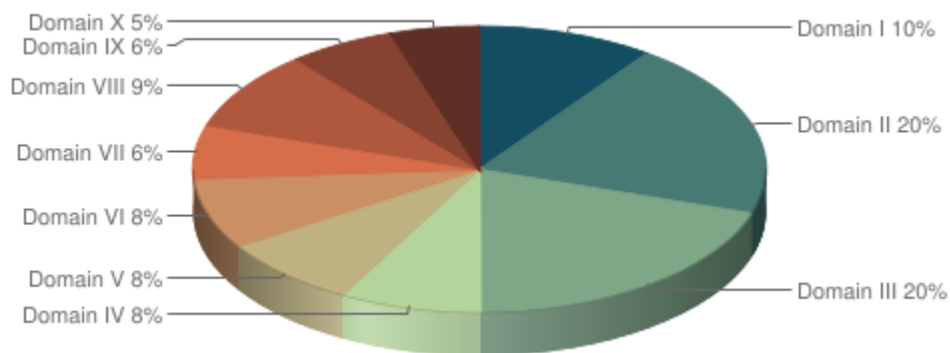
The science teacher knows and understands the science content appropriate to teach the statewide curriculum (Texas Essential Knowledge and Skills [TEKS]) in Earth and space science.

Standard XI

The science teacher knows unifying concepts and processes that are common to all sciences.

Domains and Competencies

Domain	Domain Title	Approx. Percentage of Exam	Standards Assessed
I	Scientific Inquiry and Processes	10%	Science 7–12 I–III, VI–VII, XI
II	Physics	20%	Science 7–12 VIII
III	Chemistry	20%	Science 7–12 VIII
IV	Cell Structure and Processes	8%	Science 7–12 IX
V	Heredity and Evolution of Life	8%	Science 7–12: IX
VI	Diversity of Life	8%	Science 7–12: IX
VII	Interdependence of Life and Environmental Systems	6%	Science 7–12: IX
VIII	Earth’s History and the Structure and Function of Earth Systems	9%	Science 7–12: X
IX	Components and Properties of the Solar System and the Universe	6%	Science 7–12: X
X	Science Learning, Instruction and Assessment	5%	Science 7–12: IV–V



The content covered by this exam is organized into broad areas of content called **domains**. Each domain covers one or more of the educator standards for this field. Within each domain, the content is further defined by a set of **competencies**. Each competency is composed of two major parts:

- The **competency statement**, which broadly defines what an entry-level educator in this field in Texas public schools should know and be able to do.
- The **descriptive statements**, which describe in greater detail the knowledge and skills eligible for testing.

Domain I—Scientific Inquiry and Processes

Competency 001—The teacher understands how to select and manage learning activities to ensure the safety of all students and the correct use and care of organisms, natural resources, materials, equipment and technologies.

The beginning teacher:

- Uses current sources of information about laboratory safety, including safety regulations and guidelines for the use of science facilities.
- Recognizes potential safety hazards in the laboratory and in the field and knows how to apply procedures, including basic first aid, for responding to accidents.
- Employs safe practices in planning, implementing and managing all instructional activities and designs, and implements rules and procedures to maintain a safe learning environment.
- Understands procedures for selecting, maintaining and safely using chemicals, tools, technologies, materials, specimens and equipment, including procedures for the recycling, reuse and conservation of laboratory resources and for the safe handling and ethical treatment of organisms.
- Knows how to use appropriate equipment and technology (e.g., Internet, spreadsheet, calculator) for gathering, organizing, displaying and communicating data in a variety of ways (e.g., charts, tables, graphs, diagrams, maps, satellite images, written reports, oral presentations).
- Understands how to use a variety of tools, techniques and technology to gather, organize and analyze data, how to perform calculations and how to apply appropriate methods of statistical measures and analyses.
- Knows how to apply techniques to calibrate measuring devices and understands concepts of precision, accuracy and error with regard to reading and recording numerical data from scientific instruments (e.g., significant figures).

- H. Uses the International System of Units (i.e., metric system) and performs unit conversions within and across measurement systems.

Competency 002—The teacher understands the nature of science, the process of scientific inquiry and the unifying concepts that are common to all sciences.

The beginning teacher:

- A. Understands the nature of science, the relationship between science and technology, the predictive power of science and limitations to the scope of science (i.e., the types of questions that science can and cannot answer).
- B. Knows the characteristics of various types of scientific investigations (e.g., descriptive studies, controlled experiments, comparative data analysis) and how and why scientists use different types of scientific investigations.
- C. Understands principles and procedures for designing and conducting a variety of scientific investigations — with emphasis on inquiry-based investigations — and how to communicate and defend scientific results.
- D. Understands how logical reasoning, verifiable observational and experimental evidence and peer review are used in the process of generating and evaluating scientific knowledge.
- E. Understands how to identify potential sources of error in an investigation, evaluate the validity of scientific data and develop and analyze different explanations for a given scientific result.
- F. Knows the characteristics and general features of systems; how properties and patterns of systems can be described in terms of space, time, energy and matter; and how system components and different systems interact.
- G. Knows how to apply and analyze the systems model (e.g., interacting parts, boundaries, input, output, feedback, subsystems) across the science disciplines.
- H. Understands how shared themes and concepts (e.g., systems, order and organization; evidence, models and explanation; change, constancy and measurements; evolution and equilibrium; form and function) provide a unifying framework in science.
- I. Understands the difference between a theory and a hypothesis, how models are used to represent the natural world and how to evaluate the strengths and limitations of a variety of scientific models (e.g., physical, conceptual, mathematical).

Competency 003—The teacher understands the history of science, how science impacts the daily lives of students and how science interacts with and influences personal and societal decisions.

The beginning teacher:

- A. Understands the historical development of science, key events in the history of science and the contributions that diverse cultures and individuals of both genders have made to scientific knowledge.
- B. Knows how to use examples from the history of science to demonstrate the changing nature of scientific theories and knowledge (i.e., that scientific theories and knowledge are always subject to revision in light of new evidence).

- C. Knows that science is a human endeavor influenced by societal, cultural and personal views of the world, and knows that decisions about the use and direction of science are based on factors such as ethical standards, economics and personal and societal biases and needs.
- D. Understands the application of scientific ethics to the conducting, analyzing and publishing of scientific investigations.
- E. Applies scientific principles to analyze factors (e.g., diet, exercise, personal behavior) that influence personal and societal choices concerning fitness and health (e.g., physiological and psychological effects and risks associated with the use of substances and substance abuse).
- F. Applies scientific principles, the theory of probability and risk/benefit analysis to analyze the advantages of, disadvantages of or alternatives to a given decision or course of action.
- G. Understands the role science can play in helping resolve personal, societal and global issues (e.g., recycling, population growth, disease prevention, resource use, evaluating product claims).

Domain II—Physics

Competency 004—The teacher understands the description of motion in one and two dimensions.

The beginning teacher:

- A. Generates, analyzes and interprets graphs describing the motion of a particle.
- B. Applies vector concepts to displacement, velocity and acceleration to analyze and describe the motion of a particle.
- C. Solves problems involving uniform and accelerated motion using scalar (e.g., speed) and vector (e.g., velocity) quantities.
- D. Analyzes and solves problems involving projectile motion.
- E. Analyzes and solves problems involving uniform circular and rotary motion.
- F. Understands motion of fluids.
- G. Understands motion in terms of frames of reference and relativity concepts.

Competency 005—The teacher understands the laws of motion.

The beginning teacher:

- A. Identifies and analyzes the forces acting in a given situation and constructs a free-body diagram.
- B. Solves problems involving the vector nature of force (e.g., resolving forces into components, analyzing static or dynamic equilibrium of a particle).
- C. Identifies and applies Newton's laws to analyze and solve a variety of practical problems (e.g., properties of frictional forces, acceleration of a particle on an inclined plane, displacement of a mass on a spring, forces on a pendulum).

Competency 006—The teacher understands the concepts of gravitational and electromagnetic forces in nature.

The beginning teacher:

- A. Applies the law of universal gravitation to solve a variety of problems (e.g., determining the gravitational fields of the planets, analyzing properties of satellite orbits).
- B. Calculates electrostatic forces, fields and potentials.
- C. Understands the properties of magnetic materials and the molecular theory of magnetism.
- D. Identifies the source of the magnetic field and calculates the magnetic field for various simple current distributions.
- E. Analyzes the magnetic force on charged particles and current-carrying conductors.
- F. Understands induced electric and magnetic fields and analyzes the relationship between electricity and magnetism.
- G. Understands the electromagnetic spectrum and the production of electromagnetic waves.

Competency 007—The teacher understands applications of electricity and magnetism.

The beginning teacher:

- A. Analyzes common examples of electrostatics (e.g., a charged balloon attached to a wall, behavior of an electroscope, charging by induction).
- B. Understands electric current, resistance and resistivity, potential difference, capacitance and electromotive force in conductors and circuits.
- C. Analyzes series and parallel DC circuits in terms of current, resistance, voltage and power.
- D. Identifies basic components and characteristics of AC circuits.
- E. Understands the operation of an electromagnet.
- F. Understands the operation of electric meters, motors, generators and transformers.

Competency 008—The teacher understands the conservation of energy and momentum.

The beginning teacher:

- A. Understands the concept of work.
- B. Understands the relationships among work, energy and power.
- C. Solves problems using the conservation of mechanical energy in a physical system (e.g., determining potential energy for conservative forces, conversion of potential to kinetic energy, analyzing the motion of a pendulum).
- D. Applies the work-energy theorem to analyze and solve a variety of practical problems (e.g., finding the speed of an object given its potential energy, determining the work done by frictional forces on a decelerating car).

- E. Understands linear and angular momentum.
- F. Solves a variety of problems (e.g., collisions) using the conservation of linear and angular momentum.

Competency 009—The teacher understands the laws of thermodynamics.

The beginning teacher:

- A. Understands methods of heat transfer (i.e., convection, conduction, radiation).
- B. Understands the molecular interpretation of temperature and heat.
- C. Solves problems involving thermal expansion, heat capacity and the relationship between heat and other forms of energy.
- D. Applies the first law of thermodynamics to analyze energy transformations in a variety of everyday situations (e.g., electric light bulb, power generating plant).
- E. Understands the concept of entropy and its relationship to the second law of thermodynamics.

Competency 010—The teacher understands the characteristics and behavior of waves.

The beginning teacher:

- A. Understands relationships among wave characteristics such as velocity, frequency, wavelength and amplitude and relates them to properties of sound and light (e.g., pitch, color).
- B. Compares and contrasts transverse and longitudinal waves.
- C. Describes how various waves are propagated through different media.
- D. Applies properties of reflection and refraction to analyze optical phenomena (e.g., mirrors, lenses, fiber-optic cable).
- E. Applies principles of wave interference to analyze wave phenomena, including acoustical (e.g., harmonics) and optical phenomena (e.g., patterns created by thin films and diffraction gratings).
- F. Identifies and interprets how wave characteristics and behaviors are used in medical, industrial and other real-world applications.

Competency 011—The teacher understands the fundamental concepts of quantum physics.

The beginning teacher:

- A. Interprets wave-particle duality.
- B. Identifies examples and consequences of the uncertainty principle.
- C. Understands the photoelectric effect.
- D. Uses the quantum model of the atom to describe and analyze absorption and emission spectra (e.g., line spectra, blackbody radiation).
- E. Explores real-world applications of quantum phenomena (e.g., lasers, photoelectric sensors, semiconductors, superconductivity).

Domain III—Chemistry

Competency 012—The teacher understands the characteristics of matter and atomic structure.

The beginning teacher:

- A. Differentiates between physical and chemical properties and changes of matter.
- B. Explains the structure and properties of solids, liquids and gases.
- C. Identifies and analyzes properties of substances (i.e., elements and compounds) and mixtures.
- D. Models the atom in terms of protons, neutrons and electron clouds.
- E. Identifies elements and isotopes by atomic number and mass number and calculates average atomic mass of an element.
- F. Understands atomic orbitals and electron configurations and describes the relationship between electron energy levels and atomic structure.
- G. Understands the nature and historical significance of the periodic table.
- H. Applies the concept of periodicity to predict the physical properties (e.g., atomic and ionic radii) and chemical properties (e.g., electronegativity, ionization energy) of an element.

Competency 013—The teacher understands the properties of gases.

The beginning teacher:

- A. Understands interrelationships among temperature, number of moles, pressure and volume of gases contained within a closed system.
- B. Analyzes data obtained from investigations with gases in a closed system and determines whether the data are consistent with the ideal gas law.
- C. Applies the gas laws (e.g., Charles's law, Boyle's law, combined gas law) to describe and calculate gas properties in a variety of situations.
- D. Applies Dalton's law of partial pressure in various situations (e.g., collecting a gas over water).
- E. Understands the relationship between kinetic molecular theory and the ideal gas law.
- F. Knows how to apply the ideal gas law to analyze mass relationships between reactants and products in chemical reactions involving gases.

Competency 014—The teacher understands the properties and characteristics of ionic and covalent bonds.

The beginning teacher:

- A. Relates the electron configuration of an atom to its chemical reactivity.
- B. Compares and contrasts characteristics of ionic and covalent bonds.
- C. Applies the "octet" rule to construct Lewis structures.
- D. Identifies and describes the arrangement of atoms in molecules, ionic crystals, polymers and metallic substances.
- E. Understands the influence of bonding forces on the physical and chemical properties of ionic and covalent substances.
- F. Identifies and describes intermolecular and intramolecular forces.
- G. Uses intermolecular forces to explain the physical properties of a given substance (e.g., melting point, crystal structure).
- H. Applies the concepts of electronegativity, electron affinity and oxidation state to analyze chemical bonds.
- I. Evaluates energy changes in the formation and dissociation of chemical bonds.
- J. Understands the relationship between chemical bonding and molecular geometry.

Competency 015—The teacher understands and interprets chemical equations and chemical reactions.

The beginning teacher:

- A. Identifies elements, common ions and compounds using scientific nomenclature.
- B. Uses and interprets symbols, formulas and equations in describing interactions of matter and energy in chemical reactions.
- C. Understands mass relationships involving percent composition, empirical formulas and molecular formulas.
- D. Interprets and balances chemical equations using conservation of mass and charge.
- E. Understands mass relationships in chemical equations and solves problems using calculations involving moles, limiting reagents and reaction yield.
- F. Identifies factors (e.g., temperature, pressure, concentration, catalysts) that influence the rate of a chemical reaction and describes their effects.
- G. Understands principles of chemical equilibrium and solves problems involving equilibrium constants.
- H. Identifies the chemical properties of a variety of common household chemicals (e.g., baking soda, bleach, ammonia) in order to predict the potential for chemical reactivity.

Competency 016—The teacher understands types and properties of solutions.

The beginning teacher:

- A. Analyzes factors that affect solubility (e.g., temperature, pressure, polarity of solvents and solutes) and rate of dissolution (e.g., surface area, agitation).
- B. Identifies characteristics of saturated, unsaturated and supersaturated solutions.
- C. Determines the molarity, molality, normality and percent composition of aqueous solutions.
- D. Analyzes precipitation reactions and derives net ionic equations.
- E. Understands the colligative properties of solutions (e.g., vapor pressure lowering, osmotic pressure changes, boiling-point elevation, freezing-point depression).
- F. Understands the properties of electrolytes and explains the relationship between concentration and electrical conductivity.
- G. Understands methods for measuring and comparing the rates of reaction in solutions of varying concentration.
- H. Analyzes models to explain the structural properties of water and evaluates the significance of water as a solvent in living organisms and the environment.

Competency 017—The teacher understands energy transformations that occur in physical and chemical processes.

The beginning teacher:

- A. Analyzes the energy transformations that occur in phase transitions.
- B. Solves problems in calorimetry (e.g., determining the specific heat of a substance, finding the standard enthalpy of formation and reaction of substances).
- C. Applies the law of conservation of energy to analyze and evaluate energy exchanges that occur in exothermic and endothermic reactions.
- D. Understands thermodynamic relationships among spontaneous reactions, entropy, enthalpy, temperature and Gibbs free energy.

Competency 018—The teacher understands nuclear fission, nuclear fusion and nuclear reactions.

The beginning teacher:

- A. Uses models to explain radioactivity and radioactive decay (i.e., alpha, beta, gamma).
- B. Interprets and balances equations for nuclear reactions.
- C. Compares and contrasts fission and fusion reactions (e.g., relative energy released in the reactions, mass distribution of products).
- D. Knows how to use the half-life of radioactive elements to solve real-world problems (e.g., carbon dating, radioactive tracers).
- E. Understands stable and unstable isotopes.
- F. Knows various issues associated with using nuclear energy (e.g., medical, commercial, environmental).

Competency 019—The teacher understands oxidation and reduction reactions.

The beginning teacher:

- A. Determines the oxidation state of ions and atoms in compounds.
- B. Identifies and balances oxidation and reduction reactions.
- C. Uses reduction potentials to determine whether a redox reaction will occur spontaneously.
- D. Explains the operation and applications of electrochemical cells.
- E. Analyzes applications of oxidation and reduction reactions from everyday life (e.g., combustion, rusting, electroplating, batteries).

Competency 020—The teacher understands acids, bases and their reactions.

The beginning teacher:

- A. Identifies the general properties of, and relationships among, acids, bases and salts.
- B. Identifies acids and bases using models of Arrhenius, Brønsted-Lowry and Lewis.
- C. Differentiates between strong and weak acids and bases.
- D. Applies the relationship between hydronium ion concentration and pH for acids and bases.
- E. Understands and analyzes acid-base equilibria and buffers.
- F. Analyzes and applies the principles of acid-base titration.
- G. Analyzes neutralization reactions based on the principles of solution concentration and stoichiometry.
- H. Describes the effects of acids and bases in the real world (e.g., acid precipitation, physiological buffering).

Domain IV—Cell Structure and Processes

Competency 021—The teacher understands the structure and function of biomolecules.

The beginning teacher:

- A. Identifies the chemical elements necessary for life and understands how those elements combine to form biologically important compounds.
- B. Relates the physical and chemical properties of water and carbon to the significance of those properties in basic life processes.
- C. Analyzes how a molecule's biological function is related to its shape (e.g., enzymes, tRNA, DNA, receptors, neurotransmitters, lipids).
- D. Understands the importance of chemical reactions in the synthesis and degradation of biomolecules.
- E. Identifies and compares the structures and functions of different types of biomolecules, including carbohydrates, lipids, proteins and nucleic acids.
- F. Explains how enzymes function in synthesis and degradation of biomolecules (e.g., DNA, food).

Competency 022—The teacher understands that cells are the basic structure of living things and have specialized parts that perform specific functions.

The beginning teacher:

- A. Differentiates among viruses, prokaryotic cells and eukaryotic cells (e.g., structure and function).
- B. Describes the basic components of prokaryotic and eukaryotic cells (e.g., cell membrane, cell wall, ribosomes, nucleus, mitochondrion, chloroplast), and the functions and relationships of the components.
- C. Identifies differences in cell structure and function in different types of organisms (e.g., differences in plant and animal cells).
- D. Analyzes specialization of structure and function in different types of cells in living organisms (e.g., skin, nerve and muscle cells in animals; root, stem and leaf cells in plants).

Competency 023—The teacher understands how cells carry out life processes.

The beginning teacher:

- A. Analyzes how cells maintain homeostasis (e.g., the effects of concentration gradients, rate of movement and ratio of surface area to volume).
- B. Understands processes by which cells transport water, nutrients and wastes across cell membranes (e.g., osmosis, diffusion, transport systems).
- C. Analyzes energy flow in the processes of photosynthesis and cellular respiration.
- D. Compares and contrasts anaerobic and aerobic respiration and their products.

Competency 024—The teacher understands how specialized cells, tissues, organs, organ systems and organisms grow and develop.

The beginning teacher:

- A. Understands factors (e.g., hormones, cell size) that regulate the cell cycle and the effects of unregulated cell growth (e.g., cancer).
- B. Analyzes the role of cell differentiation in the development of tissues, organs, organ systems and living organisms.
- C. Analyzes factors (e.g., genetics, disease, nutrition, exposure to toxic chemicals) affecting cell differentiation and the growth and development of organisms.
- D. Identifies the different levels of organization in multicellular organisms and relates the parts to each other and to the whole.

Domain V—Heredity and Evolution of Life

Competency 025—The teacher understands the structures and functions of nucleic acids in the mechanisms of genetics.

The beginning teacher:

- A. Relates the structure of DNA (e.g., bases, sugars, phosphates) to the nature, function and relationships of genes, chromatin and chromosomes.
- B. Relates the structures of DNA and RNA to the processes of replication, transcription, translation and genetic regulation.
- C. Compares and contrasts the organization and control of the genome in viruses, prokaryotic cells and eukaryotic cells.
- D. Understands the types, biological significance and causes of mutations.
- E. Identifies methods and applications of genetic identification and manipulation (e.g., production of recombinant DNA, cloning, PCR).
- F. Analyzes human karyotypes to identify chromosomal disorders and sex.

Competency 026—The teacher understands the continuity and variations of traits from one generation to the next.

The beginning teacher:

- A. Applies the laws of probability to determine genotypic and phenotypic frequencies in Mendelian inheritance (e.g., Punnett squares, pedigree charts).
- B. Compares the processes of meiosis and mitosis (in plants and animals) and describes their roles in sexual and asexual reproduction.
- C. Recognizes factors influencing the transmission of genes from one generation to the next (e.g., linkage, position of genes on a chromosome, crossing over, independent assortment).
- D. Understands how the genotype of an organism influences the expression of traits in its phenotype (e.g., dominant and recessive traits; monogenic, polygenic and polytypic inheritance; genetic disorders).
- E. Analyzes the effects of environmental factors (e.g., light, nutrition, moisture, temperature) on the expression of traits in the phenotype of an organism.

Competency 027—The teacher understands the theory of biological evolution.

The beginning teacher:

- A. Understands stability and change in populations (e.g., Hardy-Weinberg equilibrium) and analyzes factors leading to genetic variation and evolution in populations (e.g., mutation, gene flow, genetic drift, recombination, nonrandom mating, natural selection).
- B. Analyzes the effects of natural selection on adaptations and diversity in populations and species.
- C. Understands the role of intraspecific and interspecific competition in evolutionary change.
- D. Compares and contrasts the different effects of selection (e.g., directional, stabilizing, diversifying) on a variable characteristic.
- E. Analyzes processes that contribute to speciation (e.g., natural selection, founder effect, reproductive isolation).

- F. Analyzes the development of isolating mechanisms that discourage hybridization between species (e.g., species' recognition marks, behavioral displays, ecological separation, seasonal breeding).

Competency 028—The teacher understands evidence for evolutionary change during Earth's history.

The beginning teacher:

- A. Analyzes how fossils, DNA sequences, anatomical similarities, physiological similarities and embryology provide evidence of both common origin and change in populations and species.
- B. Understands the relationship between environmental change, mutations and adaptations of an organism over many generations.
- C. Identifies major developments in the evolutionary history of life (e.g., formation of organic molecules, self-replication, backbones, vascular tissue, colonization of the land).
- D. Understands theories regarding the causes of extinction of species and the pace and mode of evolutionary change (e.g., punctuated equilibrium, mass extinctions, adaptive radiation).

Domain VI—Diversity of Life

Competency 029—The teacher understands similarities and differences between living organisms and how taxonomic systems are used to organize and interpret the diversity of life.

The beginning teacher:

- A. Compares and contrasts structural and physiological adaptations of plants and animals living in various aquatic and terrestrial environments (e.g., freshwater and marine; forest and plain; desert and tundra).
- B. Understands the relationship between environmental changes in aquatic and terrestrial ecosystems and adaptive changes in organisms inhabiting those ecosystems.
- C. Explains the uses and limitations of classification schemes.
- D. Relates taxonomic classification to evolutionary history and knows how to distinguish between traits that are taxonomically useful (e.g., homologous traits) and those that are not (e.g., convergent traits).
- E. Analyzes relationships among organisms to develop a model of a hierarchical classification system and knows how to classify aquatic and terrestrial organisms at several taxonomic levels (e.g., species, phylum/division, kingdom) using dichotomous keys.
- F. Identifies distinguishing characteristics of domains and kingdoms, including eubacteria, archaeobacteria, protists, fungi, plants and animals.

Competency 030—The teacher understands that, at all levels of nature, living systems are found within other living systems, each with its own boundaries and limits.

The beginning teacher:

- A. Identifies the basic requirements (e.g., nutrients, oxygen, water, carbon dioxide) necessary for various organisms to carry out life functions.
- B. Compares how various organisms obtain, transform, transport, release, eliminate and store energy and matter.
- C. Analyzes characteristics, functions and relationships of systems in animals including humans (e.g., digestive, circulatory, nervous, endocrine, reproductive, integumentary, skeletal, respiratory, muscular, excretory, immune systems).
- D. Analyzes characteristics, functions and relationships of systems in plants (e.g., transport, control, reproductive, nutritional, structural systems).
- E. Identifies methods of reproduction, growth and development of various plants and animals.

Competency 031—The teacher understands the processes by which organisms maintain homeostasis.

The beginning teacher:

- A. Explains the importance of maintaining a stable internal environment.
- B. Describes the relationships among internal feedback mechanisms in maintaining homeostasis.
- C. Identifies anatomical structures and physiological processes in a variety of organisms that function to maintain homeostasis in the face of changing environmental conditions.
- D. Analyzes the importance of nutrition, environmental conditions and physical exercise on health in humans and other organisms.
- E. Analyzes the role of viruses and microorganisms in maintaining or disrupting homeostasis in different organisms (e.g., the role of bacteria in digestion, diseases of plants and animals).

Competency 032—The teacher understands the relationship between biology and behavior.

The beginning teacher:

- A. Understands how the behavior of organisms, including humans, is in response to internal and external stimuli.
- B. Recognizes that behavior in many animals is determined by a combination of genetic and learned factors.
- C. Identifies adaptive advantages of innate and learned patterns of behavior.
- D. Explains mediating factors in innate (e.g., imprinting, hormonal system) and learned (e.g., classical conditioning, play) behavior.
- E. Understands concepts linking behavior and natural selection (e.g., kin selection, courtship behavior, altruism).

Domain VII—Interdependence of Life and Environmental Systems

Competency 033—The teacher understands the relationships between abiotic and biotic factors of terrestrial and aquatic ecosystems, habitats and biomes, including the flow of matter and energy.

The beginning teacher:

- A. Analyzes types, sources and flow of energy through different trophic levels (e.g., producers, consumers, decomposers) and between organisms and the physical environment in aquatic and terrestrial ecosystems.
- B. Analyzes the flow of energy and the cycling of matter through biogeochemical cycles (e.g., carbon, water, oxygen, nitrogen, phosphorus) in aquatic and terrestrial ecosystems.
- C. Understands the concept of limiting factors (e.g., light intensity, temperature, mineral availability) and the effects that they have on the productivity and complexity of different ecosystems (e.g., tropical forest versus taiga, continental shelf versus deep ocean).
- D. Explains the relationship among abiotic characteristics of different biomes and the adaptations, variations, tolerances and roles of indigenous plants and animals in those biomes.

Competency 034—The teacher understands the interdependence and interactions of living things in terrestrial and aquatic ecosystems.

The beginning teacher:

- A. Understands the concepts of ecosystem, biome, community, habitat and niche.
- B. Analyzes interactions of organisms, including humans, in the production and consumption of energy (e.g., food chains, food webs, food pyramids) in aquatic and terrestrial ecosystems.
- C. Understands interspecific interactions in aquatic and terrestrial ecosystems (e.g., predator-prey relationships, competition, parasitism, commensalism, mutualism) and how they affect ecosystem structure.
- D. Identifies indigenous plants and animals, assesses their roles in an ecosystem and describes their relationships in different types of environments (e.g., fresh water, continental shelf, deep ocean, forest, desert, plains, tundra).
- E. Analyzes how the introduction, removal or reintroduction of an organism may alter the food chain, affect existing populations and influence natural selection in terrestrial and aquatic ecosystems.
- F. Evaluates the importance of biodiversity in an ecosystem and identifies changes that may occur if biodiversity is increased or reduced in an ecosystem.
- G. Understands types and processes of ecosystem change over time in terrestrial and aquatic ecosystems (e.g., equilibrium, cyclical change, succession) and the effects of human activity on ecosystem change.
- H. Explains the significance of plants in different types of terrestrial and aquatic ecosystems.

Competency 035—The teacher understands the relationship between carrying capacity and changes in populations and ecosystems.

The beginning teacher:

- A. Identifies basic characteristics of populations in an ecosystem (e.g., age pyramid, density, patterns of distribution).

- B. Compares concepts of population dynamics, including exponential growth, logistic (i.e., limited) growth and cycling (e.g., boom-and-bust cycles).
- C. Relates carrying capacity to population dynamics, including human population growth.
- D. Analyzes the impact of density-dependent and density-independent factors (e.g., geographic locales, natural events, diseases, birth and death rates) on populations.
- E. Compares *r*- and *K*-selected reproductive strategies (e.g., survivorship curves).

Domain VIII—Earth's History and the Structure and Function of Earth Systems

Competency 036—The teacher understands structure and function of the geosphere.

The beginning teacher:

- A. Analyzes the internal structure and composition of Earth and methods used to investigate Earth's interior (e.g., seismic waves, chemical composition of rocks).
- B. Classifies rocks according to how they are formed as described by the rock cycle (e.g., igneous, sedimentary, metamorphic) and identifies the economic significance of rocks and minerals.
- C. Uses physical properties (e.g., density, hardness, streak, cleavage) to identify common minerals and understands processes affecting rock and mineral formation (e.g., temperature, pressure, rate of cooling).
- D. Identifies different types of landforms and topographic features on the surface of Earth, including the ocean floor (e.g., faults, volcanoes, mid-ocean ridges, deltas).
- E. Identifies the types, characteristics and uses of Earth's renewable and nonrenewable resources, including marine resources (e.g., ores, minerals, soil, fossil fuels).
- F. Identifies sources and reservoirs for matter and energy (e.g., carbon, nitrogen, water, solar radiation, radioactive decay).
- G. Analyzes the cycling and transformation of matter and energy through the geosphere (e.g., mantle convection).
- H. Relates the principles of conservation of mass and energy to processes that occur in the geosphere (e.g., the melting of rock).

Competency 037—The teacher understands processes of plate tectonics, weathering, erosion and deposition that change Earth's surface.

The beginning teacher:

- A. Understands how the theory of plate tectonics explains the movement and structure of Earth's crustal plates (e.g., seafloor spreading, major tectonic plates, subduction).
- B. Understands evidence for plate movement (e.g., magnetic reversals, distribution of earthquakes, GPS measurements).

- C. Describes the historical development of the theory of plate tectonics (e.g., Wegener's continental drift hypothesis).
- D. Analyzes the effects of plate movement, including faulting, folding, mineral formation, earthquakes and volcanic activity.
- E. Knows the processes (e.g., freezing/thawing, chemical reactions) and products of weathering (e.g., soils, karst features) and compares and contrasts chemical and mechanical weathering.
- F. Identifies the causes (e.g., wind, water, gravity, glaciers) and effects of erosion and deposition (e.g., removal of topsoil, sedimentation).

Competency 038—The teacher understands the formation and history of Earth.

The beginning teacher:

- A. Knows the historical development of scientific theories relating to the origin and development of Earth (e.g., Hutton's uniformitarianism).
- B. Understands how Earth's geosphere, hydrosphere and atmosphere have changed over time and analyzes the significance of those changes (e.g., formation of oxygen in the atmosphere).
- C. Understands the organization of the geologic time scale and methods of relative (e.g., superposition, fossils) and absolute (e.g., radiometric, dendrochronology) dating.
- D. Identifies important events in the history of Earth (e.g., formation of major mountain chains, breakup of continents, appearance of life, appearance of multicellular organisms) and locates those events on the geologic time scale.
- E. Understands relationships between physical changes during Earth's history and biological evolution (e.g., plate movement and biogeography; meteoric impacts, global temperature changes, extinctions, adaptive radiations, formation of ozone layer) and predict future effects (e.g., changing ocean temperatures).
- F. Analyzes processes involved in the formation of fossils and how fossils are used to interpret the history of Earth.

Competency 039—The teacher understands structure and function of the hydrosphere.

The beginning teacher:

- A. Identifies the components and distribution of hydrologic systems (e.g., rivers, lakes, aquifers, oceans) and compares and contrasts the chemical composition (e.g., salinity, acidity) and physical attributes (e.g., density, turbidity) of fresh, brackish and salt water.
- B. Understands the water cycle and processes by which water moves through the water cycle (e.g., infiltration, runoff, evaporation, condensation, transpiration) and quantifies the dynamics of surface and groundwater movement.
- C. Identifies and uses the tools and procedures needed to collect and analyze quantitative data (e.g., pH, salinity, temperature, mineral content, nitrogen compounds, turbidity, dissolved oxygen) from hydrologic systems and describes the impact of those measured conditions on the quality of an ecosystem.

- D. Knows how to use principles of fluid statics and dynamics (e.g., Archimedes' principle, turbulence, viscosity, hydrostatic pressure) to analyze hydrologic systems.
- E. Identifies characteristics of a local watershed and the effects of natural events (e.g., floods, droughts) and human activities (e.g., irrigation, industrial use, municipal use) on a local watershed.
- F. Analyzes patterns of ocean circulation (e.g., upwelling, surface currents) and factors that influence those patterns (e.g., winds, heating).
- G. Understands the relationship between ocean depth and temperature, pressure, density and light penetration.
- H. Analyzes the causes and effects of waves, tides, tidal bores and tsunamis.
- I. Identifies the characteristics of different ocean zones (e.g., coastal zones, lighted zones, deep zones, estuaries, bays).

Competency 040—The teacher understands structure and function of the atmosphere.

The beginning teacher:

- A. Understands the composition of Earth's atmosphere.
- B. Understands the range of atmospheric conditions that organisms will tolerate (e.g., types of gases, temperature, particulate matter, moisture).
- C. Identifies the layers of the atmosphere (e.g., troposphere, ionosphere, mesosphere) and the characteristics of each layer.
- D. Recognizes that the Sun is the ultimate source of energy for the atmosphere.
- E. Understands processes of energy transfer (e.g., convection, radiation, conduction, phase changes of water) within the atmosphere and at the boundaries between the atmosphere, landmasses and oceans.
- F. Knows types, characteristics and processes of formation of clouds (e.g., cumulus, stratus, cirrus) and precipitation (e.g., rain, snow, hail).
- G. Knows the characteristics of air masses (e.g., temperature, moisture) and how air masses form and interact (e.g., fronts).
- H. Understands the types (e.g., blizzards, hurricanes, tornadoes), characteristics and causes of severe weather.
- I. Identifies the types, characteristics and distribution of climates and the factors (e.g., latitude, maritime effect, deforestation) that affect local and global climate.
- J. Identifies the effects of global phenomena (e.g., jet stream, El Niño) on local weather patterns.
- K. Understands weather maps and the principles, procedures and technology of weather forecasting (e.g., satellite technology, computer models).
- L. Understands that climate changes over time (e.g., ice ages, carbon dioxide level) and understands the evidence for those changes.

Competency 041—The teacher understands the effects of natural events and human activity on Earth systems.

The beginning teacher:

- A. Analyzes issues (e.g., economic impact, environmental effects, availability) regarding the use of Earth's resources (e.g., fossil fuels, renewable and nonrenewable resources).
- B. Analyzes the effects of natural events (e.g., fires, hurricanes, volcanic eruptions) and human activity (e.g., mining, fishing, reforestation, ocean dumping, municipal development) on aquatic and terrestrial ecosystems.
- C. Demonstrates an understanding of factors affecting the quality, use and conservation of water (e.g., floods, droughts, agriculture, dams).
- D. Evaluates methods of land use and understands issues in land-use management (e.g., development of barrier islands).
- E. Identifies the sources (e.g., burning of fossil fuels, industrial production of heavy metals, release of chlorofluorocarbons) and effects of pollution (e.g., mercury contamination of fish, acid rain, lead poisoning, ozone depletion).
- F. Recognizes that Earth is composed of interacting systems and that regional changes in the environment may have global effects (e.g., weather changes due to reforestation, global warming).
- G. Demonstrates an understanding of how individuals, communities and governments can conserve, protect and restore habitats and ecosystems.

Domain IX—Components and Properties of the Solar System and the Universe

Competency 042—The teacher understands the implications of Earth's placement and orientation in the solar system.

The beginning teacher:

- A. Analyzes the relationship between Earth's placement in the solar system and the conditions on Earth that enable organisms to survive.
- B. Demonstrates an understanding of the Sun's effects (e.g., gravitational, electromagnetic, solar wind, solar flares) on Earth.
- C. Understands the effects of Earth's rotation, revolution and tilt of axis on its environment (e.g., length of day and night, seasons).
- D. Identifies the effects of the Moon and Sun on tides.
- E. Analyzes information about lunar phases and lunar and solar eclipses to model the Earth, Moon and Sun system.

Competency 043—The teacher understands the role of the Sun in the solar system and the characteristics of planets and other objects that orbit the Sun.

The beginning teacher:

- A. Knows the approximate size, mass, motion, temperature, structure and composition of the Sun.
- B. Compares and contrasts conditions essential to life on Earth (e.g., temperature, water, mass, gases) to conditions on other planets.
- C. Compares and contrasts the planets in terms of orbit, mass, size, composition, rotation, atmosphere, moons and geologic activity.
- D. Identifies objects other than planets that orbit the Sun (e.g., asteroids, comets) and analyzes their characteristics (e.g., mass, size, composition, trajectory, origin).
- E. Relates gravitational force to the motion and interactions of objects within the solar system (e.g., Sun, planets, moons, comets, meteors).
- F. Understands theories of the formation of the solar system (e.g., planets, the Moon).

Competency 044—The teacher understands composition, history and properties of the universe.

The beginning teacher:

- A. Describes how nuclear fusion produces energy in stars, such as the Sun.
- B. Identifies different types of stars, their characteristics and motions (e.g., temperature, age, relative size, composition, magnitude and radial velocity) and understands the use of spectral analysis to determine those characteristics.
- C. Describes the characteristics of the stages in the life cycle of stars using the Hertzsprung-Russell diagram.
- D. Compares and contrasts characteristics of different types of galaxies.
- E. Interprets data to make inferences about the formation of stars and galaxies.
- F. Identifies types, characteristics and significance of other deep-space objects in the universe (e.g., pulsars, nebulae, black holes, extra-solar planets).
- G. Interprets empirical data and scientific theories regarding the estimated age, origin and evolution of the universe (e.g., big bang, inflation, role of dark matter and dark energy).
- H. Describes the role of supernovas on the chemical composition of the universe (e.g., origin of carbon on Earth).

Competency 045—The teacher understands the history and methods of astronomy.

The beginning teacher:

- A. Recognizes that all of science including current theories of the origin and evolution of the universe are based on the assumption that the fundamental laws of nature do not change over space and time.
- B. Describes the historical origins of the perceived patterns of constellations and their role in navigation.
- C. Describes the historical development and significance of the law of universal gravitation and planetary motion, the big bang theory of the origin of the universe and the theory of special relativity.
- D. Recognizes and explains the patterns of movement of the Sun, Moon, planets and stars in the sky.

- E. Demonstrates the use of units of measurement in astronomy (e.g., light year, astronomical units).
- F. Explains how various technologies (e.g., Earth- and space-based telescopes, deep-space probes, artificial satellites, human space flight) are used in advancing knowledge about the universe.
- G. Understands how mathematical models, computer simulations and data collected by the space and other science programs have contributed to scientific knowledge about Earth, the solar system and the universe.

Domain X—Science Learning, Instruction and Assessment

Competency 046—The teacher understands research-based theoretical and practical knowledge about teaching science, how students learn science and the role of scientific inquiry in science instruction.

The beginning teacher:

- A. Knows research-based theories about how students develop scientific understanding and how developmental characteristics, prior knowledge, experience and attitudes of students influence science learning.
- B. Understands the importance of respecting student diversity by planning activities that are inclusive and selecting and adapting science curricula, content, instructional materials and activities to meet the interests, knowledge, understanding, abilities, possible career paths and experiences of all students, including English-language learners.
- C. Knows how to plan and implement strategies to encourage student self-motivation and engagement in their own learning (e.g., linking inquiry-based investigations to students' prior knowledge, focusing inquiry-based instruction on issues relevant to students, developing instructional materials using situations from students' daily lives, fostering collaboration among students).
- D. Knows how to use a variety of instructional strategies to ensure all students comprehend content-related texts, including how to locate, retrieve and retain information from a range of texts and technologies.
- E. Understands the science teacher's role in developing the total school program by planning and implementing science instruction that incorporates schoolwide objectives and the statewide curriculum as defined in the Texas Essential Knowledge and Skills (TEKS).
- F. Knows how to design and manage the learning environment (e.g., individual, small-group, whole-class settings) to focus and support student inquiries and to provide the time, space and resources for all students to participate in field, laboratory, experimental and nonexperimental scientific investigation.
- G. Understands the rationale for using active learning and inquiry methods in science instruction and how to model scientific attitudes such as curiosity, openness to new ideas and skepticism.
- H. Knows principles and procedures for designing and conducting an inquiry-based scientific investigation (e.g., making observations; generating questions; researching and reviewing current knowledge in light of existing evidence; choosing tools to gather and analyze evidence; proposing answers, explanations and predictions; and communicating and defending results).
- I. Knows how to assist students with generating, refining, focusing and testing scientific questions and hypotheses.


- J. Knows strategies for assisting students in learning to identify, refine and focus scientific ideas and questions guiding an inquiry-based scientific investigation; to develop, analyze and evaluate different explanations for a given scientific result; and to identify potential sources of error in an inquiry-based scientific investigation.
- K. Understands how to implement inquiry strategies designed to promote the use of higher-level thinking skills, logical reasoning and scientific problem solving in order to move students from concrete to more abstract understanding.
- L. Knows how to guide students in making systematic observations and measurements.
- M. Knows how to sequence learning activities in a way that uncovers common misconceptions, allows students to build upon their prior knowledge and challenges them to expand their understanding of science.

Competency 047—The teacher knows how to monitor and assess science learning in laboratory, field and classroom settings.

The beginning teacher:

- A. Knows how to use formal and informal assessments of student performance and products (e.g., projects, laboratory and field journals, rubrics, portfolios, student profiles, checklists) to evaluate student participation in and understanding of inquiry-based scientific investigations.
- B. Understands the relationship between assessment and instruction in the science curriculum (e.g., designing assessments to match learning objectives, using assessment results to inform instructional practice).
- C. Knows the importance of monitoring and assessing students' understanding of science concepts and skills on an ongoing basis by using a variety of appropriate assessment methods (e.g., performance assessment, self-assessment, peer assessment, formal/informal assessment).
- D. Understands the purposes, characteristics and uses of various types of assessment in science, including formative and summative assessments, and the importance of limiting the use of an assessment to its intended purpose.
- E. Understands strategies for assessing students' prior knowledge and misconceptions about science and how to use those assessments to develop effective ways to address the misconceptions.
- F. Understands characteristics of assessments, such as reliability, validity and the absence of bias in order to evaluate assessment instruments and their results.
- G. Understands the role of assessment as a learning experience for students and strategies for engaging students in meaningful self-assessment.
- H. Recognizes the importance of selecting assessment instruments and methods that provide all students with adequate opportunities to demonstrate their achievements.
- I. Recognizes the importance of clarifying teacher expectations by sharing evaluation criteria and assessment results with students.

This reference material will also be available to you during the exam. To access it, click on the


 icon located in the lower-left corner of the screen.

PERIODIC TABLE OF THE ELEMENTS

1 1A												18 8A					
1 H 1.01	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 23.0	12 Mg 24.3	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc (98.9)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57–71	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89–103	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (294)	118 Og (294)

Lanthanide Series	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Actinide Series	89 Ac (227)	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

This reference material will also be available to you during the exam. To access it, click on the

 icon located in the lower-left corner of the screen.

Definitions and Physical Constants

The value of 9.8 m/s^2 is used for the acceleration of gravity near Earth's surface.

The universal gas constant is 8.314 J/K-mol or $0.08206 \text{ L-atm/K-mol}$.

Planck's constant is $6.6256 \times 10^{-34} \text{ J-s}$.

Avogadro's number is 6.022×10^{23} .

The right-hand rule is used with conventional current (the flow of positive charge from the positive terminal to the negative terminal).

End of Definitions and Physical Constants

Preparation Manual

Section 4: Sample Selected-Response Questions Science 7–12 (236)

This section presents some sample exam questions for you to review as part of your preparation for the exam. To demonstrate how each competency may be assessed, sample questions are accompanied by the competency that they measure. While studying, you may wish to read the competency before and after you consider each sample question. Please note that the competency statements do not appear on the actual exam.

For each sample exam question, there is a correct answer and a rationale for each answer option. The sample questions are included to illustrate the formats and types of questions you will see on the exam; however, your performance on the sample questions should not be viewed as a predictor of your performance on the actual exam.

The following reference materials will be available to you during the exam:

- Periodic Table (see page 25)
- Definitions and Physical Constants (see page 26)

Domain I—Scientific Inquiry and Processes

Competency 001—The teacher understands how to select and manage learning activities to ensure the safety of all students and the correct use and care of organisms, natural resources, materials, equipment and technologies.

1. Which of the following is safety equipment that can be found in a high school chemistry lab?

- A. Bunsen burner
- B. Eyewash station
- C. Barometer
- D. Glass mercury thermometer

Answer _____

2. Which of the following is approximately equal to the average distance between Earth and the Sun?

- A. One parsec
- B. One AU
- C. One light-year
- D. One nanometer

Answer _____

Competency 002—The teacher understands the nature of science, the process of scientific inquiry and the unifying concepts that are common to all sciences.

3. Which of the following is a scientific inference?

- A. Data suggests that Mars once had liquid water
- B. Repeated measurements of a quantity will reduce random error
- C. Electrical equipment should be grounded
- D. A measurement has three significant figures

Answer _____

Competency 003—The teacher understands the history of science, how science impacts the daily lives of students and how science interacts with and influences personal and societal decisions.

4. Investigators have designed and produced a vaccine to prevent infection of humans by a common disease-causing virus. Which of the following must the investigators do before the vaccine can be administered to people in the United States?

- A. Nothing must be done; doctors can purchase and administer the vaccine
- B. The vaccine must be tested for its efficacy in comparison to antibiotics currently available
- C. An Institutional Review Board and the Food and Drug Administration must approve an application to conduct a clinical trial
- D. The Centers for Disease Control must confirm the necessity for the vaccine and approve its use

Answer _____

Domain II—Physics

Competency 004—The teacher understands the description of motion in one and two dimensions.

5. A ball is thrown directly upward on Earth. In the absence of air resistance, which of the following is true about both the magnitude and direction of the acceleration of the ball as it rises? (g is the acceleration due to gravity near Earth's surface.)

- | | <u>Magnitude</u> | <u>Direction</u> |
|----|------------------|------------------|
| A. | $= g$ | Downward |
| B. | $= g$ | Upward |
| C. | $< g$ | Upward |
| D. | $> g$ | Downward |

Answer _____

6. A car traveling along a straight road accelerates from 20 m/s to 50 m/s in 10 s. What is the magnitude of the acceleration of the car?

- A. 2 m/s^2
- B. 3 m/s^2
- C. 5 m/s^2
- D. 7 m/s^2

Answer _____

Competency 005—The teacher understands the laws of motion.

7. Which of the following is the term for the tendency of an object to resist a change in its motion?

- A. Acceleration
- B. Weight
- C. Inertia
- D. Force

Answer _____

Competency 006—The teacher understands the concepts of gravitational and electromagnetic forces in nature.

8. On the basis of Coulomb's law, which of the following is true about the electrostatic force between two charges?

- A. It is different in magnitude for the two charges
- B. It depends on the masses of the charges
- C. It is always repulsive
- D. It increases in magnitude as the distance between the charges decreases

Answer _____

9. Of the following types of electromagnetic waves, which have the highest frequency?

- A. Ultraviolet waves
- B. Infrared waves
- C. X-rays
- D. Radio waves

Answer _____

Competency 007—The teacher understands applications of electricity and magnetism.

10. A 3Ω resistor and a 6Ω resistor are connected in parallel to an 18 V source. What is the total current in the circuit?

- A. 2 A

- B. 3 A
- C. 6 A
- D. 9 A

Answer _____

Competency 008—The teacher understands the conservation of energy and momentum.

11. A 400 g cart is moving at a constant speed of 12 cm/s along a straight horizontal air track. It collides and sticks to a second cart of mass 800 g, which is at rest. What is the speed of the two cars immediately after the collision?

- A. 0
- B. 4 cm/s
- C. 6 cm/s
- D. 12 cm/s

Answer _____

Competency 009—The teacher understands the laws of thermodynamics.

12. Which of the following phase changes involves an increase in entropy?

- A. Gas to liquid
- B. Gas to solid
- C. Liquid to gas
- D. Liquid to solid

Answer _____

Competency 010—The teacher understands the characteristics and behavior of waves.

13. Which of the following is an example of the dispersion of light?

- A. The bending and spreading of light as it passes through a narrow slit
- B. The separation of light into its component colors as it passes through a prism
- C. The deflection of light by a mirror
- D. The absorption of light by an object

Answer _____

Competency 011—The teacher understands the fundamental concepts of quantum physics.

14. According to the Bohr model of the hydrogen atom, a photon is emitted by the atom when which of the following occurs?

- A. An electron makes a transition from a higher to a lower energy level
- B. A neutron decays into a proton and an electron
- C. X-rays are absorbed by the nucleus
- D. A proton collides with another proton

Answer _____

Domain III—Chemistry

Competency 012—The teacher understands the characteristics of matter and atomic structure.

15. Which of the following is the number of neutrons in ${}^{13}_{6}\text{C}$?

- A. 0
- B. 6
- C. 7
- D. 13

Answer _____

Competency 013—The teacher understands the properties of gases.

16. If a gas with a pressure of 1.0 atm expands into a volume that is twice its original volume, and the gas is heated from 100.0 K to 400.0 K, what is the final pressure of the gas?

- A. 0.5 atm
- B. 2.0 atm
- C. 4.0 atm
- D. 8.0 atm

Answer _____

Competency 014—The teacher understands the properties and characteristics of ionic and covalent bonds.

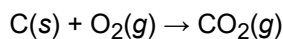
17. Of the following bonds, which would require the most energy to break?

- A. $\text{C} \equiv \text{C}$
- B. $\text{C} = \text{C}$
- C. $\text{C} - \text{C}$
- D. $\text{C} - \text{H}$

Answer _____

Competency 015—The teacher understands and interprets chemical equations and chemical reactions.

Use the equation below to answer the question that follows.



18. The reaction rate is determined for a reaction between oxygen and three thin carbon rods of uniform size and shape in a closed reaction vessel. Which of the following changes to the reaction or reactor design is most likely to result in a higher reaction rate for the one-step reaction represented above?

- A. Replacing the three thin rods with a carbon rod equal in mass to the total mass of the thin rods and with same length and height
- B. Using a design that involves removing the carbon dioxide as it forms
- C. Starting with a larger mass of oxygen gas
- D. Running the reaction in a larger vessel

Answer _____

Competency 016—The teacher understands types and properties of solutions.

19. Sugar is dissolved in water at 80°C. The temperature is reduced to 40°C and some of the sugar precipitates. Which of the following best describes the solution at 40°C when solid sugar is present?

- A. Dilute
- B. Supersaturated
- C. Unsaturated
- D. Saturated

Answer _____

Competency 017—The teacher understands energy transformations that occur in physical and chemical processes.

20. Which of the following must be true about a spontaneous chemical reaction at constant temperature and pressure?

- A. $\Delta H_{\text{rxn}} > 0$
- B. $\Delta V > 0$
- C. $\Delta G_{\text{rxn}} < 0$
- D. $\Delta S_{\text{rxn}} < 0$

Answer _____

Competency 018—The teacher understands nuclear fission, nuclear fusion and nuclear reactions.

21. Of the following types of radiation, which have the highest penetrating capacity?

- A. Alpha particles
- B. Beta particles
- C. X-rays
- D. Gamma rays

Answer _____

Competency 019—The teacher understands oxidation and reduction reactions.

22. Which of the following represents a reduction process only?

- A. $\text{Cu} \rightarrow \text{Cu}^{2+} + 2 \text{e}^-$
- B. $\text{Cu}^{2+} + 2 \text{e}^- \rightarrow \text{Cu}$
- C. $2 \text{FeO} \rightarrow 2 \text{Fe} + \text{O}_2$
- D. $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$

Answer _____

Competency 020—The teacher understands acids, bases and their reactions.

23. Which of the following is a Brønsted-Lowry acid?

- A. NH_4OH
- B. CH_3COOH
- C. CH_4
- D. XeF_4

Answer _____

Domain IV—Cell Structure and Processes

Competency 021—The teacher understands the structure and function of biomolecules.

24. Which of the following best explains why the structure of phospholipids makes them well suited to be the major component of most bacterial and eukaryotic cell membranes?

- A. Phospholipids exhibit a branching structure and so can interact with many other molecules on each side of a membrane
- B. Phospholipids are flexible and so allow a cell to contract or expand, as required under different conditions
- C. Phospholipids form bilayers with one end buried in the bilayer and the other end exposed to an aqueous environment

- D. Phospholipids are a major source of energy for cells because they contain fatty acids and phosphate groups

Answer _____

Competency 022—The teacher understands that cells are the basic structure of living things and have specialized parts that perform specific functions.

25. Which of the following cell types contains a particularly extensive smooth endoplasmic reticulum that stores a large amount of Ca^{2+} for intracellular signaling?

- A. Neuron
- B. Muscle cell
- C. Epithelial cell
- D. Lymphocyte

Answer _____

Competency 023—The teacher understands how cells carry out life processes.

26. Isolated plant cells are placed in a solution of 10% sucrose. When a sample of the cells is observed under a microscope after a few minutes in the solution, it is observed that the plasma membrane of each cell has pulled away from the cell wall. Which of the following is the best explanation?

- A. Solutes only moved out of the cells into the sucrose solution
- B. Water only moved out of the cells into the sucrose solution
- C. Sucrose moved into the cells, and water moved out of the cells into the sucrose solution
- D. Solutes and water both moved out of the cells into the sucrose solution

Answer _____

Competency 024—The teacher understands how specialized cells, tissues, organs, organ systems and organisms grow and develop.

27. Which of the following is most commonly associated with the development of liver cancer?

- A. Infection by hepatitis B virus
- B. Smoking of marijuana
- C. Long-term use of antibiotics
- D. Active Sun exposure

Answer _____

Domain V—Heredity and Evolution of Life

Competency 025—The teacher understands the structures and functions of nucleic acids in the mechanisms of genetics.

28. Which of the following accurately describes the process of transcription?

- A. A ribosome moves along an mRNA and joins amino acids according to the sequence of the mRNA
- B. A ribosome moves along a stretch of DNA and joins amino acids according to the sequence of a template strand of the DNA
- C. A DNA polymerase moves along a template strand of DNA and makes a complementary RNA copy
- D. An RNA polymerase moves along a stretch of DNA and makes a complementary RNA copy of the template strand

Answer _____

Competency 026—The teacher understands the continuity and variations of traits from one generation to the next.

29. Which of the following tables correctly compares mitosis and meiosis?

A.

	Maximum number of daughter cells	Amount of DNA relative to parent cell	Sequence of daughter DNA relative to parent
Mitosis	4	one-half	different
Meiosis	2	same	same

B.

	Maximum number of daughter cells	Amount of DNA relative to parent cell	Sequence of daughter DNA relative to parent
Mitosis	2	same	same
Meiosis	2	one-half	same

C.

	Maximum number of daughter cells	Amount of DNA relative to parent cell	Sequence of daughter DNA relative to parent
Mitosis	2	same	same
Meiosis	4	one-half	different

D.

	Maximum number of daughter cells	Amount of DNA relative to parent cell	Sequence of daughter DNA relative to parent
Mitosis	2	same	same
Meiosis	1	double	different

Answer _____

Competency 027—The teacher understands the theory of biological evolution.

30. Which of the following best illustrates the founder effect?

- A. There is significantly less variation of alleles governing tissue transplant rejection in an island colony of sheep than in the mainland population from which the colony was started in 1975
- B. The uplift of the Isthmus of Panama divided a single ancestral wrasse population into two distinct species of fish
- C. A silverback male gorilla can mate with all the adult females in his troop, most of whom immigrated to the troop from other troops
- D. The small size of most Chihuahuas is the result of selective breeding by humans for smaller dogs

Answer _____

Competency 028—The teacher understands evidence for evolutionary change during Earth's history.

31. Which of the following provides the best evidence that fish, amphibians, birds, reptiles and mammals share a common ancestor?

- A. Fossils of primitive forms of all the organisms have been discovered
- B. During development, all the organisms possess pharyngeal gill pouches and a notochord
- C. All the organisms have a special covering that includes moist skin, scales, feathers or hair
- D. All the organisms have mechanisms that permit movement from one location to another

Answer _____

Domain VI—Diversity of Life

Competency 029—The teacher understands similarities and differences between living organisms and how taxonomic systems are used to organize and interpret the diversity of life.

32. Which of the following groups of organisms is characterized by absorption of organic materials from its environment, a cell wall composed of chitin and reproduction most commonly through spore formation?

- A. Protists
- B. Plants
- C. Bacteria
- D. Fungi

Answer _____

Competency 030—The teacher understands that, at all levels of nature, living systems are found within other living systems, each with its own boundaries and limits.

33. Which of the following is an advantage of the double blood circulation of amphibians, reptiles and mammals versus the single blood circulation of fish?

- A. CO₂ diffuses out of the blood, and O₂ diffuses into the blood
- B. Contraction of the heart chambers is carefully controlled
- C. Blood carries nutrients from the digestive system to the rest of the body
- D. Blood flows under greater pressure to major organs

Answer _____

Competency 031—The teacher understands the processes by which organisms maintain homeostasis.

34. By which of the following mechanisms do marine birds maintain their water and salt balance?

- A. They obtain all the salt and water they need from the organisms they eat
- B. They concentrate and excrete excess ingested salt in their urine
- C. They use salt glands to remove excess salt from the seawater they drink
- D. They drink freshwater when it is available and store small quantities

Answer _____

Competency 032—The teacher understands the relationship between biology and behavior.

35. In an experiment, a species of migratory bird was placed in cone-shaped cages. The sides of the cages were lined with blotting paper, and ink pads were placed in the bottoms. The tops of the cages were constructed so that when located outdoors, the birds had a full view of the night sky. Directed movements by the birds were indicated by inky footprints the birds made as they walked on the blotting paper. On clear nights in the spring, most footprints were on the north side of the cages but on clear nights in the fall, most footprints were on the south side of the cages. On cloudy nights at either time of year, the location of footprints was random. Which of the following is the best explanation?

- A. The birds have an innate sense of migratory direction and were disoriented by the cages
- B. The birds use day length to orient their migration
- C. The birds use the position of the stars to orient their migration
- D. The birds use air temperature and wind direction to orient their migration

Answer _____

Domain VII—Interdependence of Life and Environmental Systems

Competency 033—The teacher understands the relationships between abiotic and biotic factors of terrestrial and aquatic ecosystems, habitats and biomes, including the flow of matter and energy.

36. The soil of tropical rain forests contains far less organic matter than the soil of temperate deciduous forests. Which of the following is the best explanation?

- A. Decaying matter is quickly broken down by living organisms or washed away by heavy rain
- B. Tropical rain forests exhibit low biodiversity and consequently have less organic matter to decay
- C. The dense canopy layer of the rain forest blocks organic matter from reaching the soil
- D. Dead organisms decay slowly in the rain forest and release little organic material into the soil

Answer _____

Competency 034—The teacher understands the interdependence and interactions of living things in terrestrial and aquatic ecosystems.

37. Which of the following best illustrates commensalism?

- A. Microorganisms that live in the gut of termites digest the cellulose that is ingested by the termites when they eat wood
- B. Cattle egrets that forage around cattle and other grazing animals exhibit much greater success in capturing prey than when they forage alone
- C. Tarantula hawk wasps lay their eggs on tarantulas that they have paralyzed, and the larvae hatch and eat the tarantulas
- D. *Rhizobium* bacteria are found in nodules of legume roots where the roots absorb nitrogen fixed by the bacteria and the legume provides organic compounds to the bacteria

Answer _____

Competency 035—The teacher understands the relationship between carrying capacity and changes in populations and ecosystems.

38. Which of the following is the best example of a density-independent variable that may alter the carrying capacity of a region for a particular animal?

- A. An infection of several animals by a virus specific to the species
- B. A destructive tornado passing through the region
- C. The presence in the region of a predator of the animals
- D. Introduction of another species occupying the same niche

Answer _____

Domain VIII—Earth’s History and the Structure and Function of Earth Systems

Competency 036—The teacher understands structure and function of the geosphere.

39. Which of the following is a metamorphic rock?

- A. Basalt

- B. Shale
- C. Topaz
- D. Gneiss

Answer _____

Competency 037—The teacher understands processes of plate tectonics, weathering, erosion and deposition that change Earth's surface.

40. The Alps mountain range in Europe is theorized to have formed by which of the following means?

- A. Collision of the African and Eurasian tectonic plates
- B. Eruption of a supervolcano over a hot spot
- C. Impact of a large asteroid
- D. Mounds of debris from an enormous tsunami in the Mediterranean Sea

Answer _____

Competency 038—The teacher understands the formation and history of Earth.

41. The Paleozoic era ended with which of the following?

- A. A mass extinction
- B. The splitting of one large continent into smaller continents
- C. A worldwide flood that covered Earth's landmass
- D. The sudden appearance of many new plant and animal species

Answer _____

Competency 039—The teacher understands structure and function of the hydrosphere.

42. Fjords are the result of which of the following?

- A. Volcanic activity
- B. Glaciation
- C. Earthquakes
- D. Chemical weathering

Answer _____

Competency 040—The teacher understands structure and function of the atmosphere.

43. Which of the following is true about a parcel of air as it warms up?

- A. The equilibrium vapor pressure of water in the air parcel decreases
- B. The amount of water vapor in the air parcel increases
- C. The relative humidity of the air parcel decreases
- D. Some of the water vapor in the air parcel will condense forming precipitation

Answer _____

Domain IX—Components and Properties of the Solar System and the Universe

Competency 042—The teacher understands the implications of Earth’s placement and orientation in the solar system.

44. Which of the following is true about the Earth-Moon-Sun system?

- A. Earth rotates on its axis, but the Moon does not rotate on its axis; this results in the same side of the Moon facing Earth at all times
- B. Tides on Earth are affected by gravitational forces between Earth and the Moon, and between Earth and the Sun
- C. A lunar eclipse is an event in which the view of the Sun from Earth is blocked when the Moon is positioned between Earth and the Sun
- D. Earth rotates on its axis once in approximately 365 days, which is the length of one year

Answer _____

Competency 043—The teacher understands the role of the Sun in the solar system and the characteristics of planets and other objects that orbit the Sun.

45. Which of the planets has the largest mass even though it is composed largely of hydrogen and helium?

- A. Jupiter
- B. Mars
- C. Venus
- D. Neptune

Answer _____

Competency 044—The teacher understands composition, history and properties of the universe.

46. Of the following, which is the latest stage in the life cycle of a small star with a mass similar to our Sun?

- A. Red giant
- B. Protostar
- C. White dwarf

D. Supernova

Answer _____

Domain X—Science Learning, Instruction and Assessment

Competency 046—The teacher understands research-based theoretical and practical knowledge about teaching science, how students learn science and the role of scientific inquiry in science instruction.

47. Which of the following is an element of inquiry-based science instruction?

- A. A teacher-led question and answer session
- B. A video presentation of science principles to be included in a unit of study
- C. A student forming a hypothesis prior to a lab activity
- D. A student writing a report after researching information on the Internet

Answer _____

Competency 047—The teacher knows how to monitor and assess science learning in laboratory, field and classroom settings.

48. Which of the following is a type of summative assessment?

- A. A final examination
- B. A homework exercise
- C. An interview
- D. A question-and-answer session

Answer _____

Preparation Manual

Section 4: Sample Selected-Response Answers and Rationales Science 7–12 (236)

This section presents some sample exam questions for you to review as part of your preparation for the exam. To demonstrate how each competency may be assessed, sample questions are accompanied by the competency that they measure. While studying, you may wish to read the competency before and after you consider each sample question. Please note that the competency statements do not appear on the actual exam.

For each sample exam question, there is a correct answer and a rationale for each answer option. The sample questions are included to illustrate the formats and types of questions you will see on the exam; however, your performance on the sample questions should not be viewed as a predictor of your performance on the actual exam.

The following reference materials will be available to you during the exam:

- Periodic Table (see page 25)
- Definitions and Physical Constants (see page 26)

Domain I—Scientific Inquiry and Processes

Competency 001—The teacher understands how to select and manage learning activities to ensure the safety of all students and the correct use and care of organisms, natural resources, materials, equipment and technologies.

1. Which of the following is safety equipment that can be found in a high school chemistry lab?

- A. Bunsen burner
- B. Eyewash station
- C. Barometer
- D. Glass mercury thermometer

Answer

Option B is correct because an eyewash station is used to flush the eyes when liquids have been splashed or sprayed into a person's eyes. **Option A is incorrect** because a Bunsen burner is used to heat some materials in the lab and must be used with care. **Option C is incorrect** because a barometer is used to measure atmospheric pressure. **Option D is incorrect** because a glass mercury thermometer can pose a significant hazard due to possible broken glass and mercury exposure.

2. Which of the following is approximately equal to the average distance between Earth and the Sun?

- A. One parsec
- B. One AU
- C. One light-year

D. One nanometer

Answer

Option B is correct because although the distance of Earth from the Sun varies throughout its orbit around the Sun, the average distance of Earth from the Sun is approximately 149,669,000,000 meters which is very close to one astronomical unit (one AU = 149,597,870,700 meters). **Option A is incorrect** because one parsec is 3.26 light-years. **Option C is incorrect** because a light-year is the distance that light travels in one year (approximately 9.46×10^{12} kilometers). **Option D is incorrect** because one nanometer equals 1×10^{-9} meter.

Competency 002—The teacher understands the nature of science, the process of scientific inquiry and the unifying concepts that are common to all sciences.

3. Which of the following is a scientific inference?

- A. Data suggests that Mars once had liquid water
- B. Repeated measurements of a quantity will reduce random error
- C. Electrical equipment should be grounded
- D. A measurement has three significant figures

Answer

Option A is correct because it is a reasonable conclusion drawn from data, which defines a scientific inference. **Option B is incorrect** because it is a mathematical statement of fact. **Option C is incorrect** because it describes a safety practice. **Option D is incorrect** because it is an observation.

Competency 003—The teacher understands the history of science, how science impacts the daily lives of students and how science interacts with and influences personal and societal decisions.

4. Investigators have designed and produced a vaccine to prevent infection of humans by a common disease-causing virus. Which of the following must the investigators do before the vaccine can be administered to people in the United States?

- A. Nothing must be done; doctors can purchase and administer the vaccine
- B. The vaccine must be tested for its efficacy in comparison to antibiotics currently available
- C. An Institutional Review Board and the Food and Drug Administration must approve an application to conduct a clinical trial
- D. The Centers for Disease Control must confirm the necessity for the vaccine and approve its use

Answer

Option C is correct because testing of drugs, vaccines and procedures is carefully regulated to protect human health. **Option A is incorrect** because the vaccine must be tested in carefully regulated clinical trials prior to use in people. **Option B is incorrect** because antibiotics are used to treat bacterial infections, not viral infections, in which they are ineffective. **Option D is incorrect** because the CDC does not regulate which vaccines are produced or approve them for use. The major function of the CDC is to monitor and protect public health and safety.

Domain II—Physics

Competency 004—The teacher understands the description of motion in one and two dimensions.

5. A ball is thrown directly upward on Earth. In the absence of air resistance, which of the following is true about both the magnitude and direction of the acceleration of the ball as it rises? (g is the acceleration due to gravity near Earth's surface.)

	<u>Magnitude</u>	<u>Direction</u>
A.	$= g$	Downward
B.	$= g$	Upward
C.	$< g$	Upward
D.	$> g$	Downward

Answer

Option A is correct because the acceleration of the rising ball is equal to g in magnitude and is oriented downward. **Option B is incorrect** because the acceleration of the rising ball is oriented downward, not upward. **Option C is incorrect** because the acceleration of the rising ball is equal to g in magnitude and is oriented downward. **Option D is incorrect** because the acceleration of the rising ball is equal to g in magnitude.

6. A car traveling along a straight road accelerates from 20 m/s to 50 m/s in 10 s. What is the magnitude of the acceleration of the car?

- A. 2 m/s^2
- B. 3 m/s^2
- C. 5 m/s^2
- D. 7 m/s^2

Answer

Option B is correct because it properly computes the acceleration from the formula $v_f = v_i + at$, where v_f is the final speed, v_i is the initial speed, a is the acceleration, and t is the time. Applying the equation gives $50 \text{ m/s} = 20 \text{ m/s} + 10a$, or $a = 3 \text{ m/s}^2$. **Option A is incorrect** because it uses the initial speed of 20 m/s only to compute the acceleration. **Option C is incorrect** because it uses the final speed of 50 m/s only to compute the acceleration. **Option D is incorrect** because it uses the sum instead of the difference of the two speeds to compute the acceleration.

Competency 005—The teacher understands the laws of motion.

7. Which of the following is the term for the tendency of an object to resist a change in its motion?

- A. Acceleration
- B. Weight
- C. Inertia
- D. Force

Answer

Option C is correct because the inertia of a body is the tendency of a body to resist a change in its motion.

Option A is incorrect because acceleration is the rate at which the velocity of an object changes. **Option B is incorrect** because the weight of an object is the gravitational force exerted on the object. **Option D is incorrect** because force will typically cause a change in motion.

Competency 006—The teacher understands the concepts of gravitational and electromagnetic forces in nature.

8. On the basis of Coulomb's law, which of the following is true about the electrostatic force between two charges?

- A. It is different in magnitude for the two charges
- B. It depends on the masses of the charges
- C. It is always repulsive
- D. It increases in magnitude as the distance between the charges decreases

Answer

Option D is correct because, according to Coulomb's law, the electrostatic force between two charges is inversely proportional to the square of the distance between the charges and, therefore, increases in magnitude as the distance between the charges decreases. **Option A is incorrect** because, according to Coulomb's law, the magnitude of the force acting on each charge is the same. **Option B is incorrect** because, according to Coulomb's law, the electrostatic force between two charges depends on the magnitudes of the charges, not of the masses. **Option C is incorrect** because, according to Coulomb's law, the electrostatic force between two charges depends on the relative signs of the charges and will be attractive when the two charges are oppositely charged and will be repulsive when the two charges are either both positively charged or both negatively charged.

9. Of the following types of electromagnetic waves, which have the highest frequency?

- A. Ultraviolet waves
- B. Infrared waves
- C. X-rays
- D. Radio waves

Answer

Option C is correct because x-rays have a higher frequency than all other types of electromagnetic waves except for gamma rays. **Option A is incorrect** because ultraviolet light is lower in frequency than are x-rays. **Option B is incorrect** because infrared radiation is lower in frequency than both ultraviolet light and x-rays. **Option D is incorrect** because radio waves have a lower frequency than all other types of electromagnetic waves.

Competency 007—The teacher understands applications of electricity and magnetism.

10. A $3\ \Omega$ resistor and a $6\ \Omega$ resistor are connected in parallel to an 18 V source. What is the total current in the circuit?

- A. 2 A
- B. 3 A
- C. 6 A
- D. 9 A

Answer

Option D is correct because it properly notices that, since the two resistors are connected in parallel, the voltage across each resistor is 18 V. It follows from Ohm's law that the current through the $3\ \Omega$ resistor is 6 A and the current through the $6\ \Omega$ resistor is 3 A, giving a total current in the circuit equal to $3\ \text{A} + 6\ \text{A} = 9\ \text{A}$. **Option A is incorrect** because it gives the result for a $3\ \Omega$ and a $6\ \Omega$ resistor connected in series, not parallel. **Option B is incorrect** because it gives the current through the $6\ \Omega$ resistor, not the total current in the circuit. **Option C is incorrect** because it gives the current through the $3\ \Omega$ resistor, not the total current in the circuit.

Competency 008—The teacher understands the conservation of energy and momentum.

11. A 400 g cart is moving at a constant speed of 12 cm/s along a straight horizontal air track. It collides and sticks to a second cart of mass 800 g, which is at rest. What is the speed of the two cars immediately after the collision?

- A. 0
- B. 4 cm/s
- C. 6 cm/s
- D. 12 cm/s

Answer

Option B is correct because it properly applies the law of conservation of linear momentum to obtain the equation $(400\ \text{g}) \times (12\ \text{cm/s}) = (400\ \text{g} + 800\ \text{g}) \times v$, which can be solved to determine that the correct speed v of the coupled cars just after the collision is 4 cm/s. **Option A is incorrect** because, based on the law of conservation of linear momentum, the coupled cars must be moving. **Option C is incorrect** because it uses the mass of the 800 g cart to compute the speed of the coupled carts instead of the combined mass of the two carts. **Option D is incorrect** because it assumes that the speed of the coupled cars is equal to the original speed of the 400 g cart before the collision, which is not true.

Competency 009—The teacher understands the laws of thermodynamics.

12. Which of the following phase changes involves an increase in entropy?

- A. Gas to liquid
- B. Gas to solid
- C. Liquid to gas
- D. Liquid to solid

Answer

Option C is correct because a gas has less order than a liquid and therefore greater entropy. Thus, a liquid-to-gas phase change involves an increase in entropy. **Option A is incorrect** because a liquid has more order than a gas and therefore less entropy. Thus, a gas-to-liquid phase change involves a decrease in entropy. **Option B is incorrect** because a solid has more order than a gas, and therefore less entropy. Thus, a gas-to-solid phase change involves a decrease in entropy. **Option D is incorrect** because a solid has more order than a liquid and therefore less entropy. Thus, a liquid-to-solid phase change involves a decrease in entropy.

Competency 010—The teacher understands the characteristics and behavior of waves.

13. Which of the following is an example of the dispersion of light?

- A. The bending and spreading of light as it passes through a narrow slit
- B. The separation of light into its component colors as it passes through a prism
- C. The deflection of light by a mirror
- D. The absorption of light by an object

Answer

Option B is correct because the separation of the light into its component frequencies by a prism is an example of dispersion. **Option A is incorrect** because it is an example of the diffraction of light, not dispersion. **Option C is incorrect** because it is an example of the reflection, or scattering, of light, not dispersion. **Option D is incorrect** because absorption involves the manner in which electromagnetic energy is taken up by matter.

Competency 011—The teacher understands the fundamental concepts of quantum physics.

14. According to the Bohr model of the hydrogen atom, a photon is emitted by the atom when which of the following occurs?

- A. An electron makes a transition from a higher to a lower energy level
- B. A neutron decays into a proton and an electron
- C. X-rays are absorbed by the nucleus

D. A proton collides with another proton

Answer

Option A is correct because the Bohr model describes an atom in terms of discrete stationary energy levels, and it is the transition of an electron from a higher energy level to a lower energy level that results in the emission of a photon by an atom. **Option B is incorrect** because it describes beta decay, not emission of a photon. **Option C is incorrect** because it is a process outside of the scope of the Bohr model. **Option D is incorrect** because the Bohr model is not concerned with proton-proton collisions.

Domain III—Chemistry

Competency 012—The teacher understands the characteristics of matter and atomic structure.

15. Which of the following is the number of neutrons in $^{13}_6\text{C}$?

- A. 0
- B. 6
- C. 7
- D. 13

Answer

Option C is correct because there are 7 neutrons in $^{13}_6\text{C}$. The atomic number is 6 and equal to the number of protons in the atom. The mass number is 13 and is equal to the number of protons plus neutrons. Hence, the number of neutrons is 7 ($13 - 6 = 7$). **Option A is incorrect** because all atoms have neutrons, with the exception of one isotope of hydrogen. **Option B is incorrect** because 6 is the number of protons. **Option D is incorrect** because 13 is the number of protons plus neutrons.

Competency 013—The teacher understands the properties of gases.

16. If a gas with a pressure of 1.0 atm expands into a volume that is twice its original volume, and the gas is heated from 100.0 K to 400.0 K, what is the final pressure of the gas?

- A. 0.5 atm
- B. 2.0 atm
- C. 4.0 atm
- D. 8.0 atm

Answer

Option B is correct because the pressure is 2.0 atm, calculated as follows: $P_2 = P_1 \times \frac{V_1}{V_2} \times \frac{T_2}{T_1} = 1 \text{ atm} \times \frac{1}{2} \times$

$\frac{400}{100} = 2 \text{ atm}$. **Option A is incorrect** because 0.50 is four times smaller than the correct pressure. **Option C is**

incorrect because 4.0 is twice the correct pressure. **Option D is incorrect** because 8.0 is four times larger than the correct pressure.

Competency 014—The teacher understands the properties and characteristics of ionic and covalent bonds.

17. Of the following bonds, which would require the most energy to break?

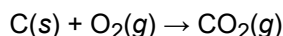
- A. $\text{C} \equiv \text{C}$
- B. $\text{C} = \text{C}$
- C. $\text{C} - \text{C}$
- D. $\text{C} - \text{H}$

Answer

Option A is correct because a triple bond between two carbon atoms is stronger than either a double bond or a single bond between carbon atoms. It is also stronger than a single bond between C and H (which is stronger than a single bond between carbon atoms but weaker than a double bond between carbon atoms). **Option B is incorrect** because a double bond between carbon atoms is weaker than a triple bond. **Option C is incorrect** because a single bond between carbon atoms is weaker than a triple bond. **Option D is incorrect** because a single bond between carbon and hydrogen atoms is weaker than a double bond between carbon atoms.

Competency 015—The teacher understands and interprets chemical equations and chemical reactions.

Use the equation below to answer the question that follows.



18. The reaction rate is determined for a reaction between oxygen and three thin carbon rods of uniform size and shape in a closed reaction vessel. Which of the following changes to the reaction or reactor design is most likely to result in a higher reaction rate for the one-step reaction represented above?

- A. Replacing the three thin rods with a carbon rod equal in mass to the total mass of the thin rods and with same length and height
- B. Using a design that involves removing the carbon dioxide as it forms
- C. Starting with a larger mass of oxygen gas
- D. Running the reaction in a larger vessel

Answer

Option C is correct because starting with a larger mass of oxygen gas will increase the concentration of oxygen in the vessel and thus increase the rate of reaction ($\text{rate} = k[\text{O}_2]$ for this one-step reaction). **Option A is incorrect** because using one thick carbon rod will reduce the surface area that can react with the oxygen and thus result in a lower initial reaction rate. **Option B is incorrect** because removing carbon dioxide will not affect the reaction rate since it is not part of the rate equation. **Option D is incorrect** because running the reaction in a larger vessel will reduce the oxygen pressure (and concentration) and thus reduce the reaction rate.

Competency 016—The teacher understands types and properties of solutions.

19. Sugar is dissolved in water at 80°C. The temperature is reduced to 40°C and some of the sugar precipitates. Which of the following best describes the solution at 40°C when solid sugar is present?

- A. Dilute
- B. Supersaturated
- C. Unsaturated
- D. Saturated

Answer

Option D is correct because the solution is saturated as evidenced by the precipitation of sugar. The dissolved sugar exceeds the maximum solubility for 40°C and the excess sugar precipitated. **Option A is incorrect** because "dilute" would indicate that very little sugar is present in solution, when in fact there is a significant amount of dissolved sugar in solution. **Option B is incorrect** because "supersaturated" describes a solution in which more than the maximum amount of solute is dissolved and there is no precipitate. **Option C is incorrect** because "unsaturated" means that the maximum amount that could be dissolved has not been reached and that no precipitate would be present.

Competency 017—The teacher understands energy transformations that occur in physical and chemical processes.

20. Which of the following must be true about a spontaneous chemical reaction at constant temperature and pressure?

- A. $\Delta H_{\text{rxn}} > 0$
- B. $\Delta V > 0$
- C. $\Delta G_{\text{rxn}} < 0$
- D. $\Delta S_{\text{rxn}} < 0$

Answer

Option C is correct because at constant temperature and pressure, $\Delta G_{\text{rxn}} < 0$ for a spontaneous process. **Option A is incorrect** because spontaneity of the reaction cannot be predicted by ΔH_{rxn} alone. **Option B is incorrect** because spontaneity of the reaction cannot be predicted by ΔV . **Option D is incorrect** because spontaneity of the reaction cannot be predicted by ΔS_{rxn} alone.

Competency 018—The teacher understands nuclear fission, nuclear fusion and nuclear reactions.

21. Of the following types of radiation, which have the highest penetrating capacity?

- A. Alpha particles
- B. Beta particles
- C. X-rays
- D. Gamma rays

Answer

Option D is correct because the relative penetrating capacity is as follows: gamma rays > x-rays > beta particles > alpha particles. **Option A is incorrect** because alpha particles have the least penetrating capacity of the four listed. **Option B is incorrect** because beta particles have less penetrating capacity than gamma rays. **Option C is incorrect** because x-rays have lower energy and longer wavelengths than gamma rays.

Competency 019—The teacher understands oxidation and reduction reactions.

22. Which of the following represents a reduction process only?

- A. $\text{Cu} \rightarrow \text{Cu}^{2+} + 2 \text{e}^{-}$
- B. $\text{Cu}^{2+} + 2 \text{e}^{-} \rightarrow \text{Cu}$
- C. $2 \text{FeO} \rightarrow 2 \text{Fe} + \text{O}_2$
- D. $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$

Answer

Option B is correct because Cu^{2+} (oxidation number is +2) is reduced in oxidation number to Cu (oxidation number is 0) by the addition of 2 electrons. **Option A is incorrect** because Cu is oxidized as Cu^{2+} forms. **Option C is incorrect** because the reaction $2 \text{FeO} \rightarrow 2 \text{Fe} + \text{O}_2$ involves both oxidation and reduction. **Option D is incorrect** because the reaction $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ involves both oxidation and reduction.

Competency 020—The teacher understands acids, bases and their reactions.

23. Which of the following is a Brønsted-Lowry acid?

- A. NH_4OH
- B. CH_3COOH
- C. CH_4
- D. XeF_4

Answer

Option B is correct because when CH_3COOH is dissolved in water, it donates a proton to H_2O to form H_3O^+ .

Option A is incorrect because NH_4OH is a Brønsted base. **Option C is incorrect** because CH_4 is neither a Brønsted acid nor a Brønsted base. **Option D is incorrect** because XeF_4 is neither a Brønsted acid nor a Brønsted base.

Domain IV—Cell Structure and Processes

Competency 021—The teacher understands the structure and function of biomolecules.

24. Which of the following best explains why the structure of phospholipids makes them well suited to be the major component of most bacterial and eukaryotic cell membranes?

- A. Phospholipids exhibit a branching structure and so can interact with many other molecules on each side of a membrane
- B. Phospholipids are flexible and so allow a cell to contract or expand, as required under different conditions
- C. Phospholipids form bilayers with one end buried in the bilayer and the other end exposed to an aqueous environment
- D. Phospholipids are a major source of energy for cells because they contain fatty acids and phosphate groups

Answer

Option C is correct because phospholipids are amphipathic, meaning that one end is charged and hydrophilic and the other end, the one composed of fatty acid tails, is hydrophobic. In an aqueous environment, such as a cell, a phospholipid bilayer is formed in which the hydrocarbon tails are forced together by hydrophobic interactions and the charged heads of the phospholipids are on the outer surfaces of the membrane, in contact with the cytosol, or with the interior of an organelle, or with the extracellular environment. **Option A is incorrect** because phospholipids do not branch. **Option B is incorrect** because phospholipids do not regulate the size of a cell through flexibility, although they are frequently added to and removed from a plasma membrane as a cell secretes or ingests materials, respectively. **Option D is incorrect** because the lipids that provide energy are triglycerides rather than phospholipids, which provide structure.

Competency 022—The teacher understands that cells are the basic structure of living things and have specialized parts that perform specific functions.

25. Which of the following cell types contains a particularly extensive smooth endoplasmic reticulum that stores a large amount of Ca^{2+} for intracellular signaling?

- A. Neuron
- B. Muscle cell
- C. Epithelial cell
- D. Lymphocyte

Answer

Option B is correct because muscle cells have an extensive membrane system composed of the sarcolemma and T-tubules, derived from the smooth endoplasmic reticulum that stores Ca^{2+} , which is released during muscle contraction. **Options A, C and D are incorrect** because each cell type has a smooth endoplasmic reticulum that performs a variety of functions, including the storage of a small amount of Ca^{2+} , but the smooth endoplasmic reticulum is not unusually extensive.

Competency 023—The teacher understands how cells carry out life processes.

26. Isolated plant cells are placed in a solution of 10% sucrose. When a sample of the cells is observed under a microscope after a few minutes in the solution, it is observed that the plasma membrane of each cell has pulled away from the cell wall. Which of the following is the best explanation?

- A. Solutes only moved out of the cells into the sucrose solution
- B. Water only moved out of the cells into the sucrose solution
- C. Sucrose moved into the cells, and water moved out of the cells into the sucrose solution
- D. Solutes and water both moved out of the cells into the sucrose solution

Answer

Option B is correct because the cells are in a hyperosmotic (hypertonic) solution, and so water—the only molecule that can move freely between the plasma membrane lipids—moves out of the cell to bring the solute concentration inside and outside the cell to equilibrium. **Option A is incorrect** for two reasons: solutes will not move by passive transport from a lower concentration to a higher concentration to bring the solute concentration to equilibrium, and solutes cannot freely cross the plasma membrane. **Option C is incorrect** because sucrose cannot cross the plasma membrane into the cell without the help of a pump protein; only water moves out. **Option D is incorrect** because only water moves out of the cells; solutes will not move by passive transport from a lower concentration to a higher concentration to bring the solute concentration to equilibrium, and solutes cannot freely cross the plasma membrane.

Competency 024—The teacher understands how specialized cells, tissues, organs, organ systems and organisms grow and develop.

27. Which of the following is most commonly associated with the development of liver cancer?

- A. Infection by hepatitis B virus
- B. Smoking of marijuana
- C. Long-term use of antibiotics
- D. Active Sun exposure

Answer

Option A is correct because liver cancer (hepatic carcinoma) frequently occurs after an infection by a hepatitis B virus. In countries with a high incidence of hepatitis B infection, there is also a much higher incidence of hepatic carcinoma. **Option B is incorrect** because there is no known association between marijuana and hepatic

carcinoma. **Option C is incorrect** because no association has been shown between long-term use of antibiotics and hepatic carcinoma, although long-term antibiotic use can lead to emergence of strains of antibiotic-resistant bacteria. **Option D is incorrect** because there is no known association between hepatic carcinoma and excessive Sun exposure, although the latter can lead to various forms of skin cancer.

Domain V—Heredity and Evolution of Life

Competency 025—The teacher understands the structures and functions of nucleic acids in the mechanisms of genetics.

28. Which of the following accurately describes the process of transcription?

- A. A ribosome moves along an mRNA and joins amino acids according to the sequence of the mRNA
- B. A ribosome moves along a stretch of DNA and joins amino acids according to the sequence of a template strand of the DNA
- C. A DNA polymerase moves along a template strand of DNA and makes a complementary RNA copy
- D. An RNA polymerase moves along a stretch of DNA and makes a complementary RNA copy of the template strand

Answer

Option D is correct because RNA polymerase catalyzes the addition of ribonucleotides into RNA according to the DNA sequence encountered by the polymerase as it moves along the template strand of a gene, which occupies a stretch of DNA. **Option A is incorrect** because the option describes translation. **Option B is incorrect** because ribosomes move along mRNAs, not DNA, and join amino acids as they translate the codon sequence found in the mRNAs. **Option C is incorrect** because DNA polymerases make complementary DNA copies of template strands of DNA during DNA replication.

Competency 026—The teacher understands the continuity and variations of traits from one generation to the next.

29. Which of the following tables correctly compares mitosis and meiosis?

A.

	Maximum number of daughter cells	Amount of DNA relative to parent cell	Sequence of daughter DNA relative to parent
Mitosis	4	one-half	different
Meiosis	2	same	same

B.

	Maximum number of daughter cells	Amount of DNA relative to parent cell	Sequence of daughter DNA relative to parent
Mitosis	2	same	same
Meiosis	2	one-half	same

C.	Maximum number of daughter cells	Amount of DNA relative to parent cell	Sequence of daughter DNA relative to parent
Mitosis	2	same	same
Meiosis	4	one-half	different

D.	Maximum number of daughter cells	Amount of DNA relative to parent cell	Sequence of daughter DNA relative to parent
Mitosis	2	same	same
Meiosis	1	double	different

Answer

Option C is correct because two cells that are identical to the parent result from mitosis, while four cells with half as much DNA as the parent and slightly differing DNA sequence result from meiosis. Both mitosis and meiosis commence after DNA replication, when each chromosome becomes composed of a pair of identical chromatids. In meiosis, the homologous pairs of chromosomes pair up during prophase, crossing over when DNA exchange occurs between non-sister chromatids, and the homologues separate into two daughter cells at the first division. The sister chromatids, no longer completely identical, separate at the second division. Mitosis, which does not involve pairing of homologues, includes only one division at which sister chromatids separate. **Option A is incorrect** because the descriptions of mitosis and meiosis are reversed. **Option B is incorrect** because it incorrectly indicates that meiosis gives rise to a maximum of two cells and that their DNA sequence is identical to that of the parent. **Option D is incorrect** because it incorrectly indicates that meiosis gives rise to a maximum of one cell, with a DNA content double that of the parent.

Competency 027—The teacher understands the theory of biological evolution.

30. Which of the following best illustrates the founder effect?

- A. There is significantly less variation of alleles governing tissue transplant rejection in an island colony of sheep than in the mainland population from which the colony was started in 1975
- B. The uplift of the Isthmus of Panama divided a single ancestral wrasse population into two distinct species of fish
- C. A silverback male gorilla can mate with all the adult females in his troop, most of whom immigrated to the troop from other troops
- D. The small size of most Chihuahuas is the result of selective breeding by humans for smaller dogs

Answer

Option A is correct because the founder effect results when a small population, such as the sheep, splits off and isolates from a larger population. Because the population is smaller, there is not as much genetic variability as in the original population, and the incidence of certain traits may be increased or decreased relative to the incidence in the original population. **Option B is incorrect** because it illustrates allopatric speciation in which two populations of the same species become geographically isolated from each other and form distinct species.

Option C is incorrect because it illustrates an increase in gene flow, from the immigration of female gorillas from different troops, rather than a decrease. **Option D is incorrect** because it illustrates artificial selection rather than isolation of a population of a species.

Competency 028—The teacher understands evidence for evolutionary change during Earth’s history.

31. Which of the following provides the best evidence that fish, amphibians, birds, reptiles and mammals share a common ancestor?

- A. Fossils of primitive forms of all the organisms have been discovered
- B. During development, all the organisms possess pharyngeal gill pouches and a notochord
- C. All the organisms have a special covering that includes moist skin, scales, feathers or hair
- D. All the organisms have mechanisms that permit movement from one location to another

Answer

Option B is correct because embryological similarity of specific traits that may not be present in the adult points to a common ancestor. **Option A is incorrect** because the discovery of fossils of primitive forms of the organisms provides no information about similarities between the fossils. **Option C is incorrect** because all organisms have some sort of external surface. **Option D is incorrect** because the ability to move from one location to another is too broad a trait to indicate relatedness.

Domain VI—Diversity of Life

Competency 029—The teacher understands similarities and differences between living organisms and how taxonomic systems are used to organize and interpret the diversity of life.

32. Which of the following groups of organisms is characterized by absorption of organic materials from its environment, a cell wall composed of chitin and reproduction most commonly through spore formation?

- A. Protists
- B. Plants
- C. Bacteria
- D. Fungi

Answer

Option D is correct because fungi are heterotrophs that secrete enzymes to break down organic materials in the environment or in cells so that the materials can be absorbed by the fungi. Fungi are surrounded by cell walls composed of chitin. Most fungi propagate, either asexually or sexually, by producing spores. **Option A is incorrect** because protists are autotrophs or heterotrophs (or both) that make or ingest food but do not absorb it. They reproduce asexually or sexually, without spores. **Option B is incorrect** because the cell walls of plants are composed primarily of cellulose rather than of chitin and, although plants do produce spores, which divide mitotically to produce gametes, plants are autotrophs. **Option C is incorrect** because bacteria include both autotrophs and heterotrophs that utilize a diverse range of energy sources, and they reproduce by binary fission.

Competency 030—The teacher understands that, at all levels of nature, living systems are found within other living systems, each with its own boundaries and limits.

33. Which of the following is an advantage of the double blood circulation of amphibians, reptiles and mammals versus the single blood circulation of fish?

- A. CO₂ diffuses out of the blood, and O₂ diffuses into the blood
- B. Contraction of the heart chambers is carefully controlled
- C. Blood carries nutrients from the digestive system to the rest of the body
- D. Blood flows under greater pressure to major organs

Answer

Option D is correct because pumping by the heart increases the pressure of blood flow to the major organs after the blood passes through the capillary beds of the lungs. **Option A is incorrect** because gas exchange in the blood occurs in fish as well, which have capillary beds in their gills that are in close contact with water. **Option B is incorrect** because contraction of the heart is carefully controlled in fish as well as in amphibians, reptiles, and mammals. **Option C is incorrect** because blood circulates nutrients from the digestive system in fish as well as in amphibians, reptiles and mammals.

Competency 031—The teacher understands the processes by which organisms maintain homeostasis.

34. By which of the following mechanisms do marine birds maintain their water and salt balance?

- A. They obtain all the salt and water they need from the organisms they eat
- B. They concentrate and excrete excess ingested salt in their urine
- C. They use salt glands to remove excess salt from the seawater they drink
- D. They drink freshwater when it is available and store small quantities

Answer

Option C is correct because marine birds, as well as sea turtles and marine iguanas, possess salt glands on their beaks which contain specialized transport epithelial cells that remove and concentrate excess Na⁺ and Cl⁻ ions from the blood. **Option A is incorrect** because marine birds do drink salt water in addition to that which they ingest with their food. **Option B is incorrect** because very little salt appears in the urine of marine birds. **Option D is incorrect** because many have little exposure to freshwater, and they have no means of storing it.

Competency 032—The teacher understands the relationship between biology and behavior.

35. In an experiment, a species of migratory bird was placed in cone-shaped cages. The sides of the cages were lined with blotting paper, and ink pads were placed in the bottoms. The tops of the cages were constructed so that when

located outdoors, the birds had a full view of the night sky. Directed movements by the birds were indicated by inky footprints the birds made as they walked on the blotting paper. On clear nights in the spring, most footprints were on the north side of the cages but on clear nights in the fall, most footprints were on the south side of the cages. On cloudy nights at either time of year, the location of footprints was random. Which of the following is the best explanation?

- A. The birds have an innate sense of migratory direction and were disoriented by the cages
- B. The birds use day length to orient their migration
- C. The birds use the position of the stars to orient their migration
- D. The birds use air temperature and wind direction to orient their migration

Answer

Option C is correct because the stars appear at different positions in the sky at different times of the year, and birds that migrate at night navigate by the positions of the stars, as long as they are not obscured by clouds.

Option A is incorrect because birds do depend on some sort of compass, generally based on the Sun, the stars, or Earth's magnetic field, and the data suggest that the birds in the experiment point in a particular direction as long as they can see the stars. **Option B is incorrect** because the data from this experiment indicate that visibility of the stars rather than day length determined the position of the bird footprints. **Option D is incorrect** because birds do not appear to depend on air temperature or wind, and the data also suggest otherwise.

Domain VII—Interdependence of Life and Environmental Systems

Competency 033—The teacher understands the relationships between abiotic and biotic factors of terrestrial and aquatic ecosystems, habitats and biomes, including the flow of matter and energy.

36. The soil of tropical rain forests contains far less organic matter than the soil of temperate deciduous forests. Which of the following is the best explanation?

- A. Decaying matter is quickly broken down by living organisms or washed away by heavy rain
- B. Tropical rain forests exhibit low biodiversity and consequently have less organic matter to decay
- C. The dense canopy layer of the rain forest blocks organic matter from reaching the soil
- D. Dead organisms decay slowly in the rain forest and release little organic material into the soil

Answer

Option A is correct because material that falls to the ground is quickly broken down by decomposers, encouraged by the high heat and humidity of the rain forest. The heavy rain characteristic of the rain forest also removes much of the organic matter. **Option B is incorrect** because tropical rain forests exhibit greater biodiversity than any other biome and have dense flora and fauna, except where harmed by people. **Option C is incorrect** because organic matter comes from organisms growing from or living on the forest floor and so is not blocked by the canopy. **Option D is incorrect** because dead organisms decay very rapidly due to the heat and humidity.

Competency 034—The teacher understands the interdependence and interactions of living things in terrestrial and aquatic ecosystems.

37. Which of the following best illustrates commensalism?

- A. Microorganisms that live in the gut of termites digest the cellulose that is ingested by the termites when they eat wood
- B. Cattle egrets that forage around cattle and other grazing animals exhibit much greater success in capturing prey than when they forage alone
- C. Tarantula hawk wasps lay their eggs on tarantulas that they have paralyzed, and the larvae hatch and eat the tarantulas
- D. *Rhizobium* bacteria are found in nodules of legume roots where the roots absorb nitrogen fixed by the bacteria and the legume provides organic compounds to the bacteria

Answer

Option B is correct because commensalism is defined as symbiosis in which one organism benefits while the other is neither harmed nor helped. Cattle egrets benefit from the greater availability of insects and other small prey disturbed by the cattle; on the other hand, the cattle are neither harmed nor helped, although the egrets do sometimes remove ticks from the cattle. **Option A is incorrect** because it illustrates a mutualistic relationship in which both the microorganisms and termites benefit nutritionally. **Option C is incorrect** because it illustrates parasitism in which the wasps benefit and the tarantulas are killed. **Option D is incorrect** because it illustrates a mutualistic relationship in which both the bacteria and the legume benefit.

Competency 035—The teacher understands the relationship between carrying capacity and changes in populations and ecosystems.

38. Which of the following is the best example of a density-independent variable that may alter the carrying capacity of a region for a particular animal?

- A. An infection of several animals by a virus specific to the species
- B. A destructive tornado passing through the region
- C. The presence in the region of a predator of the animals
- D. Introduction of another species occupying the same niche

Answer

Option B is correct because the density of the animal population does not affect the percent of animals that are affected by the tornado. **Option A is incorrect** because a greater density of animals means that an infected animal is more likely to have contact with and possibly infect an uninfected animal. **Option C is incorrect** because animals of a population that is of greater density are more likely to fall prey to a particular predator. **Option D is incorrect** because the introduced species competes with the established species for resources; the greater number of each species, the greater the competition.

Domain VIII—Earth’s History and the Structure and Function of Earth Systems

Competency 036—The teacher understands structure and function of the geosphere.

39. Which of the following is a metamorphic rock?

- A. Basalt
- B. Shale
- C. Topaz
- D. Gneiss

Answer

Option D is correct because gneiss is a metamorphic rock. **Option A is incorrect** because basalt is an igneous rock. **Option B is incorrect** because shale is a sedimentary rock. **Option C is incorrect** because topaz is a mineral.

Competency 037—The teacher understands processes of plate tectonics, weathering, erosion and deposition that change Earth’s surface.

40. The Alps mountain range in Europe is theorized to have formed by which of the following means?

- A. Collision of the African and Eurasian tectonic plates
- B. Eruption of a supervolcano over a hot spot
- C. Impact of a large asteroid
- D. Mounds of debris from an enormous tsunami in the Mediterranean Sea

Answer

Option A is correct because current evidence supports that the Alps were formed by the collision of the African and Eurasian tectonic plates. **Option B is incorrect** because there is no evidence of a significant hot spot in the area that could have formed the Alps via volcanic activity, and the Alps are not made primarily of volcanic rock. **Option C is incorrect** because the impact of an asteroid on Earth would leave an impact crater rather than form a mountain range. **Option D is incorrect** because although a tsunami could push large amounts of debris on land and the Alps are relatively near the Mediterranean Sea, the enormous height of the Alps would make this impossible. Also, the rock types and structures in the Alps do not support this option.

Competency 038—The teacher understands the formation and history of Earth.

41. The Paleozoic era ended with which of the following?

- A. A mass extinction
- B. The splitting of one large continent into smaller continents
- C. A worldwide flood that covered Earth’s landmass
- D. The sudden appearance of many new plant and animal species

Answer

Option A is correct because the end of the Paleozoic era is marked by a mass extinction. **Option B is incorrect** because it is believed that the supercontinent Pangea began to break apart during the Mesozoic era. **Option C is incorrect** because Earth's landmass was not flooded by water at the end of the Paleozoic era. **Option D is incorrect** because instead of the sudden appearance of many new plant and animal species, there was a mass extinction.

Competency 039—The teacher understands structure and function of the hydrosphere.

42. Fjords are the result of which of the following?

- A. Volcanic activity
- B. Glaciation
- C. Earthquakes
- D. Chemical weathering

Answer

Option B is correct because fjords were carved out by glacial activity. **Option A is incorrect** because fjords are not caused by volcanic activity. **Option C is incorrect** because fjords are not caused by earthquakes. **Option D is incorrect** because fjords do not appear simply as a result of chemical weathering.

Competency 040—The teacher understands structure and function of the atmosphere.

43. Which of the following is true about a parcel of air as it warms up?

- A. The equilibrium vapor pressure of water in the air parcel decreases
- B. The amount of water vapor in the air parcel increases
- C. The relative humidity of the air parcel decreases
- D. Some of the water vapor in the air parcel will condense forming precipitation

Answer

Option C is correct because as temperature increases the equilibrium vapor pressure of water increases, meaning the relative humidity will decrease. Relative humidity is a measure of how much water vapor is in the air compared to the maximum amount that could be in the air parcel at that temperature (saturation vapor pressure). **Option A is incorrect** because the equilibrium vapor pressure of H₂O increases as temperature increases. **Option B is incorrect** because the amount of gaseous water in the air parcel will not increase unless additional water vapor is introduced from outside the air parcel. The amount will either remain constant, or it may decrease if some of the water vapor condenses — but that is less likely to occur as the temperature increases. In either case, the amount of water vapor will not increase by simply warming the parcel of air. **Option D is incorrect** because the water vapor will not condense unless the temperature drops below the dew point, the point at which relative humidity is 100% (vapor pressure of water in the air parcel is equal to the saturation vapor pressure).

Domain IX—Components and Properties of the Solar System and the Universe

Competency 042—The teacher understands the implications of Earth’s placement and orientation in the solar system.

44. Which of the following is true about the Earth-Moon-Sun system?

- A. Earth rotates on its axis, but the Moon does not rotate on its axis; this results in the same side of the Moon facing Earth at all times
- B. Tides on Earth are affected by gravitational forces between Earth and the Moon, and between Earth and the Sun
- C. A lunar eclipse is an event in which the view of the Sun from Earth is blocked when the Moon is positioned between Earth and the Sun
- D. Earth rotates on its axis once in approximately 365 days, which is the length of one year

Answer

Option B is correct because tides are caused by the rotation of Earth and the combined effects of the gravitational forces between Earth and the Moon and, to a lesser extent, Earth and the Sun. **Option A is incorrect** because both Earth and the Moon rotate on their respective axes. **Option C is incorrect** because a lunar eclipse is an event in which the view of the Moon is obscured when Earth is positioned exactly between the Moon and the Sun. **Option D is incorrect** because Earth rotates on its axis once in 24 hours, which is the length of one day.

Competency 043—The teacher understands the role of the Sun in the solar system and the characteristics of planets and other objects that orbit the Sun.

45. Which of the planets has the largest mass even though it is composed largely of hydrogen and helium?

- A. Jupiter
- B. Mars
- C. Venus
- D. Neptune

Answer

Option A is correct because Jupiter is a gas giant, and its mass is approximately 1.9×10^{27} kg. **Option B is incorrect** because Mars is a terrestrial planet, and its mass is much less than that of Jupiter and is approximately 6.4×10^{23} kg. **Option C is incorrect** because Venus is a terrestrial planet, and its mass is much less than that of Jupiter and is approximately 4.9×10^{24} kg. **Option D is incorrect** because although Neptune is a gas giant, its mass is less than that of Jupiter and is approximately 1.0×10^{26} kg.

Competency 044—The teacher understands composition, history and properties of the universe.

46. Of the following, which is the latest stage in the life cycle of a small star with a mass similar to our Sun?
- A. Red giant
 - B. Protostar
 - C. White dwarf
 - D. Supernova

Answer

Option C is correct because for a star of this size, the white dwarf is the latest stage in the life cycle of the star. **Option A is incorrect** because the red giant phase is earlier than the white dwarf phase. **Option B is incorrect** because the protostar phase is very early in the life cycle of a star. **Option D is incorrect** because the supernova phase is the latest event in the life cycle of larger stars, but not for stars with a mass similar to the Sun.

Domain X—Science Learning, Instruction and Assessment

Competency 046—The teacher understands research-based theoretical and practical knowledge about teaching science, how students learn science and the role of scientific inquiry in science instruction.

47. Which of the following is an element of inquiry-based science instruction?
- A. A teacher-led question and answer session
 - B. A video presentation of science principles to be included in a unit of study
 - C. A student forming a hypothesis prior to a lab activity
 - D. A student writing a report after researching information on the Internet

Answer

Option C is correct because inquiry-based learning does involve students proposing a hypothesis prior to designing an experiment to test the hypothesis. **Option A is incorrect** because a teacher asking questions is important, but it is not an element of inquiry-based science instruction. **Option B is incorrect** because videos can be helpful, but they are not elements of inquiry-based learning. **Option D is incorrect** because writing reports can have value, but it is not an element of inquiry-based learning.

Competency 047—The teacher knows how to monitor and assess science learning in laboratory, field and classroom settings.

48. Which of the following is a type of summative assessment?
- A. A final examination
 - B. A homework exercise
 - C. An interview
 - D. A question-and-answer session

Answer

Option A is correct because it occurs after completion of learning and assesses what has been learned and how well it has been learned. **Option B is incorrect** because it is a type of formative assessment. **Option C is incorrect** because it is a type of diagnostic assessment. **Option D is incorrect** because it is a type of formative assessment.