TEA™ TEXAS EDUCATION AGENCY
TEXAS EDUCATOR CERTIFICATION

TExES TExMaT TASC/TASC-ASL

Texas Examinations of Educator Standards™ (TExES™) Program

Preparation Manual

Physical Science 6–12 (237)

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About The Test

Test Name	Physical Science 6–12
Test Code	237
Time	5 hours
Number of Questions	100 multiple-choice questions
Format	Computer-administered test (CAT)

The TExES Physical Science 6–12 (237) test 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 100 multiple-choice questions are based on the Physical Science 6–12 test framework. Questions on this test range from grades 6–12. The test may contain questions that do not count toward the score.

The number of scored questions will not vary; however, the number of questions that are not scored may vary in the actual test. Your final scaled score will be based only on scored questions.

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The Domains

Domain	Domain Title	Approx. Percentage of Test	Standards Assessed
I.	Scientific Inquiry and Processes	14%	Physical Science 6–12 I–III, VI—VII, XI
II.	Physics	36%	Physical Science 6–12 VIII
III.	Chemistry	41%	Physical Science 6–12 VIII
IV.	Science Learning, Instruction and Assessment	9%	Physical Science 6–12 IV–V

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The Standards

Physical Science 6–12 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.

Physical Science 6–12 Standard II
The science teacher understands the correct use of tools, materials, equipment and technologies.

Physical Science 6–12 Standard III
The science teacher understands the process of scientific inquiry and its role in science instruction.

Physical Science 6–12 Standard IV
The science teacher has theoretical and practical knowledge about teaching science and about how students learn science.

Physical Science 6–12 Standard V
The science teacher knows the varied and appropriate assessments and assessment practices to monitor science learning.

Physical Science 6–12 Standard VI
The science teacher understands the history and nature of science.

Physical Science 6–12 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.

Physical Science 6–12 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.

Physical Science 6–12 Standard XI
The science teacher knows unifying concepts and processes that are common to all sciences.

Domains and Competencies

The content covered by this test 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:

A. Uses current sources of information about laboratory safety, including safety regulations and guidelines for the use of science facilities.

B. 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.

C. Employs safe practices in planning, implementing and managing all instructional activities and designs and implements rules and procedures to maintain a safe learning environment.

D. 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.

E. 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).

F. 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.

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G. 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; and 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 in order 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.

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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.

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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.

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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 interrelationships 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).

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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.

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Competency 014: *The teacher understands 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.

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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.

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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 by 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.

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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 — Science Learning, Instruction and Assessment

Competency 021: *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 school-wide 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; 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 022: *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.

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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.

Approaches to Answering Multiple-Choice Questions

The purpose of this section is to describe multiple-choice question formats that you will typically see on the Physical Science 6–12 test and to suggest possible ways to approach thinking about and answering them. These approaches are intended to supplement and complement familiar test-taking strategies with which you may already be comfortable and that work for you. Fundamentally, the most important component in assuring your success on the test is knowing the content described in the test framework. This content has been carefully selected to align with the knowledge required to begin a career as a Physical Science 6–12 teacher.

The multiple-choice questions on this test are designed to assess your knowledge of the content described in the test framework. In most cases, you are expected to demonstrate more than just your ability to recall factual information. You may be asked to think critically about the information, to analyze it, consider it carefully, compare it with other knowledge you have or make a judgment about it.

When you are ready to respond to a multiple-choice question, you must choose one of four answer options. Leave no questions unanswered. Questions for which you mark no answer are counted as incorrect. Your score will be determined by the number of questions for which you select the correct answer.

Calculators. Some test questions for Physical Science 6–12 are designed to be solved with a graphing calculator. An online calculator is available as part of the testing software for tests that require the use of a calculator. Do not bring your own calculator to the test administration.

Periodic Table of the Elements. A Periodic Table of the Elements will be provided as part of the test for use on science questions. A copy of this periodic table is provided on page 27.

Physical Constants. A set of physical constants will be provided as part of the test. A copy of those physical constants is provided on page 28 of this preparation manual.

The Physical Science 6–12 test is designed to include a total of 100 multiple-choice questions, out of which 80 are scored. The number of scored questions will not vary; however, the number of questions that are not scored may vary in the actual test. Your final scaled score will be based only on scored questions. The questions that are not scored are being pilot tested to collect information about how these questions will perform under actual testing conditions. These pilot questions are not identified on the test.

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How to Approach Unfamiliar Question Formats

Some questions include introductory information such as a map, table, graph or reading passage (often called a stimulus) that provides the information the question asks for. New formats for presenting information are developed from time to time. Tests may include audio and video stimulus materials such as a movie clip or some kind of animation, instead of a map or reading passage. Other tests may allow you to zoom in on the details in a graphic or picture.

Tests may also include interactive types of questions. These questions take advantage of technology to assess knowledge and skills that go beyond what can be assessed using standard single-selection multiple-choice questions. If you see a format you are not familiar with, **read the directions carefully**. The directions always give clear instructions on how you are expected to respond.

For most questions, you will respond by clicking an oval to choose a single answer choice from a list of options. Other questions may ask you to respond by:

- **Typing in an entry box.** When the answer is a number, you might be asked to enter a numeric answer or, if the test has an on-screen calculator, you might need to transfer the calculated result from the calculator into the entry box. Some questions may have more than one place to enter a response.
- **Clicking check boxes.** You may be asked to click check boxes instead of an oval when more than one choice within a set of answers can be selected.
- **Clicking parts of a graphic.** In some questions, you will choose your answer by clicking on location(s) on a graphic such as a map or chart, as opposed to choosing from a list.
- **Clicking on sentences.** In questions with reading passages, you may be asked to choose your answer by clicking on a sentence or sentences within the reading passage.
- **Dragging and dropping answer choices into "targets" on the screen.** You may be asked to choose an answer from a list and drag it into the appropriate location in a table, paragraph of text or graphic.
- **Selecting options from a drop-down menu.** This type of question will ask you to select the appropriate answer or answers by selecting options from a drop-down menu (e.g., to complete a sentence).

Remember that with every question, you will get clear instructions on how to respond.

Question Formats

You may see the following types of multiple-choice questions on the test:

— Single Questions
— Clustered Questions

On the following pages, you will find descriptions of these commonly used question formats, along with suggested approaches for responding to each type.

Single Questions

The single-question format presents a direct question or an incomplete statement. It can also include a reading passage, graphic, table or a combination of these. Four answer options appear below the question.

The following question is an example of the single-question format. It tests knowledge of Physical Science 6–12 Competency 017: *The teacher understands energy transformations that occur in physical and chemical processes.*

Example

For a given reaction, ΔH = 13.6 kJ and ΔS = 145 J/K. Assuming these values are independent of temperature, at what temperature will the reaction become spontaneous?

A. 94 K
B. 94ºC
C. 11 K
D. 11ºC

Suggested Approach

Read the question carefully and critically. Think about what it is asking and the situation it is describing. Eliminate any obviously wrong answers, select the correct answer choice and mark your answer.

The first step in this problem is to consider the information given and the question being asked. In this case, the change in enthalpy (ΔH) and change in disorder or entropy (ΔS) are given for a chemical reaction, and you are asked for the temperature at which the reaction occurs spontaneously. The spontaneity of a reaction can be determined by calculating the Gibbs free energy of a system (ΔG). The free energy of a system is the maximum useful energy obtainable in the form of work from a given reaction at constant temperature and pressure. If $\Delta G > 0$, then the reaction is nonspontaneous. If $\Delta G < 0$, then the reaction is spontaneous. The system is at equilibrium when there is no net gain or loss of free energy within

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the system ($\Delta G = 0$). Equilibrium is also the threshold at which the reaction becomes spontaneous. The expression for the free energy is $\Delta G = \Delta H - T\Delta S$, where T, the temperature, is expressed using the Kelvin scale.

Thus, the question requires that you determine at what temperature the reaction will become spontaneous, $\Delta G = 0$.

Because $\Delta G = 0$, then $T\Delta S = \Delta H$, and $T = \Delta H/\Delta S$.

Inserting the given values gives $T = \frac{13.6\text{ kJ}}{145\text{ J/K}}$. Converting kilojoules to joules,

13.6 kJ = 13,600 J, and simplifying results in $T = \frac{13{,}600\text{ J}}{145\text{ J/K}} = 93.8\text{ K}$.

This answer is closest to response option A.

Option B comes from confusing the Celsius and Kelvin temperature scales. Option C results from incorrectly solving the expression for $\Delta G = 0$ and obtaining $T = \Delta S/\Delta H$. Option D comes from both incorrectly solving the equation and using the incorrect temperature scale.

Clustered Questions

Clustered questions are made up of a stimulus and two or more questions relating to the stimulus. The stimulus material can be a reading passage, description of an experiment, graphic, table or any other information necessary to answer the questions that follow.

You can use several different approaches to respond to clustered questions. Some commonly used strategies are listed below.

Strategy 1 Skim the stimulus material to understand its purpose, its arrangement and/or its content. Then read the questions and refer again to the stimulus material to obtain the specific information you need to answer the questions.

Strategy 2 Read the questions *before* considering the stimulus material. The theory behind this strategy is that the content of the questions will help you identify the purpose of the stimulus material and locate the information you need to answer the questions.

Strategy 3 Use a combination of both strategies. Apply the "read the stimulus first" strategy with shorter, more familiar stimuli and the "read the questions first" strategy with longer, more complex or less familiar stimuli. You can experiment with the sample questions in this manual and then use the strategy with which you are most comfortable when you take the actual test.

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

Whether you read the stimulus before or after you read the questions, you should read it carefully and critically. You may want to note its important points to help you answer the questions.

As you consider questions set in educational contexts, try to enter into the identified teacher's frame of mind and use that teacher's point of view to answer the questions that accompany the stimulus. Be sure to consider the questions only in terms of the information provided in the stimulus — not in terms of your own experiences or individuals you may have known.

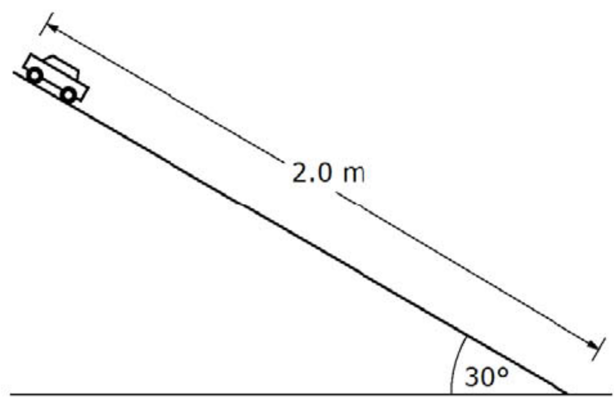
Example

First read the stimulus (a description of a physics experiment along with a data table).

Use the information below to answer the questions that follow.

A group of students is measuring how long it takes a toy car released from rest to roll down a straight inclined track. The data from the experiment are summarized below.

Mass of car	0.1 kg
Length of incline	2.0 m
Slope of incline	30°
Average time	1.2 s



Now you are prepared to address the first of the two questions associated with this stimulus. The first question measures Physical Science 6–12 Competency 005: *The teacher understands the laws of motion.*

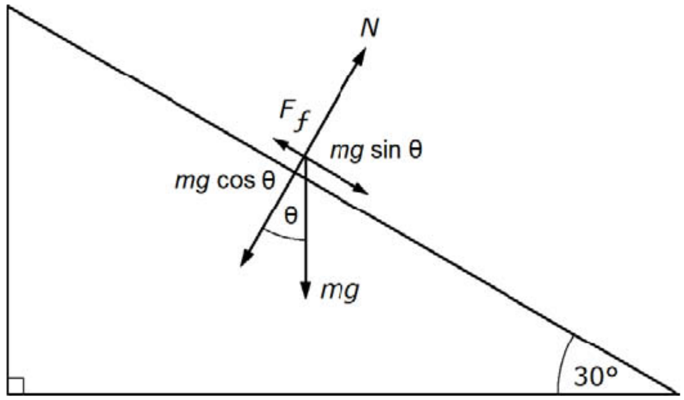
1. What is the magnitude of the gravitational force acting on the car in the direction of the toy car's motion down the track?

   A. 0.10 N
   B. 0.49 N
   C. 0.85 N
   D. 0.98 N

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

Suggested Approach

The first step is to identify the forces acting on the car. In this case, the forces acting on the car are the force of gravity, the force of friction and the normal force from the inclined plane on the car. The next step is to draw a free body diagram showing these forces resolved into their appropriate components.



To determine the magnitude of the gravitational force acting on the car in the direction of the car's motion down the track, it is necessary to determine the component of the gravitational force along the incline. For an inclined plane, this component is given by $F = mg \sin \theta$, where m is the mass of the car, g is the acceleration due to gravity (9.8 m/s^2), and $\sin \theta$ is the sine of the angle of the incline with the horizontal. Substituting the given values into the expression and using the fact that $\sin 30° = 0.5$ results in the numerical value for the force component acting along the plane, or $F = 0.49$ N. **Therefore, the correct response is option B.**

Option A is the mass of the car and is therefore incorrect. Option C results from incorrectly using $mg \cos 30°$ for the component of the gravitational force in the direction of the car's motion. Option D is the weight of the car, which is equal to the magnitude of the gravitational force mg toward the center of the earth.

Now you are ready to answer the second question. This question also measures Physical Science 6–12 Competency 005: *The teacher understands the laws of motion.*

2. Assuming the acceleration of the car down the track is constant, what is the net force acting on the car in the direction of the car's motion down the track?

   A. 0.21 N
   B. 0.28 N
   C. 0.56 N
   D. 0.98 N

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

Suggested Approach

The second question for this stimulus asks for the net force acting on the car in the direction of the car's motion. According to Newton's second law of motion, the net force on any object in the direction of the object's motion is equal to the object's mass multiplied by its acceleration, or $F_{net} = ma$. Because the mass of the car is known, it is necessary to find the acceleration of the car. The question tells us to assume the acceleration is constant. Also, it is given from the original stimulus data that the car starts from rest and travels a distance of 2.0 m in 1.2 s. The expression for the distance traveled by an object undergoing constant acceleration, $x = \frac{1}{2}at^2 + v_0t + x_0$, simplifies to $x = \frac{1}{2}at^2$. In this problem, therefore, solving for a yields $a = \frac{2x}{t^2} = \frac{2(2.0)}{(1.2)^2} = 2.8 \text{ m/s}^2$. Multiplying this value by the mass of the car results in 0.28 N, which is option B. **Therefore, the correct response is option B.** Option A results from incorrectly calculating the acceleration as the distance the object travels divided by the time required, or $\frac{2.0}{1.2}$, and using this value to find the force. Option C results from correctly determining the acceleration and multiplying the result by the mass of the car but then incorrectly trying to find the component of the force parallel to the plane by dividing the result by sin 30°, or 0.5. Option D is the force of gravity on the object.

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

Multiple-Choice Practice Questions

This section presents some sample test questions for you to review as part of your preparation for the test. To demonstrate how each competency may be assessed, each sample question is accompanied by the competency that it measures. 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 test.

For each sample test question, there is a correct answer and a rationale for each answer option. Please note that the sample questions are not necessarily presented in competency order.

The sample questions are included to illustrate the formats and types of questions you will see on the test; however, your performance on the sample questions should not be viewed as a predictor of your performance on the actual test.

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

PERIODIC TABLE OF THE ELEMENTS

1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.179
11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.938	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.91	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57 ***La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.02	89 **†Ac** 227.03	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (264)	108 **Hs** (277)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (272)	112 **§** (277)						

§Not yet named

*Lanthanide Series	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
†Actinide Series	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	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)

NOTE: After clicking on a link, right click and select “Previous View” to go back to original text.

Definitions and Physical Constants for Physical Science 6–12

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 L-atm/K-mol.

Planck's constant is 6.6256×10^{-34} 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

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

COMPETENCY 001

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 and Rationale

COMPETENCY 002

2. 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 and Rationale

COMPETENCY 003

3. Of the following, which contributes the most to water pollution in streams near mountains?

   A. Nuclear power plants
   B. Mine drainage
   C. Carbon dioxide emissions from gas-powered automobiles
   D. Oil-well drilling

Answer and Rationale

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

COMPETENCY 003

4. Historically, the Bohr model was successful in explaining which of the following?

   A. The emission spectrum of the hydrogen atom
   B. The red shift in the spectrum of light from distant stars
   C. The black-body radiation spectrum
   D. The photoelectric effect

Answer and Rationale

COMPETENCY 004

5. A ball of mass *m* is thrown horizontally with an initial speed υ_0 from the top of a building that is height *h* above level ground. In the absence of air resistance, how much time will elapse before the ball strikes the ground?

   A. $\frac{\upsilon_0}{g}$
   B. $\frac{h}{\upsilon_0}$
   C. $\sqrt{2gh}$
   D. $\sqrt{\frac{2h}{g}}$

Answer and Rationale

COMPETENCY 004

6. Two satellites are each in a circular orbit around Earth at a distance *R* and 2*R*, respectively, from Earth's center. If the satellite at distance *R* has an orbital speed of υ, the satellite at distance 2*R* must have an orbital speed equal to

   A. 2υ
   B. $\sqrt{2}\,\upsilon$
   C. υ
   D. $\frac{\upsilon}{\sqrt{2}}$

Answer and Rationale

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

COMPETENCY 005

7. A 50 N force is applied to a 10 kg block that is initially at rest on a rough horizontal surface. If the block accelerates uniformly at 2 m/s^2, what is the magnitude of the frictional force acting on the object?

   A. 98 N
   B. 50 N
   C. 30 N
   D. 20 N

Answer and Rationale

COMPETENCY 006

8. A simple pendulum with period T on Earth is transported to the Moon where the gravitational force is about one-sixth the gravitational force on Earth. The period of the pendulum on the Moon is approximately equal to which of the following?

   A. $6T$
   B. $\sqrt{6}\,T$
   C. T
   D. $\frac{T}{6}$

Answer and Rationale

COMPETENCY 006

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

   A. It increases in magnitude as the distance between the charges increases
   B. It is dependent on the masses of the charges
   C. It can be attractive or repulsive
   D. It is equal to the magnetic force between the charges

Answer and Rationale

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

COMPETENCY 007

10. A 5 Ω resistor connected in series with a voltage source dissipates 20 W of power. If the source voltage is doubled, the power dissipated by the resistor will be equal to which of the following?

A. 80 W
B. 40 W
C. 20 W
D. 5 W

Answer and Rationale

COMPETENCY 008

11. A railroad boxcar of mass M is moving along a straight horizontal track with speed υ. It collides and couples with a second boxcar of mass $4M$ that is at rest. What is the kinetic energy of the coupled box cars immediately after the collision?

A. 0
B. $\frac{1}{10}M\upsilon^2$
C. $\frac{1}{2}M\upsilon^2$
D. $\frac{5}{2}M\upsilon^2$

Answer and Rationale

COMPETENCY 009

12. The first law of thermodynamics is a statement of which of the following?

A. The ideal gas law
B. The uncertainty principle
C. The law of conservation of energy
D. The behavior of the entropy of a system

Answer and Rationale

NOTE: After clicking on a link, right click and select “Previous View” to go back to original text.

COMPETENCY 010

13. A light ray passes from air (n = 1) into glass (n = 1.55). Which of the following is true about the angle of refraction?

   A. It is equal to the angle of incidence
   B. It is less than the angle of incidence
   C. It is equal to the angle of reflection
   D. It is greater than the angle of reflection

Answer and Rationale

COMPETENCY 010

14. Of the following phenomena, which is characteristic of light but not of sound?

   A. Diffraction
   B. Interference
   C. Polarization
   D. Dispersion

Answer and Rationale

COMPETENCY 011

15. According to the Bohr model of the hydrogen atom, the energy E_n of an electron in the nth energy level of the atom is equal to $E_n = -\frac{13.6}{n^2}\text{ eV}$. What is the energy of the photon emitted when an electron makes a transition from the $n = 2$ level to the $n = 1$ level?

   A. 6.8 eV
   B. 10.2 eV
   C. 13.6 eV
   D. 17.0 eV

Answer and Rationale

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

COMPETENCY 011

16. In the photoelectric effect, light is incident on a metallic surface and photoelectrons are emitted. If f and λ represent the frequency and wavelength, respectively, of the incident light, and W represents the work function of the metal, which of the following equations correctly gives the maximum kinetic energy E of the emitted photoelectrons?

    A. $E = h\lambda$
    B. $E = hf$
    C. $E = W$
    D. $E = hf - W$

Answer and Rationale

COMPETENCY 012

17. Of the following, which is an example of a physical change only?

    A. Snow sublimating in the Arctic
    B. An iron nail rusting
    C. A candle burning
    D. A lead storage battery recharging

Answer and Rationale

COMPETENCY 012

18. Based on its position on the periodic table, which of the following elements has the most metallic chemical properties?

    A. Cs
    B. Au
    C. Sb
    D. Br

Answer and Rationale

NOTE: After clicking on a link, right click and select “Previous View” to go back to original text.

COMPETENCY 013

Use the equation below to answer the question that follows.

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

19. If 44.8 L of O_2, measured at 273 K and 1 atm, reacts completely with 2.00 mol of CH_4, what volume of CO_2, measured at 273 K and 1 atm, is produced?

    A. 11.2 L
    B. 22.4 L
    C. 44.8 L
    D. 89.6 L

Answer and Rationale

COMPETENCY 014

20. In which of the following compounds is there both covalent and ionic bonding in the solid state?

    A. $MgCl_2$
    B. H_2S
    C. CCl_2H_2
    D. $CaSO_4$

Answer and Rationale

COMPETENCY 015

21. Which of the following is the balanced equation for the displacement reaction of potassium with aluminum nitrate?

    A. $3\ K + Al(NO_3)_3 \rightarrow 3\ KNO_3 + Al$
    B. $K + AlNO_3 \rightarrow KNO_3 + Al$
    C. $3\ K + AlNO_3 \rightarrow K_3N + AlO_3$
    D. $K + AlN \rightarrow KN + Al$

Answer and Rationale

NOTE: After clicking on a link, right click and select “Previous View” to go back to original text.

COMPETENCY 015

Use the equation below to answer the question that follows.

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

22. Which of the following is the equilibrium constant, K_C, for the reaction represented above?

   A. $K_C = \dfrac{[CO_2]}{[C][O_2]}$

   B. $K_C = \dfrac{[C][O_2]}{[CO_2]}$

   C. $K_C = \dfrac{[CO_2]}{[O_2]}$

   D. $K_C = \dfrac{[O_2]}{[CO_2]}$

Answer and Rationale

COMPETENCY 016

23. Which of the following is the molar concentration of KNO_3 in a 4.00 L solution that contains 50.5 g of KNO_3?

   A. 2.00 M
   B. 0.500 M
   C. 0.250 M
   D. 0.125 M

Answer and Rationale

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

COMPETENCY 017

24. If 5.0 mL of 80.0°C water is mixed with 15.0 mL of 20.0°C water in a thermally insulated container, which of the following will be the temperature of the water once thermal equilibrium is reached?

    A. 75°C
    B. 50°C
    C. 35°C
    D. 25°C

Answer and Rationale

COMPETENCY 018

25. The half-life of a radioactive isotope X is 12 hours. Starting with a pure 80.0 g sample of the isotope, how much of the isotope will remain in the sample after 48 hours have elapsed?

    A. 40 g
    B. 20 g
    C. 10 g
    D. 5 g

Answer and Rationale

COMPETENCY 019

26. Which of the following is the oxidation number for Cr in K_2CrO_4?

    A. +1
    B. +4
    C. +6
    D. +8

Answer and Rationale

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

COMPETENCY 020

27. Which of the following is a weak acid?

A. HF
B. HCl
C. HNO_3
D. RbOH

Answer and Rationale

COMPETENCY 020

28. What is the pH of 0.00006 M HNO_3(*aq*)?

A. 4.0
B. 4.2
C. 5.0
D. 6.0

Answer and Rationale

COMPETENCY 021

29. 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 and Rationale

NOTE: After clicking on a link, right click and select “Previous View” to go back to original text.

COMPETENCY 021

30. Which of the following student responses is an example of correct conceptual understanding?

    A. Air has no mass
    B. The Sun is a star
    C. Heavy objects cannot float
    D. The Moon and the Sun are the same size

Answer and Rationale

COMPETENCY 022

31. 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 and Rationale

COMPETENCY 022

32. Giving a short quiz before starting a new unit is most appropriate to help with which of the following?

    A. Planning the major content outcomes for the unit
    B. Discovering what prior knowledge or misconceptions the students may have
    C. Assessing which students will probably learn the most from the upcoming unit
    D. Assessing which students will require more of the teacher's time outside of class

Answer and Rationale

NOTE: After clicking on a link, right click and select "Previous View" to go back to original text.

Answer Key and Rationales

Question Number	Competency Number	Correct Answer	Rationales
1	001	B	**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. Back to Question
2	002	A	**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 is describes a safety practice. **Option D is incorrect** because it is an observation. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
3	003	B	**Option B is correct** because acid and metal ion mine-drainage from abandoned coal mines has a significant impact on many streams in mountainous coal-mining regions. **Option A is incorrect** because although nuclear power plants can contribute to thermal pollution, plants are typically located near rivers or oceans, not in mountain regions near streams. Radioactive emissions are not common and are not the major source of water pollution in mountain streams. **Option C is incorrect** because carbon dioxide emissions can lead to a minor amount of dissolved carbon dioxide (carbonic acid), but the level is not considered significant. **Option D is incorrect** because oil-well drilling is not typically done in areas that could affect streams in mountainous regions. Back to Question
4	003	A	**Option A is correct** because the primary success of the Bohr model was its derivation of the Rydberg formula for the spectral emission lines of hydrogen. **Option B is incorrect** because the Bohr model is not germane to the red shift of light coming from distant stars, which is explained by the Doppler effect. **Option C is incorrect** because the Bohr model is not germane to the spectrum of black-body radiation, which is explained by Planck's radiation formula. **Option D is incorrect** because the Bohr model is not germane to the photoelectric effect, which is explained by Einstein's photoelectric equation. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
5	004	D	**Option D is correct** because it properly recognizes that the horizontal and vertical motions of the ball are independent of each other and then uses the equations of straight-line motion applied to the vertical motion of the ball to calculate the time that elapses before the ball strikes the ground. The kinematical equations of motion give $h = \frac{1}{2}gt^2$. Thus, solving for the time *t* gives $t^2 = \frac{2h}{g}$, or $t = \sqrt{\frac{2h}{g}}$. **Option A is incorrect** because it assumes that $\upsilon_0 = gt$, which is not true. **Option B is incorrect** because it ignores gravity and assumes that the vertical component of the speed is constant and equal in value to υ_0, which is not true. **Option C is incorrect** because it is equal to the vertical component of the speed of the ball just before it strikes the ground and not the time it takes to fall. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
6	004	D	**Option D is correct** because it properly applies the equation for an object in circular motion in Earth's gravitational field to compute the orbital speed. The equation for the orbital speed is $\upsilon^2 = \frac{GM}{R}$, where G is the universal gravitational constant, M is the mass of the Earth, and R is the distance from Earth's center. When the orbital radius is doubled, the orbital speed decreases by a factor of $\frac{1}{\sqrt{2}}$. **Option A is incorrect** because it assumes that the orbital speed is proportional to R, which is not true. **Option B is incorrect** because it assumes that the orbital speed is proportional to $\sqrt{R}$, which is not true. **Option C is incorrect** because it assumes that the orbital speed does not depend on the radius of the orbit, which is not true. Back to Question
7	005	C	**Option C is correct** because it properly assumes that the net force acting on the block is equal to the applied force minus the frictional force, and then it applies Newton's second law of motion to obtain the equation 50 N - f = 10 kg × 2 m/s^2, which, solving for the frictional force f, gives f = 30 N. **Option A is incorrect** because it assumes the frictional force is equal to the weight of the object, or 10 kg × 9.8 m/s^2, which is not true. **Option B is incorrect** because it assumes that the frictional force is equal to the applied force of 50 N. **Option D is incorrect** because it assumes that the frictional force is equal to the mass of the block times its acceleration, or 10 kg × 2 m/s^2, which is not true. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
8	006	B	**Option B is correct** because the period of a simple pendulum is equal to $2\pi\sqrt{\frac{L}{g}}$, where L is the length of the pendulum and g is the acceleration due to gravity, and because $g_{Moon} = \frac{1}{6}g_{Earth}$, the period on the Moon is equal to $\sqrt{6}\,T$, as the following calculation shows: $T_{Moon} = 2\pi\sqrt{\frac{L}{g_{Moon}}} = 2\pi\sqrt{\frac{L}{\frac{1}{6}g_{Earth}}} = 2\pi\sqrt{\frac{6L}{g_{Earth}}} = \sqrt{6} \times 2\pi\sqrt{\frac{L}{g_{Earth}}} = \sqrt{6}\,T$. **Option A is incorrect** because it assumes that the period of a simple pendulum is proportional to $\frac{1}{g}$ instead of $\frac{1}{\sqrt{g}}$, where g is the acceleration due to gravity. **Option C is incorrect** because it assumes that the period of the pendulum is independent of the acceleration due to gravity g. **Option D is incorrect** because it assumes that the period of a simple pendulum is proportional to g instead of $\frac{1}{\sqrt{g}}$, where g is the acceleration due to gravity. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
9	006	C	**Option C is correct** 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. **Option A is incorrect** 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, decreases in magnitude as the distance between the charges increases. **Option B is incorrect** because, according to Coulomb's law, the electrostatic force between two charges is not dependent on the masses of the charges. **Option D is incorrect** because Coulomb's law is not concerned with magnetic forces. Back to Question
10	007	A	**Option A is correct** because Ohm's law gives the equation $P = \frac{V^2}{R}$ for the power P dissipated by a resistor, where R is the resistance of the resistor and V is the voltage across the resistor. Thus, doubling the source voltage quadruples the power dissipated, giving a value of 80 W. **Option B is incorrect** because it assumes that doubling the source voltage doubles the power dissipated, which is not true. **Option C is incorrect** because it assumes that doubling the source voltage has no effect on the power dissipated, which is not true. **Option D is incorrect** because it assumes that doubling the source voltage reduces the power dissipated by a factor of four, which is not true. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
11	008	B	**Option B is correct** because it properly applies the law of conservation of linear momentum to determine that the correct speed of the coupled cars just after the collision is given by the equation $M\upsilon = (M + 4M)\upsilon_{coupled}$, which can be solved to give $\upsilon_{coupled} = \frac{\upsilon}{5}$. It then uses this speed to calculate that the kinetic energy of the coupled cars just after the collision is equal to $\frac{1}{2}(M + 4M)\left(\frac{\upsilon}{5}\right)^2 = \frac{1}{10}M\upsilon^2$. **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 assumes that the kinetic energy is conserved, which is only true of an elastic collision. The coupling indicates that the collision is inelastic. **Option D is incorrect** because it assumes that the speed of the coupled cars is υ, which is not true. Back to Question
12	009	C	**Option C is correct** because the first law of thermodynamics is simply a statement of the law of conservation of energy. **Option A is incorrect** because the ideal gas law is a consequence of the kinetic theory of gases, not of the first law of thermodynamics. **Option B is incorrect** because the uncertainty principle is a consequence of quantum mechanics, not of the first law of thermodynamics. **Option D is incorrect** because the second law of thermodynamics, not the first law, is a statement about the behavior of the entropy of a system. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
13	010	B	**Option B is correct** because, by Snell's law, the light ray will be bent toward the normal to the surface when it passes from air into glass, which means that the angle of refraction is less than the angle of incidence. **Option A is incorrect** because, by Snell's law, the light ray will be bent toward the normal to the surface when it passes from air into glass, which means that the angle of refraction is less than, and not equal to, the angle of incidence. **Option C is incorrect** because, by Snell's law, the light ray will be bent toward the normal to the surface when it passes from air into glass, which means that the angle of refraction is less than the angle of incidence. Because the angle of incidence is equal to the angle of reflection, the angle of refraction is less than, and not equal to, the angle of reflection. **Option D is incorrect** because, by Snell's law, the light ray will be bent toward the normal to the surface when it passes from air into glass, which means that the angle of refraction is less than the angle of incidence. Because the angle of incidence is equal to the angle of reflection, the angle of refraction is less than, and not greater than, the angle of reflection. Back to Question
14	010	C	**Option C is correct** because polarization is a phenomenon exhibited only by transverse waves, such as light, and not by longitudinal waves, such as sound. **Option A is incorrect** because diffraction is a phenomenon exhibited by all waves, including light and sound. **Option B is incorrect** because interference is a phenomenon exhibited by all waves, including light and sound. **Option D is incorrect** because dispersion is a phenomenon exhibited by all waves, including light and sound. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
15	011	B	**Option B is correct** because it properly computes the energy difference as $E_2 - E_1 = -\frac{13.6}{2^2}\text{ eV} + \frac{13.6}{1^2}\text{ eV} = 10.2\text{ eV}$. **Option A is incorrect** because it computes the energy difference with $\frac{1}{n}$ instead of $\frac{1}{n^2}$. **Option C is incorrect** because it simply computes the energy of the first level. **Option D is incorrect** because it makes an error with the algebraic signs of the terms. Back to Question
16	011	D	**Option D is correct** because it properly accounts for the fact that the maximum kinetic energy of the emitted photoelectrons depends directly on the frequency of the incident light and that the electrons must have a minimum energy *W* before they can be emitted from the metal. **Option A is incorrect** because it assumes that the maximum kinetic energy of the emitted photoelectrons is directly proportional to the wavelength of the incident light, which is not true. **Option B is incorrect** because it fails to account for the fact that the electrons must have a minimum energy *W* before they can be emitted from the metal. **Option C is incorrect** because it assumes that the maximum kinetic energy of the emitted photoelectrons is equal to the work function of the metal, which is not true. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
17	012	A	**Option A is correct** because snow (H_2O) changes state from solid to gas, which is a physical change, and no chemical changes occur. **Option B is incorrect** because Fe in the iron nail reacts with O_2 to form FeO_2, which is a chemical change. **Option C is incorrect** because a candlewick reacts with oxygen in the flame, and a combustion reaction occurs, which is a chemical change. **Option D is incorrect** because recharging a lead storage battery involves an electro-chemical reaction. Back to Question
18	012	A	**Option A is correct** because in the periodic table, metallic chemical properties generally increase going down the columns and decrease going across the rows. Cs is in the lower left corner of the periodic table. **Option B is incorrect** because Au is much farther to the right than Cs on the periodic table and is a very unreactive metal. **Option C is incorrect** because Sb is much farther to the right and higher than Cs on the periodic table. Sb is a metalloid. **Option D is incorrect** because Br is much farther to the right and higher than Rb on the periodic table. Br is a nonmetal. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
19	013	B	**Option B is correct** because the volume produced is 22.4 L at 298 K and 1 atm. Because 44.8 L of O_2 contains about 2 mol of O_2, it is the limiting reagent. According to the balanced reaction, 1 mol of CO_2 will be produced if the 2 moles of oxygen are consumed. One mol of gas at this temperature and pressure has a volume of about 22.4 L. **Option A is incorrect** because 11.2 L is half the volume of CO_2 that is produced. **Option C is incorrect** because 44.8 L is twice the volume of CO_2 that is produced. **Option D is incorrect** because 89.6 L is four times the volume of CO_2 that is produced. Back to Question
20	014	D	**Option D is correct** because there is covalent bonding between the S and O atoms that form the polyatomic anion SO_4^-, and there is ionic bonding between the SO_4^- anions and the Ca^{2+} cations in the solid crystal. **Option A is incorrect** because in $MgCl_2$ there is ionic bonding between Mg^{2+}cations and Cl^- anions. **Option B is incorrect** because in H_2S there is covalent bonding between the H and S atoms. **Option C is incorrect** because in CCl_2H_2 there is covalent bonding between the Cl and C atoms and between the H and C atoms. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
21	015	A	**Option A is correct** because the reaction of potassium with aluminum nitrate forms KNO_3 and Al, and the formula for aluminum nitrate is $Al(NO_3)_3$, the formula for potassium nitrate is KNO_3 and the equation is balanced with an equal number of each type of atom on the right and left side of the equation (i.e., three K atoms, one Al atom, three N atoms, and nine O atoms). **Option B is incorrect** because the formula for aluminum nitrate is not correctly represented. **Option C is incorrect** because the incorrect products are formed, and the formula for aluminum nitrate is not correctly represented. **Option D is incorrect** because the incorrect products are formed, and the compound formulas are not correctly represented. Back to Question
22	015	C	**Option C is correct** because the equilibrium constant in terms of concentration K_C is equal to the concentration of each aqueous or gaseous product over the concentration of each aqueous or gaseous reactant, with each raised to the power that is equal to the coefficient of that component in the balanced equation. Because C(*s*) is a solid, it does not appear in the expression. And because the coefficient for the gaseous product CO_2 and the gaseous reactant O_2 are both 1, they are each raised to the power of one. **Option A is incorrect** because [C] should not be included. **Option B is incorrect** because [C] should not be included; the reactant is in the numerator, and the product is in the denominator. **Option D is incorrect** because the reactant is in the numerator and the product is in the denominator. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
23	016	D	**Option D is correct** because the concentration of KNO_3 is 0.125 M, which is calculated as follows: $[KNO_3] = \frac{50.5\text{ g}}{4.00\text{ L}} \times \frac{1\text{ mol }KNO_3}{101\text{ g }KNO_3} = 0.125\text{ M}$. **Option A is incorrect** because 2.00 M is sixteen times more concentrated than the correct concentration. **Option B is incorrect** because 0.500 M is four times more concentrated than the correct concentration. **Option C is incorrect** because 0.250 M is two times more concentrated than the correct concentration. Back to Question
24	017	C	**Option C is correct** because the temperature of the mixture is 35°C at thermal equilibrium, calculated as follows: The warmer water loses the amount of heat that the cooler water gains: $\Delta \text{Heat}_{(80^\circ)} = -\Delta \text{Heat}_{(20^\circ)}$. Thus, $5\text{ mL} \times (80 - T) = -15\text{ mL} \times (20 - T)$. And solving for T gives T = 35°C. **Option A is incorrect** because 75°C is much too warm considering that much less of the warmer water was added. **Option B is incorrect** because 50°C is too warm considering that it is not reasonable that the final temperature would be halfway between the two original temperatures because the volumes of water mixed were not equal. **Option D is incorrect** because it is too low, based on the correct calculations, although, as a guess, it is more likely than A or B. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
25	018	D	**Option D is correct** because the amount remaining is 5 g. 48 hours is four half-lives. After 12 hours (one half-life), half of the original X atoms will have decayed into another isotope, leaving 40 g of the X atoms. Then after another 12 hours, half of the 40 g of X will have decayed, leaving 20 g of X. Then after another 12 hours, half of the 20 g of X will have decayed, leaving 10 g of X. Then after another 12 hours, half of the 10 g of X will have decayed, leaving 5 g of isotope X. **Option A is incorrect** because 40 g of isotope X would remain after 12 hours. **Option B is incorrect** because 20 g of isotope X would remain after 24 hours. **Option C is incorrect** because 10 g of isotope X would remain after 36 hours. Back to Question
26	019	C	**Option C is correct** because in K_2CrO_4, the oxidation number for K is +1 and the oxidation number for O is -2. Because the net charge on the compound is zero, then (oxidation number of Cr) + 2(+1) +4(−2) = 0. Hence, the oxidation number of Cr is +6. **Option A is incorrect** because if the oxidation number was +1 for Cr, then the compound would have a net charge of −5. But the compound has a net charge of zero. **Option B is incorrect** because if the oxidation number was +4 for Cr, then the compound would have a net charge of −2. But the compound has a net charge of zero. **Option D is incorrect** because if the oxidation number was +8 for Cr, then the compound would have a net charge of +2. But the compound has a net charge of zero. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
27	020	A	**Option A is correct** because HF is a weak acid that only partially dissociates in water with $K_a = 6 \times 10^{-4}$. **Option B is incorrect** because HCl is a strong acid that dissociates almost completely in water. **Option C is incorrect** because HNO_3 is a strong acid that dissociates almost completely in water. **Option D is incorrect** because RbOH is a base, not an acid. Back to Question
28	020	B	**Option B is correct** because pH = 4.2. The pH = $-\log[H^+]$. The concentration 0.00006 M can be expressed as 6×10^{-5} M. Hence, $\text{pH} = -\log(6 \times 10^{-5}) = -\log(6) - \log(10^{-5}) = -0.8 - (-5) = 4.2$. **Option A is incorrect** because pH = 4.0 is the pH of 1×10^{-4} M $HNO_3(aq)$. **Option C is incorrect** because pH = 5.0 is the pH of 1×10^{-5} M $HNO_3(aq)$. **Option D is incorrect** because pH = 6.0 is the pH of 1×10^{-6} M $HNO_3(aq)$. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
29	021	C	**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. Back to Question
30	021	B	**Option B is correct** because the Sun is a star. **Option A is incorrect** because air does have mass. **Option C is incorrect** because heavy objects can float. **Option D is incorrect** because the Sun is much larger than the Moon. Back to Question

Question Number	Competency Number	Correct Answer	Rationales
31	022	A	**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. Back to Question
32	022	B	**Option B is correct** because a brief quiz can reveal the areas of prior knowledge as well as any misconceptions the students may have that should be addressed during the unit. **Option A is incorrect** because planning the major content outcomes should have already been done. **Option C is incorrect** because a short quiz cannot predict which students will learn the most from the unit. **Option D is incorrect** because a short quiz is not adequate to assess how much help various students will need outside of class. Back to Question

Study Plan Sheet

STUDY PLAN						
Content covered on test	**How well do I know the content?**	**What material do I have for studying this content?**	**What material do I need for studying this content?**	**Where can I find the materials I need?**	**Dates planned for study of content**	**Date Completed**

Preparation Resources

The resources listed below may help you prepare for the TExES test in this field. These preparation resources have been identified by content experts in the field to provide up-to-date information that relates to the field in general. You may wish to use current issues or editions to obtain information on specific topics for study and review.

JOURNALS

American Scientist, Sigma XI, the Scientific Research Society.

ChemMatters, American Chemical Society.

Nature, The Nature Publishing Group.

Texas Science Teacher, Science Teachers Association of Texas.

The Physics Teacher, American Association of Physics Teachers.

The Science Teacher, National Science Teachers Association.

OTHER RESOURCES

Arons, A. B. (1997). *Teaching Introductory Physics*. Wiley.

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Zumdahl, S. S., and Zumdahl, S. A. (2013). *Chemistry*, Ninth Edition. Brooks Cole.

Online Resources

American Association for the Advancement of Science — www.aaas.org

American Association of Physics Teachers — www.aapt.org

American Chemical Society — www.acs.org

American Physical Society — www.aps.org

National Science Teachers Association — www.nsta.org