

## Middle School Science (0439)

### Test at a Glance

Test Name	Middle School Science		
Test Code	0439		
Time	2 hours		
Number of Questions	90 Multiple-choice questions (Part A); 3 constructed-response questions (short-answer essay) (Part B)		
Format	90 Multiple-choice and 3 short constructed-response questions		
Weighting	Multiple-choice: 75% of total score Short constructed-response: 25% of total score		
	Content Categories	Approximate Number of Questions	Approximate Percentage of Examination
	I. Scientific Methodology, Techniques, and History	9	8%
	II. Basic Principles	14	11%
	III. Physical Sciences	22	18%
	IV. Life Sciences	18	15%
	V. Earth/Space Sciences	18	15%
	VI. Science, Technology, and Society	9	8%
	VII. Short Content Essays	3	25%
	<ol style="list-style-type: none"> <li>1. Physical Sciences</li> <li>2. Life Sciences</li> <li>3. Earth/Space Sciences</li> </ol>		
Pacing and Special Tips	In allocating time on this assessment, it is expected that about 90 minutes will be spent on the multiple-choice section and about 30 minutes will be spent on the constructed-response section; the sections are not independently timed.		

## About This Test

The Middle School Science test is designed to measure the knowledge and competencies necessary for a beginning teacher of middle school science, such as a knowledge of scientific principles, facts, methodology, philosophy, scientific concepts, and an ability to integrate basic knowledge from all of the sciences. Teachers need to understand the subject matter from a more advanced viewpoint than is actually presented to the students. Accordingly, some questions of a more advanced nature are included. These questions deal with topics typically introduced in freshman college-level courses in chemistry, physics, life sciences, and earth/space sciences. The questions require a variety of abilities, including definition of terms, comprehension of critical concepts, application, and analysis, to address and solve problems. Some questions may require the examinee to integrate concepts from more than one content area.

This test may contain some questions that will not count toward your score.

The test contains three equally weighted constructed-response questions that assess the examinee's ability to use and analyze critical concepts in science and to integrate knowledge from science, technology, and society. One question deals with a topic in the physical sciences (chemistry/physics), the second with a topic in the life sciences, and the third with a topic in the earth/space sciences. One question will assess an examinee's understanding of concepts and models; the second will assess skills in data analysis, experimental design, and investigations; and the third will assess understanding of the patterns and processes that occur in natural systems. In addition, one of the questions will contain a component that assesses the ability to deal with issues concerning science, technology, and society.

## Topics Covered

Representative descriptions of topics covered in each category are provided below.

### I. Scientific Methodology, Techniques, and History

#### A. Methodology and Philosophy

- Demonstrate understanding of scientific methods of problem solving
- Distinguish among scientific facts, models, theories and laws
- Use science process skills in experiments and investigations, and to solve problems
- Demonstrate understanding of experimental design
- Demonstrate knowledge of the historical roots of science
- Demonstrate understanding of the unified, integrative nature of the various disciplines and concepts in science

#### B. Mathematics, Measurement, and Data Manipulation

- Demonstrate understanding of scientific measurement and notation systems
- Demonstrate understanding of processes involved in scientific data collection, manipulation, interpretation, and presentation
- Interpret and draw conclusions from data, including those presented in tables, graphs, maps, and charts
- Identify and demonstrate an understanding of sources of error in data that is presented

#### C. Laboratory Procedures and Safety

- Demonstrate understanding of procedures for safe preparation, storage, use, and disposal of laboratory and field materials
- Identify laboratory and field equipment appropriate for scientific procedures
- Demonstrate knowledge of safety and emergency procedures for the science classroom and laboratory

## II. Basic Principles

### A. Matter and Energy

- Demonstrate understanding of the structure and properties of matter
- Demonstrate understanding of the factors that influence the occurrence and abundance of the elements
- Distinguish between physical and chemical changes of matter
- Demonstrate understanding of the conservation of mass/energy
- Demonstrate understanding of energy transformations

### B. Heat and Thermodynamics

- Distinguish between heat and temperature
- Demonstrate understanding of measurement, transfer, and effects of thermal energy on matter
- Solve quantitative problems dealing with the measurement and transfer of thermal energy
- Demonstrate understanding of the First and Second Laws of thermodynamics

### C. Atomic and Nuclear Structure

- Demonstrate understanding of atomic models and their experimental bases
- Demonstrate understanding of atomic and nuclear structure and forces
- Relate electron configuration to the chemical and physical properties of an atom
- Demonstrate knowledge of characteristics of radioisotopes and radioactivity (for example, half-life)
- Identify products of nuclear reactions

## III. Physical Sciences

### A. Physics

#### 1. Mechanics

- Demonstrate understanding of (the variables involved in) straight line motion, projectile motion, circular motion, and periodic motion
- Demonstrate understanding of Newton's laws of motion
- Distinguish between weight and mass
- Demonstrate understanding of friction
- Distinguish among work, energy, and power

- Demonstrate understanding of simple machines and torque

- Demonstrate understanding of linear momentum
- Demonstrate understanding of the conservation of energy and the conservation of linear momentum
- Demonstrate understanding of angular momentum and torque and angular momentum conservation
- Demonstrate understanding of the force of gravity
- Demonstrate understanding of pressure and Pascal's principle for fluids
- Demonstrate understanding of Archimedes' principle (buoyancy)
- Demonstrate understanding of Bernoulli's principle for fluids

#### 2. Electricity and Magnetism

- Demonstrate understanding of the repulsion and attraction of electric charges
- Demonstrate understanding of the characteristics of current electricity and simple circuits (for example, resistance and Ohm's law, electromotive force, potential difference capacitance, current)
- Compare and contrast series and parallel circuits
- Compare and contrast conductors and insulators
- Apply Ohm's law to series and parallel circuits
- Compare and contrast direct current and alternating current
- Identify sources of EMF (for example, batteries, photo cells, generators)
- Demonstrate understanding of magnets, magnetic fields, and magnetic forces
- Demonstrate understanding of how transformers and motors work

#### 3. Waves

- Define and use the terms speed, amplitude, wavelength, and frequency
- Distinguish between the characteristics of transverse and longitudinal waves
- Demonstrate understanding of reflection, refraction, dispersion, absorption, transmission, scattering, and superposition
- Demonstrate understanding of diffraction and interference
- Demonstrate understanding of the Doppler Effect
- Demonstrate understanding of polarization

- Recognize the characteristics of sound waves (for example, pitch, loudness, speed)
  - Demonstrate understanding of how sound waves are produced by the vibrations of air columns and strings
  - Characterize the electromagnetic spectrum (gamma rays to radio waves)
  - Demonstrate understanding of color and the visible spectrum (for example, addition and subtraction, relationship to wave frequency)
  - Demonstrate understanding of geometric optics (mirrors, lenses, prisms, fiber optics) and of polarization
- B. Chemistry
1. Periodicity
- Demonstrate understanding of the meaning of chemical periodicity
  - Demonstrate understanding of periodic trends in chemical and physical properties
2. The Mole and Chemical Bonding
- Demonstrate understanding of the mole concept and chemical composition
  - Interpret and use chemical formulas
  - Demonstrate understanding of the systematic nomenclature of inorganic compounds
  - Demonstrate understanding of the nomenclature of simple organic compounds
  - Identify the various types of bonds
  - Interpret electron dot and structural formulas
3. The Kinetic Theory and States of Matter
- Demonstrate understanding of kinetic molecular theory
  - Demonstrate understanding of phase changes
  - Demonstrate understanding of the relationships among temperature, pressure, volume, and number of molecules of a gas
  - Demonstrate understanding of the characteristics of crystals
4. Chemical Reactions
- Demonstrate ability to balance chemical equations
  - Identify the various types of chemical reactions
  - Distinguish between endothermic and exothermic chemical reactions

- Demonstrate understanding of the effects of temperature, pressure, concentration, and the presence of catalysts on chemical reactions
  - Demonstrate understanding of practical applications of electrochemistry
5. Solutions and Solubility
- Demonstrate understanding of solution terminology and distinguish among types of solutions
  - Demonstrate understanding of various types of solvents and factors affecting the dissolving process
  - Demonstrate understanding of the effect of temperature and pressure on the solubility of a solute
  - Demonstrate understanding of the physical and chemical properties of acids, bases, and salts
  - Demonstrate knowledge of the meaning of pH and the effects of buffers

#### IV. Life Sciences

- A. The Cell
- Demonstrate knowledge of the structure and function of organelles, including membranes
  - Distinguish between prokaryotic and eukaryotic cells
  - Demonstrate understanding of the cell cycle and cytokinesis
  - Demonstrate understanding of chemical reactions in respiration and photosynthesis
  - Demonstrate understanding of mitosis and meiosis
- B. Genetics
- Demonstrate understanding of DNA replication
  - Demonstrate understanding of the processes involved in protein synthesis
  - Demonstrate understanding of the causes and results of mutation
  - Demonstrate understanding of Mendelian inheritance (monohybrid and dihybrid crosses)
  - Demonstrate understanding of some aspects of non-Mendelian inheritance (for example, multiple alleles, multiple genes)
  - Demonstrate knowledge of how recombinant DNA is constructed
  - Identify uses of recombinant DNA (for example, in the production of insulin)

- Demonstrate understanding of the interaction between heredity and environment
  - Identify chromosomal and gene aberrations that lead to common human genetic disorders (for example, Down syndrome)
- C. Evolution
- Identify evidence that supports the theory of evolution
  - Demonstrate understanding of the mechanisms of evolution
  - Demonstrate knowledge of isolating mechanisms and speciation
  - Demonstrate understanding of the scientific hypotheses for the origin of life on Earth
- D. Diversity of Life
- Demonstrate understanding of the levels of organization and characteristics of life
  - Identify the elements of the hierarchical classification scheme into kingdom, phylum, class, order, family, genus, and species
  - Demonstrate knowledge of the characteristics of viruses, bacteria, protists, fungi, plants, and animals
- E. Plants
- Demonstrate understanding of the characteristics of vascular and nonvascular plants
  - Demonstrate understanding of the structure and function of roots, stems, and leaves
  - Demonstrate understanding of control mechanisms (for example, hormones, photoperiods, and tropisms)
  - Demonstrate understanding of water and nutrient uptake and transport systems
  - Demonstrate understanding of sexual and asexual reproduction in plants
- F. Animals
- Demonstrate understanding of the anatomy and physiology of structures associated with life functions of organisms in the animal kingdom: digestion; circulation; respiration; excretion; nervous control; musculo-skeletal system; immunity; the endocrine system; reproduction and development
  - Demonstrate knowledge of homeostasis and how it is maintained
  - Demonstrate knowledge of how animals respond to stimuli
- G. Ecology
- Demonstrate understanding of population dynamics
  - Demonstrate knowledge of social behaviors (for example, territoriality, dominance, altruism, threat display)
  - Demonstrate understanding of intraspecific competition
  - Demonstrate understanding of interspecific relationships (for example, commensalism, mutualism, parasitism)
  - Demonstrate understanding of succession
  - Demonstrate understanding of the concepts of stability of ecosystems and the effects of disturbances
  - Demonstrate understanding of energy flow (for example, trophic levels and food webs)
  - Demonstrate understanding of biogeochemical cycles (for example, nitrogen, carbon, water)
  - Identify the types and characteristics of biomes
- V. Earth/Space Sciences**
- A. Physical Geology
- Demonstrate understanding of the processes of mineral and rock formation
  - Demonstrate understanding of the methods used to identify and classify different types of minerals, rocks, and soils
  - Demonstrate knowledge of the structure of Earth and the physical characteristics of Earth's various layers
  - Demonstrate understanding of the internal processes and resulting features of Earth, including folding, faulting, earthquakes, and volcanoes
  - Demonstrate understanding of plate tectonic theory and the evidence that supports this theory
  - Demonstrate understanding of the hydrologic cycle and the processes by which water moves through the cycle
  - Demonstrate understanding of the processes of weathering, erosion, and deposition
- B. Historical Geology
- Demonstrate understanding of the principle of uniformitarianism

- Demonstrate understanding of the basic principles of stratigraphy
  - Distinguish between relative and absolute time
  - Recognize the processes involved in the formation of fossils
  - Demonstrate understanding of the types of information fossils provide
  - Demonstrate understanding of the geologic time scale and how it was developed
  - Outline the sequence of important events in the Earth's history
- C. Oceanography
- Demonstrate understanding of the geographic location of oceans and seas
  - Demonstrate understanding of the processes involved in the formation and movement of ocean waves
  - Demonstrate understanding of the primary causes and factors that influence tides
  - Demonstrate knowledge of the major surface and deep-water currents in the oceans and the causes of these currents
  - Demonstrate understanding of the processes that influence the topography and landforms of the ocean floor and shorelines
  - Demonstrate understanding of the factors that influence the physical and chemical properties of seawater and nutrient cycles of the ocean
- D. Meteorology
- Demonstrate knowledge of the structure of the atmosphere and thermal and chemical properties of atmospheric layers
  - Demonstrate knowledge of the chemical composition of the atmosphere
  - Demonstrate understanding of the factors influencing seasonal and latitudinal variation of solar radiation
  - Demonstrate understanding of the causes of global wind belts
  - Identify the factors that contribute to small-scale atmospheric circulation
  - Distinguish among the terms relative humidity, absolute humidity, dew point, and frost point
  - Demonstrate knowledge of various cloud and precipitation types and their formation
  - Characterize major types of air masses in terms of temperature, moisture content, and source areas
  - Demonstrate understanding of high- and low-pressure systems
  - Demonstrate understanding of the structure and movement of frontal systems (cold, warm, stationary, occluded) and the air circulation around and weather associated with frontal systems
  - Interpret information on weather maps
  - Demonstrate understanding of the analyses needed to perform short-term weather forecasting and recognize some of the methods used to perform long-term weather forecasting
  - Demonstrate understanding of the regional and local natural factors that affect climate
  - Demonstrate understanding of how humans affect and are affected by climate (for example, desertification, greenhouse effect, volcanic ash effect, El Niño)
- E. Astronomy
- Demonstrate knowledge of the major theories of origin and structure of the universe
  - Define and use large units of distance (for example, astronomical unit light-year, parsec)
  - Demonstrate understanding of the origin and life cycle of stars
  - Demonstrate understanding of the major theories involving the origin of the solar system
  - Identify the major features and characteristics of the Sun and the source of the Sun's energy
  - Identify the components of the solar system and characterize the physical features and movements of the planets, asteroids, comets, and other solar system components
  - Demonstrate understanding of the geometry of the Earth-Moon-Sun system and the causes of lunar and solar eclipses
  - Demonstrate understanding of the causes of moon phases
  - Demonstrate understanding of the causes of Earth's seasons
  - Demonstrate knowledge of how units of time (for example, year, day, hour) are based on Earth's motions
  - Demonstrate understanding of time zones on Earth

- Demonstrate understanding of geosynchronous orbits and recognize how satellites have contributed to science and technology
- Recognize the contributions of manned and unmanned space missions and the present limitations of space exploration
- Recognize the scientific contributions of remote sensing

## VI. Science, Technology, and Society

- Demonstrate understanding of the uses and applications of science and technology in daily life (e.g., production, transmission, and use of energy; production, storage, use, management, and disposal of consumer products; management of natural resources; nutrition and public health issues, agricultural practices, etc.)
- Demonstrate understanding of the social, political, ethical, and economic issues arising from the use of certain technologies (e.g., cloning, prolonging life, prenatal testing, etc.) and the impact of science and technology on the environment and human affairs

### B. Data Analysis, Experimental Design, and Investigations (1 QUESTION)

This question assesses one or more of the following competencies:

- Analyze and interpret data obtained from an experiment or investigation, including graphical data
- Design an experiment or investigation that tests a simple hypothesis
- Describe a laboratory or field demonstration that would illustrate a fundamental scientific concept

### C. Systems: Patterns and Processes (1 QUESTION)

This question assesses the following competency:

- Analyze relationships among the interacting parts of a natural system
- Identify and explain the processes that follow patterns and cycles in natural systems

In addition, one of the three questions will contain a component that requires an understanding of the scientific concepts and principles involved in the interrelationships among science, technology, and society.

## VII. Short Content Essays

This part of the test contains three constructed-response questions. In each edition of the test one question will deal with a topic in each of the following content areas: Physical Sciences (Chemistry/Physics), Life Sciences, and Earth/Space Sciences. A description of the topics in these content areas can be found in the description of the multiple choice section of the test.

In addition, the questions will assess each of the following skills:

### A. Concepts and Models (1 QUESTION)

This question assesses one or more of the following competencies:

- Formulate scientific concepts correctly and identify and correct improperly formulated concepts
- Use models (defined as ideas or constructs created as tentative descriptions of structures or processes in nature) to communicate concepts and to explain natural phenomena

## Sample Test Questions

The sample questions that follow illustrate the types of questions in the test. They are not, however, representative of the entire scope of the test in either content or difficulty. Answers with explanations follow the questions.

**Directions:** Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case.



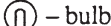
- According to some scientists, the Earth's average surface temperature is rising as a result of the greenhouse effect. An increase in the atmospheric concentration of which of the following gases is considered to be primarily responsible?
  - Nitrogen
  - Oxygen
  - Sulfur dioxide
  - Carbon dioxide
- Finding that a solution conducts an electric current shows conclusively that the solution
  - has a high boiling point
  - contains molecules
  - is a good oxidizing agent
  - contains ions
- Boron atom, atomic number 5, atomic mass 13
  - Carbon atom, atomic number 6, atomic mass 11
  - Carbon atom, atomic number 6, atomic mass 12
  - Nitrogen atom, atomic number 7, atomic mass 13

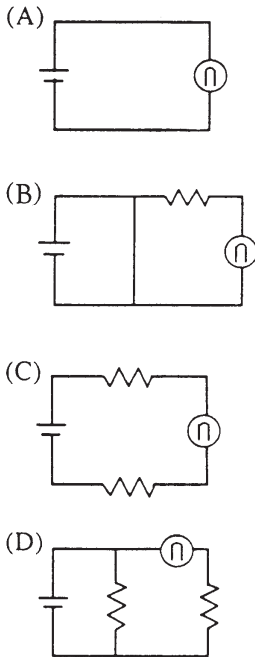
Consider the atoms described above. Which of the following are isotopes of each other?

  - I and IV only
  - II and III only
  - II and IV only
  - III and IV only
- Some substances have no noticeable odor because these substances
  - are soluble in water
  - cannot lose the heat that must be lost before an odor can be detected
  - have relatively few molecules escaping into the air
  - do not have molecules with one of the two molecular arrangements required to give an odor
- Several vehicles, initially at a complete stop, begin a long race at the same starting point. The vehicle that has a constant value for which of the following is most likely to win?
  - Linear speed
  - Linear velocity
  - Linear acceleration
  - Momentum
- Which of the following statements is true of hurricanes but not of tornadoes?
  - They form only over warm oceans.
  - They have very high winds.
  - They may cause great property damage.
  - They may cause human fatalities.
- The agent most widely and most consistently at work changing the appearance of the Earth's surface is
  - fire
  - volcanism
  - water
  - wind
- A gelatinous sample of material from a previously unexplored marine environment is thought to be living or to be composed of recently living material. Which of the following would most clearly confirm that the material has a biological origin?
  - The presence of cells in the sample
  - The presence of hydrogen in the sample
  - Diffusion of material out of the sample
  - Movement of the sample

9. Which of the following is most directly involved with controlling levels of sugar in blood?
- (A) Hemoglobin
  - (B) Calcitonin
  - (C) Thyroid-stimulating hormone
  - (D) Insulin

10. In which of the following is the battery short-circuited?

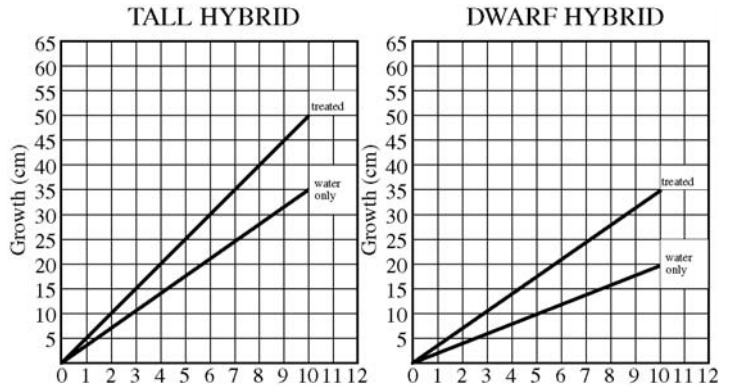
 - battery     - resistance     - bulb



11. A piece of paper that appears blue in sunlight is illuminated solely by a red light that is passed through a green filter. What color does the paper appear under this illumination?
- (A) Blue
  - (B) Green
  - (C) Red
  - (D) Black

12. What quantity of oxygen,  $O_2$ , contains very nearly the same number of molecules as 36.0 grams of water,  $H_2O$ ?
- (A) 64.0 grams
  - (B) 32.0 grams
  - (C) 16.0 grams
  - (D) 8.0 grams

In an experiment to study the effect of a new fertilizer on the growth of tall hybrid corn and dwarf hybrid corn, from immediately after germination to ten days of growth, the data below were obtained. Other growing conditions such as water and sunlight were the same for both groups.



13. Which of the following is the most reasonable conclusion that can be drawn from the data above?
- (A) The new fertilizer influences the growth of both corn varieties tested.
  - (B) The new fertilizer causes faster growth rate for both varieties than do other fertilizers.
  - (C) The new fertilizer improves the root system of the tall hybrid to a greater extent than it does that of the dwarf hybrid.
  - (D) The new fertilizer is effective in producing faster growth for both varieties for the first ten days only.
14. The Earth's seasons can be attributed primarily to which of the following in conjunction with its revolution about the Sun?
- (A) The tilt of the Earth's axis of rotation relative to the ecliptic
  - (B) The varying amount of sunspot activity
  - (C) The Earth's orbit about the Sun as an ellipse rather than a circle
  - (D) The rotation of the Earth during a 24-hour day

## Answers

1. The correct answer is (D). Although there are additional gases such as methane and water vapor that are considered to be greenhouse gases, carbon dioxide accounts for the largest percentage of the annual human-caused input of these gases.
2. The correct answer is (D). Substances whose water solutions conduct an electric current are called electrolytes. Electrolytes, when in solution, break down into smaller particles called ions.
3. The correct answer is (B). Isotopes are atoms of the same element that have different atomic masses. In order to be the same element, they must have the same number of protons. Therefore, they must possess different numbers of neutrons if they are isotopes.
4. The correct answer is (C). In order for us to smell a particular substance, it must enter the nasal cavity via the air. In addition, it must be sufficiently soluble in water to dissolve in the fluid coating of the cells lining the nasal cavity.
5. The correct answer is (C). The car having a constant value for linear acceleration would constantly increase its speed over time. Therefore, a car that constantly accelerated would cover a given distance in the shortest time and most likely win a race against cars with constant values for the other parameters listed.
6. The correct answer is (A). The other options are true of both tornadoes and hurricanes. However, hurricanes require warm ocean surface waters in order to develop, and it is from these warm waters and the release of latent heat that they derive their energy. Tornadoes are associated with thunderstorms, form over land, and are most likely to occur when large differences in temperature and moisture exist between two air masses and the boundary between the air masses is sharp.
7. The correct answer is (C). While the agents given in the other options do influence and change the appearance of Earth's surface, water is constantly acting upon terrestrial features in the form of precipitation, glaciers, streams, rivers, and oceans. Therefore, it contributes to the chemical and mechanical weathering of the land surface in most parts of the globe.
8. The correct answer is (A). According to the cell theory, the basic biological unit of structure and function is the cell, and cells come from other cells. Although the other options could be found in living material or material of biological origin, they are not unique to it and would not clearly confirm that the sample was biological in nature.
9. The correct answer is (D). In response to rising levels of glucose in the blood, cells in the pancreas secrete the hormone insulin. Circulating insulin lowers blood sugar levels by enhancing the transport of glucose and other simple sugars into body cells, especially muscle cells.
10. The correct answer is (B). In this diagram the path of the circuit is such that current will be diverted from passing through the resistor and the bulb. When the part of a circuit with the most resistance is bypassed, and all of the current flows through the part with zero (negligible) resistance, a short circuit is said to exist.
11. The correct answer is D. The green filter absorbs all colors except green, which it passes. Therefore, the red light will be absorbed by the filter, which will pass no light. The paper will not be illuminated, and so it will appear black, regardless of its initial color.
12. The correct answer is A. 36 grams of water is 2 moles ( $2 \times 18.0$  grams). A 2-mole sample of  $O_2$  contains the same number of molecules as does 2 moles of any other substance. A 2-mole sample of  $O_2$  would have a mass of  $2 \times 32.0$  grams = 64.0 grams.
13. The correct answer is A. Both graphs indicate more rapid growth for the treated samples than for the untreated samples. The other options describe results not tested in the experiments and so not indicated by the data.
14. The correct answer is A. Seasons are best explained as resulting from the Earth's axial tilt and not from distance variations, sunspot activity, atmospheric transparency, or rotation.

*This section presents sample questions and constructed-response samples along with the standards used in scoring the responses. When you read these sample responses, keep in mind that they will be less polished than if they had been developed at home, edited, and carefully presented. Examinees do not know what questions will be asked and must decide, on the spot, how to respond. Readers take these circumstances into account when scoring the responses.*

*Readers will assign scores based on the following scoring guide.*

## Scoring Guide

**3**

- Demonstrates a thorough understanding of the most significant parts of any stimulus material presented
- Responds appropriately to all parts of the question
- Where required, provides a strong explanation that is well supported by relevant evidence
- Demonstrates a strong knowledge of concepts, theories, facts, procedures or methodologies relevant to the question

**2**

- Demonstrates basic understanding of the most significant aspects of any stimulus material presented
- Responds appropriately to most aspects of the question
- Where required, provides an explanation that is sufficiently supported by relevant evidence
- Demonstrates a sufficient knowledge of concepts, theories, facts, procedures, or methodologies relevant to the question

**1**

- Demonstrates misunderstanding of significant aspects of any stimulus material presented
- Fails to respond appropriately to most parts of the question
- Where required, provides a weak explanation that is not well supported by relevant evidence
- Demonstrates a weak knowledge of concepts, theories, facts, procedures, or methodologies relevant to the question

**0**

- Blank, off-topic, or totally incorrect response; rephrases the question

## Sample Question 1

A 4-liter, thin-metal can with its screw-top lid removed contains 100 milliliters of water. It is heated until the water boils. The can is then removed from the heat and its lid firmly replaced. Describe what will happen to the can as it cools and why.

### Sample Response That Received a Score of 3:

The sides of the can will start to collapse inward until the point of equilibrium is reached between the pressure inside the can, the pressure outside the can, and the strength of the can's walls.

This is caused by the liquid water being heated enough to turn to vapor. This vapor then displaces the air molecules inside. When the can is taken off of the heat source, the vapor then condenses back into liquid, and because the lid was airtight, this creates a lower pressure inside the can than outside, since there are less air molecules in the same space. Thus the can collapses until the pressure inside the can equals that outside.

### Sample Response That Received a Score of 1:

When the water in the can starts to boil, air escapes and water evaporates. Not much, because you'll remove it immediately and cover with the lid. As the can starts to cool, the can will produce sweat drops on the outside of the can. Being a thin metal can and tightly covered with a lid, the can will slowly alter. The sides will recede and pull inward as the cooling continues.

## Sample Question 2

- (A) Given five different hand-sized samples of unidentified minerals, discuss how you would determine their order of relative hardness.
- (B) Describe, in terms of their relative hardness, how the shapes of these minerals would be affected over time in a fast-moving stream or river.

### Sample Response That Received a Score of 3:

Geologists determine the hardness of various minerals by using Mohs hardness scale. Using the scale, you compare the hardness of the minerals you are trying to identify to the ones in Mohs scale. Talc, for example, is classified as a "1." If the mineral you are looking at scratches the talc, it has a hardness that is greater than "1" and you would try the next hardest mineral, which is gypsum, and so on, until you found the correct hardness. (Neither mineral would scratch the other one.)

Minerals that have a hardness of 1, such as talc, would be worn down very quickly by a fast-moving stream or river. Softer minerals would therefore be broken down, while harder minerals would be rounded and smoothed. The hardest minerals, such as diamond would not be affected as much over periods of time. It would take a very long time for rough edges to be worn down.

### Sample Response That Received a Score of 1:

You would observe the surface of these rocks and look for fractures and cracks, then you would chip off pieces with a hammer and determine the amount of force it takes to break each one. Softer rocks would break up easily on the bed of a stream, and it would take a relatively short amount of time. Harder rocks would not break but they would be worn smooth by rolling along the bottom between the current and the streambed.



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