ETS PRAXIS

The *PRAXIS*® Study Companion

General Science (5436)

ETS Professional Educator PROGRAMS

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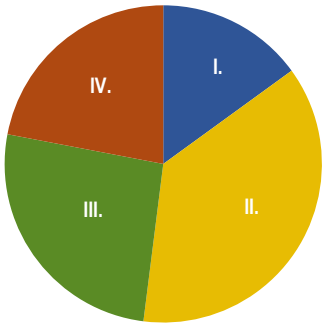
General Science (5436)

Test at a Glance

The *Praxis*® General Science test is designed to measure knowledge and competencies important for safe and effective beginning practice as a teacher of general science. Test takers have typically completed a bachelor's degree program with appropriate coursework in general science and education.

<table>
<tr><td>Test Name</td><td colspan="3">General Science</td></tr>
<tr><td>Test Code</td><td colspan="3">5436</td></tr>
<tr><td>Time</td><td colspan="3">2 hours 30 minutes</td></tr>
<tr><td>Number of Questions</td><td colspan="3">135 selected-response questions</td></tr>
<tr><td>Format</td><td colspan="3">The test consists of a variety of selected-response questions, where you select one or more answer choices, and other types of questions. You can review the possible question types in "Understanding Question Types."</td></tr>
<tr><td>Test Delivery</td><td colspan="3">Computer Delivered</td></tr>
<tr><td rowspan="6"> 
</td><td>Content Categories</td><td>Approximate Number of Questions</td><td>Approximate Percentage of Examination</td></tr>
<tr><td>I. Nature and Impact of Science and Engineering</td><td>20</td><td>15%</td></tr>
<tr><td>II. Physical Science</td><td>50</td><td>37%</td></tr>
<tr><td>III. Life Science</td><td>35</td><td>26%</td></tr>
<tr><td>IV. Earth and Space Science</td><td>30</td><td>22%</td></tr>
<tr><td colspan="3">Half or more of the questions integrate a Science and Engineering Practice, and approximately one-quarter to one-third of the questions assess content applied to a Task of Teaching of Science.</td></tr>
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About The Test

The content topics for the General Science test span the general science curriculum, including content related to (I) Nature and Impact of Science and Engineering, (II) Physical Science, (III) Life Science, and (IV) Earth and Space Science.

The assessment is designed and developed through work with practicing general science teachers, teacher educators, and higher education content specialists to reflect the science knowledge teachers need to teach the general science curriculum and to reflect state and national standards, including the National Science Teaching Association Preparation Standards for general science. Content and practices measured reflect the Disciplinary Core Ideas (DCIs) and Science and Engineering Practices (SEPs) established by the National Research Council in A Framework for K-12 Science Education and included in the Next Generation Science Standards.

The 135 selected-response questions measure concepts, terms, phenomena, methods, applications, data analysis, and problem solving in science. A full list of the topics covered is provided in **Content Topics**.

Test takers will not need to use calculators in taking this test. The periodic table of the elements is available as a Help screen, along with a table of information that presents various physical constants and a few conversion factors among SI units. Whenever necessary, additional values of physical constants are included with the text of a question.

Test takers can expect half of the questions on the test to integrate general science content knowledge with one or more of the SEPs, listed under **Science and Engineering Practices**.

Test takers will also find that approximately one-quarter to one-third of the questions call for application of general science content and processes within a teaching scenario or an instructional task. Such questions—designed to measure applications of general science knowledge to the kinds of decisions and evaluations a teacher must make during work with students, curriculum, and instruction—situate general science content questions in tasks critical for teaching. Below, in **Tasks of Teaching Science**, is a list of tasks that are a routine part of general science instruction. These tasks, identified based on research on science instruction, have been confirmed by a national committee of teachers and teacher educators as important for effective teaching of secondary science.

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

Content Topics

This list details the General Science topics that may be included on the test. All test questions cover one or more of these topics.

Discussion Questions

In this section, discussion questions are open-ended questions or statements intended to help test your knowledge of fundamental concepts and your ability to apply those concepts to classroom or real-world situations. We do **not** provide answers for the discussion questions but thinking about the answers will help improve your understanding of fundamental concepts and may help you answer a broad range of questions on the test. Most of the questions require you to combine several pieces of knowledge to formulate an integrated understanding and response. They are written to help you gain increased understanding and facility with the test's subject matter. You may want to discuss these questions with a teacher or mentor.

I. Nature and Impact of Science and Engineering

A. Nature of Science

1. Nature of scientific knowledge
   a. Based on empirical evidence collected through observation or experimentation
   b. How major concepts develop and change over time based on new evidence
   c. Asking questions and forming hypotheses
   d. Use of laws and theories to describe and explain natural phenomena
   e. Development and application of models to explain natural phenomena
   f. Process skills (e.g., observing, categorizing, comparing, generalizing, inferring, and concluding)
2. Investigation design, data collection, and analysis
   a. Standard units of measurement, dimensional analysis, and unit conversion
   b. Scientific notation and use of significant figures
   c. Investigation design, including identifying variables, planning data collection, and how design supports answering the question or testing the hypothesis
   d. Processing, organizing, and reporting of data
   e. Error analysis, including accuracy and precision, mean, and percent error
   f. Identifying the sources and effects of error (e.g., systematic, random, sampling)
   g. Interpreting, extrapolating, and drawing conclusions from data
3. Appropriate and safe use of materials and equipment in the laboratory and field
   a. Preparation, use, storage, and disposal of materials
   b. Selection, use, calibration, and maintenance of equipment
   c. Safety procedures and precautions

B. Science, Engineering, Technology, Society, and the Environment

1. Interdependence of science, engineering, and technology
   a. Engineering advances leading to important discoveries in science
   b. How science and technology drive each other forward
   c. Engineering design
      - Defining problems, including identifying the success criteria and the constraints
      - Designing solutions, including proposing and evaluating in terms of criteria, constraints, and limitations
      - Optimizing the design, including systematic modification and refinement
2. Use of science and engineering to identify and address adverse impacts on the environment and society
   a. Acid rain
   b. Air and water pollution (e.g., eutrophication)
   c. Greenhouse gases (e.g., global climate change, ocean acidification, rising sea levels)
   d. Ozone layer depletion (e.g., causes, environmental effects)
   e. Polymers and plastics
   f. Waste disposal and recycling
   g. Invasive species, loss of habitat and biodiversity
3. Issues associated with the use and extraction of energy and natural resources
   a. Sustainable energy use
   b. Renewable and nonrenewable energy resources
   c. Advantages and disadvantages of energy resources (e.g., fossil fuels, nuclear, hydro, solar, wind, and geothermal)
   d. Global distribution, extraction, and use of resources (e.g., ores and groundwater, mineral, and energy resources)
   e. Land surface use (e.g., urban development, agricultural practices, degradation of soil, deforestation)
   f. Consumer products and lifecycle cost analysis (e.g., production, use, disposal, and recycling)
4. Applications and contributions of science and technology in daily life
   a. Scientific ethics and decision making
   b. Chemistry (e.g., water purification, soaps, plastics, batteries)
   c. Physics (e.g., communications technology, telescopes, medical imaging)
   d. Life science (e.g., medicine, public health, biotechnology)
   e. Earth and space science (e.g., satellites, GPS, identification and prediction of natural hazards)

Discussion Questions: Nature of Science

- What are the characteristics of a valid scientific hypothesis?
- Name a scientific law and explain why it is a law rather than a theory.

- How have theories about the structure of the solar system changed over time?
- What is the difference between an observation and an inference?
- Compare information obtained from television, a newspaper article, a Web site, and a scientific journal for accuracy. Compare for understandability. Compare for use in the classroom setting.
- How many millimeters are equivalent to 1,000 kilometers?
- Express the number 0.002270 using scientific notation. How many significant figures does the number have in decimal notation? How many in scientific notation?
- What is the density of a brass cube, expressed to the correct number of significant figures, if a side and the mass are measured and recorded as $2.5\,\text{cm}$ and $64.92\,\text{g}$?
- What is the difference between the accuracy of a data set and the precision of a data set? Design an experiment and identify the independent variable and the dependent variable. Does the experimental design include a control?
- Describe how to prepare $500\,\text{mL}$ of $1\,M\,\text{HCl}(aq)$ using $12\,M\,\text{HCl}(aq)$ and distilled water.
- What is a volumetric flask used for?
- What safety precautions should be taken when preparing a dilute solution of HCl from concentrated HCl?
- What is the proper way to clean up a small spill of concentrated HCl?

Discussion Questions: Science, Engineering, Technology, Society, and the Environment

- What are the major contributors of acid rain?
- What is the greenhouse effect and how does it relate to climate change?
- What are the beneficial and adverse effects on humans and the environment of engineered structures such as dams, levees, and canals that are used to control or divert water?
- Give some reasons why electronic waste such as computers should be recycled.
- Compare the availability and limitation of the following sources of power: geothermal, nuclear, hydroelectric, solar, and fossil fuel.
- Why do polarized sunglasses reduce glare while nonpolarized sunglasses simply reduce the total amount of light reaching the eyes?
- What limitation of Earth-based telescopes has been solved by the Hubble space telescope?
- What technique enables forensic scientists to be able to generate a DNA profile of a suspect from a small sample of DNA collected from a crime scene?
- List some childhood diseases that are commonly prevented through immunization.
- How has recombinant DNA technology been used to treat diabetes?

II. Physical Science

A. Principles and Models of Matter and Energy

1. Atomic and nuclear structure and processes
   a. Current model of atomic structure
      - Description of basic model, including location of protons, neutrons, and electrons
      - Atomic number, atomic mass, isotopes
      - Electron configurations of the elements
      - Uses of absorption and emission spectra in science
   b. Characteristics, processes, and effects of radioactivity
      - Radioactivity and radioactive decay processes
      - Alpha particles, beta particles, and gamma radiation
      - Half-life
      - Fission and fusion
      - Balancing nuclear reactions
2. Relationships between energy and matter
   a. Organization of matter
      - Pure substances (elements and compounds)
      - Mixtures (homogeneous, heterogeneous, solutions, suspensions, colloids)
      - States of matter (solid, liquid, gas, and plasma)
      - Atoms, ions, molecules
   b. Difference between chemical and physical properties and changes
      - Chemical versus physical properties
      - Chemical versus physical changes
      - Intensive versus extensive properties
   c. Conservation of energy and matter
      - Conservation of matter in chemical and physical processes
      - Conservation of energy in chemical and physical processes
      - Mechanical energy (kinetic and potential energy)
      - Other forms of energy including chemical, electrical, thermal, electromagnetic, and nuclear
      - Transformations between different forms of energy (e.g., chemical to electrical)
   d. Temperature, thermal energy, and heat capacity
      - Temperature scales
      - Mechanisms of energy transfer (conduction, convection, radiation)
      - Heat capacity and specific heat
      - Calorimetry
   e. Energy concepts and calculations involving phase changes, including particulate and mathematical models
      - Interpreting phase diagrams
      - Heats of vaporization and fusion
      - Heating curves

f. Kinetic molecular theory, including particulate and mathematical models
   - Assumptions and applications of the kinetic molecular theory
   - Ideal gas behavior and the ideal gas laws

g. Relationship between thermodynamics and chemical and physical processes
   - Changes in entropy (second law of thermodynamics)
   - Exothermic and endothermic processes
   - Reaction progress diagrams based on potential energy of reactants and products
   - Energy absorbed in breaking bonds and energy released in forming bonds

B. Chemistry

1. Chemical composition, bonding, and structure
   a. Chemical composition
      - Mole concept and application to chemical systems
      - Avogadro's number, molar mass, and mole conversions
      - Percent composition and chemical formulas

   b. Names and chemical formulas for simple compounds
      - Interpreting chemical formulas
      - Naming compounds based on formulas
      - Writing formulas based on names
      - Structural formulas (e.g., Lewis electron-dot diagrams)

   c. Properties and models of bonding
      - Ionic bonding
      - Covalent bonding (polar, nonpolar)
      - Metallic bonding
      - Relative bond strengths

   d. How bonding, structure, and interparticle interactions are related to physical properties of pure substances
      - Intermolecular forces (e.g., hydrogen bonding, dipole-dipole, London dispersion forces)
      - Boiling points and melting points
      - Solubility

2. The periodic table
   a. The periodic table as a model
      - Arranged in groups and periods
      - Identifying symbols, atomic numbers, and atomic masses given the periodic table of the elements
      - Location of metals, nonmetals, metalloids, and transition elements

   b. Trends in properties of the elements based on their position on the periodic table
      - Atomic radius
      - Ionization energy
      - Electronegativity
      - Physical properties
      - Chemical properties and reactivity

3. Basic principles of chemical reactions
   a. Using chemical equations for simple chemical reactions
      - Writing equations
      - Balancing equations
      - Simple mass-mole calculations based on balanced equations
   b. Types of reactions (e.g., combustion, neutralization, synthesis, decomposition, single and double replacement reactions, oxidation-reduction)
   c. Factors affecting reaction rate (e.g., concentration, surface area, temperature, pressure, activation energy and catalysts)
   d. Factors that affect equilibrium in chemical systems (Le Chatelier's principle)
4. Solutions and solubility
   a. Types of solutions
      - Dilute, concentrated, unsaturated, saturated, and supersaturated
      - Identification of solute and solvent
      - Concentration units (e.g., molarity, percent by mass or volume)
      - Simple calculations needed to prepare solutions, including dilutions
   b. Factors affecting solubility
      - Rate of dissolving (temperature, pressure, surface area, stirring)
      - Solubility and solubility curves (temperature and pressure dependence, precipitation)
      - Polar and nonpolar solutes and solvents
      - Characteristics of electrolytes and nonelectrolytes, (e.g., electrical conductivity of solutions; freezing-point depression and boiling-point elevation)
5. Acids and bases
   a. Distinguishing between acids and bases (Arrhenius and Brønsted-Lowry; strong versus weak)
   b. Understanding the pH scale, including simple calculations
   c. Definition and applications of buffers
   d. Use of acid-base indicators (e.g., phenolphthalein, pH paper, litmus paper)

C. Physics

1. Mechanics
   a. Description of motion in one and two dimensions
      - Scalar quantities (e.g., mass, speed, time, distance, energy)
      - Vector quantities (e.g., displacement, velocity, acceleration, force, momentum)
   b. Newton's laws of motion
      - First law (mass, inertia)
      - Second law (net force, mass, acceleration)
      - Third law (action-reaction pairs)
   c. Mass, weight, and gravity
      - Distinguish between weight and mass
      - Newton's law of universal gravitation and gravity fields

- Acceleration due to gravity

d. Analysis of motion and forces
   - Contact forces (e.g., friction, normal force, and tension)
   - Projectile motion
   - Uniform circular motion and centripetal acceleration
   - Rotational motion and torque
   - Periodic motion (e.g., Hooke's law; pendulum and spring oscillations)
   - Work, mechanical energy, and power (e.g., conservation of energy, mechanical advantage, efficiency)
   - Conservation of linear momentum (one dimension)
   - Properties of fluids (e.g., buoyancy, density, pressure)

2. Electricity and magnetism
   a. Electrical nature of common materials
      - Electric charge and charge separation (attractive and repulsive forces)
      - Coulomb's law and electric fields
      - Conductors and insulators
   b. Basic electrical concepts
      - Current, resistance, capacitance, potential difference (sometimes called voltage), and power
      - Ohm's law
      - Distinguish between direct current and alternating current
      - Sources of potential difference (e.g., batteries, generators, photocells)
      - Analysis of simple series and parallel circuits
   c. Magnetic fields, forces, and materials
      - Magnetic forces and fields (magnetic poles, attractive and repulsive forces)
      - Magnets (e.g., permanent magnets, electromagnets)
      - Magnetic field generated by steady current
      - Electric current generated by a changing magnetic field
      - Motors and generators
3. Waves and optics
   a. Electromagnetic waves and the electromagnetic spectrum
      - Nature of light (e.g., electric and magnetic fields, speed of light, energy, photons)
      - Electromagnetic spectrum, including the visible spectrum (colors)
   b. Types of waves and their characteristics
      - Distinguish between transverse and longitudinal waves
      - Distinguish between mechanical and electromagnetic waves
      - Relationships between amplitude, wavelength, frequency, period, wave speed, and energy
   c. Wave phenomena
      - Reflection, refraction, dispersion, and total internal reflection

- Diffraction, interference, superposition (standing waves), polarization
- Scattering, absorption, transmission
- Doppler effect, including apparent frequency and wavelength, moving source or observer

d. Basic geometric optics
- Mirrors (plane, convex, concave)
- Lenses and their applications (e.g., human eye, microscope, telescope)

e. Sound
- Sound as a longitudinal (compression) wave
- Pitch (frequency) and loudness (intensity)
- Applications of Doppler effect

Discussion Questions: Principles and Models of Matter and Energy

- What are the limitations of the Bohr model of the atom?
- What is the relationship between the position of an element on the periodic table and its electron configuration?
- Compare the mass and charge of alpha particles and beta particles. How is gamma radiation different from alpha radiation and beta radiation?
- If a sample that initially contains $100\ \text{g}$ of a radioactive isotope contains $25\ \text{g}$ of the isotope after 4 days, what is the half-life of the radioactive isotope?
- Why is lead found in all deposits of uranium ore?
- Compare and contrast liquids and gases in terms of shape, volume, fluidity, and compressibility.
- Compare and contrast the arrangement and motions of molecules of a substance in its solid, liquid, and gaseous states.
- If $100\ \text{g}$ of water at $20°\text{C}$ absorbs $5\ \text{kJ}$, by what amount will the temperature of the water increase?
- If a sample of gas is heated at a constant pressure, what will happen to the volume of the gas?
- How does the internal energy of a closed system change when as gas expands?
- What phase changes involve an increase in entropy?

Discussion Questions: Chemistry

- How many carbon atoms are in one mole of propane?
- What information is provided in the formula for calcium hydroxide, Ca(OH)_2?
- Name each of the following compounds: Na_2O, Cu_2O, P_2O_5.
- Write the electron dot and structural formulas for formaldehyde, CH_2O.
- List the elements H, He, Li, and Be in order of increasing atomic radius.
- How do the chemical properties of the elements in a period change from left to right across the periodic table?
- Balance the following equation: $\text{Al} + \text{CuCl}_2 \rightarrow \text{AlCl}_3 + \text{Cu}$. What type(s) of reaction is it?

- Consider the following equilibrium reaction:
  $2\ NO_2\left(g\right) \rightleftharpoons N_2O_4\left(g\right) + 58\ kJ$
  Predict what will happen to the equilibrium if the temperature, pressure, or concentration of one of the reactants is changed.
- Is the following process an oxidation or reduction: $Ni^{2+} + 2\ e^- \rightarrow Ni$?
- Why is ammonia gas very soluble in water while oxygen is only slightly soluble?
- Which of the following $1M$ solutions will have the lowest freezing point: CH_2H_5OH, KI, $MgCl_2$?
- If the pH of a solution decreases from 5 to 4, by how much does the concentration of its hydrogen ions increase?
- What is an example of a buffer solution? How will the pH change as acid is added to the buffer solution?

Discussion Questions: Physics

- What is the difference between speed and velocity?
- What is meant by the term "terminal velocity"?
- What is the relationship between the distance that separates two objects and the force of gravitational attraction?
- What is the direction of the centripetal force acting on an object that is moving in uniform circular motion?
- A ball is dropped and another ball of smaller mass is fired horizontally from the same height. Which ball hits the ground first?
- What are the forces that act on a crate that is at rest on an inclined ramp?
- What variables affect the period of a pendulum?
- How does the conservation of momentum apply to collisions?
- Which requires more work: lifting a 100-kilogram sack a vertical distance of 2 meters or lifting a 50-kilogram sack a vertical distance of 4 meters?
- Explain mechanical advantage using a lever as an example.
- Why are metals good conductors of electricity?
- How are series circuits different from parallel circuits?
- What energy transformation occurs in a battery?
- Describe the orientation of field lines of a bar magnet.
- What color light is transmitted through a piece of blue glass?
- Compare the energy and the frequency of gamma rays to those of microwaves.
- What wave phenomena are involved in the separation of white light into a spectrum of colors by a prism?
- Does the size of the image of an object in a plane mirror change as the object moves away from the mirror?
- What happens to parallel rays of light when they pass through a convex lens?
- If you blow air across the open top of a bottle partially filled with water to produce a sound, how would the frequency change as you fill the bottle with additional water?

III. Life Science

A. Cells and Processes, Including Genetics

1. Basic structure and function of cells and their organelles
   a. Structure and function of cell membranes (e.g., phospholipid bilayer, passive and active transport, homeostasis)
   b. Structure and function of eukaryotic cell organelles
   c. Structure and function of prokaryotic cell organelles
   d. Levels of organization (cells, tissues, organs, organ systems)
   e. Major features of common animal cell types (e.g., blood, muscle, nerve, epithelial, gamete)
   f. Prokaryotes (eubacteria and archaea) and eukaryotes (animals, plants, fungi, protists)
2. Key aspects of cell reproduction and division
   a. Cell cycle phases
   b. Mitosis
   c. Meiosis
   d. Cytokinesis
   e. Binary fission
3. Basic biochemistry of life
   a. Aerobic and anaerobic cellular respiration
   b. Photosynthesis
   c. Biological molecules (e.g., nucleic acids, carbohydrates, proteins, lipids)
4. Basic genetics and protein synthesis
   a. Structure, function, and replication of DNA and structure and function of RNA
   b. Central dogma: transcription and translation
   c. Chromosomes, genes, alleles
   d. Dominant and recessive traits
   e. Mendelian inheritance (e.g., genotype, phenotype, use of Punnett squares, sex-linked traits, pedigrees, probability)
   f. Non-Mendelian inheritance (e.g., incomplete dominance, codominance)
   g. Mutations, chromosomal abnormalities, and common genetic disorders, genetic counseling

B. Evolution, Diversity of Life, and Ecology

1. Theory and key mechanisms of evolution
   a. Natural selection as the mechanism of evolution (e.g., adaptations and reproductive fitness)
   b. Speciation, extinction, and selection pressures
   c. Supporting evidence (e.g., fossil record, comparative amino acid and nucleotide sequences, homologous structures, embryology)
   d. Artificial selection, contemporary evolution (rapid microevolution)
   e. Genetic diversity (e.g., mutation, sexual reproduction, genetic drift)
2. Organismal classification and relationships

   a. Use and interpretation of cladograms and phylogenetic trees
   b. Defining characteristics of prokaryotes, animals, plants, fungi, and protists
3. Basic structures of plants and plant growth
   a. Structure and function of roots, leaves, and stems (e.g., stomata, xylem, phloem) in vascular plants
   b. Asexual (budding) and sexual reproduction (flowers, fruit, seeds, spores)
   c. Relationship between photosynthesis and growth
   d. Responses to stimuli (e.g., light, temperature, water, gravity)
4. Basic structure and function of animal systems
   a. Homeostasis and response to stimuli; negative and positive feedback loops
   b. Exchange with the environment (e.g., respiratory, circulatory, nervous, endocrine, excretory, and digestive systems)
   c. Reproduction, development, and growth
   d. Immune system and disease (e.g., antibodies, vaccines, autoimmune disorders)
5. Key aspects of ecology
   a. Hierarchical structure of the biosphere (e.g., organisms, populations, communities, ecosystems, biomes)
   b. Intraspecific relationships (e.g., competition and altruism)
   c. Interspecific relationships (e.g., symbiotic relationships including mutualism, parasitism, and commensalism; predation)
   d. Influence of biotic and abiotic components of an ecosystem on populations (e.g., niche, resource availability, limiting factors, population growth and carrying capacity, critical population size)
   e. Ecosystem function and stability (e.g., energy flow; biodiversity; ecological succession; phenology; water, nitrogen, and carbon cycles)
   f. Ecosystem disturbances and change (e.g., climate change; ocean acidification; cascading effects such as loss of pollinators; keystone species; invasive species)

Discussion Questions: Cells and Processes, Including Genetics

- What structures would you expect to find in a typical plant cell but not in a typical animal cell? What functions do these unique structures carry out for the plant?
- Compare and contrast the daughter cells after one cycle of mitosis to the daughter cells from the same parent cell after one cycle of meiosis.
- In general terms, what are the different pathways that are involved in cellular respiration under aerobic conditions and under anaerobic conditions?

- What is the percent likelihood that a biological child of one parent with blood type AB and the other parent with blood type O will have blood type A? What are the genotypes for blood type A?
- Why do more males have red-green color-blindness than do females?
- How are Mendel's laws related to the behavior of chromosomes during the formation of gametes?

Discussion Questions: Evolution, Diversity of Life, and Ecology

- Explain the following concepts relative to Darwin's theory of the origin of species: (a) descent with modification, (b) struggle for existence, and (c) survival of the fittest.
- How is genetic drift different from natural selection?
- What are some structures that organisms use for locomotion?
- What are the similarities and differences between fungi and plants?
- Under what environmental conditions would you expect transpiration rate to be highest in a mature deciduous tree?
- Describe how a germinating seed responds to gravity and light.
- What are the roles of insulin and glucagon in the human endocrine system?
- Why must the human body digest large macromolecules into small monomers before it can use them?
- Of proteins, carbohydrates, and fats, which type of nutrient has the highest caloric value per gram?
- Relate the structural differences between the three muscle types to their functions.
- Under what conditions would a population grow exponentially?
- What are the possible outcomes when two species strongly compete for the same resources?
- Compare the types of vegetation encountered with increasing altitude (e.g., traveling up a mountainside) and with increasing latitude (e.g., traveling toward the North Pole).
- What is the difference between primary and secondary succession?
- Create a food web, with organisms placed within an appropriate trophic level, with the following organisms: bald eagle, herring gull, lake trout, phytoplankton, smelt (small fish), and zooplankton. Based on the food web, describe how the pesticide DDT would be distributed through the ecosystem.

IV. Earth and Space Science

A. Astronomy

1. The Sun-Earth-Moon System
   a. Earth's motions and their characteristics and consequences
      - Rotation and revolution
      - Effects of axial tilt (e.g., seasons, solstices, and equinoxes)
   b. Relationships within the Sun-Earth-Moon system
      - Tides (e.g., causes, cycles, spring, neap)

- Eclipses (solar, lunar)
- Phases of the Moon
- Effects of solar wind on Earth (e.g., communication satellites, blackouts, auroras)

2. The solar system
   a. Formation and organization of the solar system
   b. Structure and characteristics of the Sun (e.g., layers, sunspots, nuclear fusion)
   c. Location and orbits of the planets and the Moon (e.g., Kepler's laws of planetary motion)
   d. Characteristics of solar-system objects (e.g., planets, asteroids, moons, comets, dwarf planets)
3. The universe and its stars
   a. Life cycle of stars (e.g., main sequence, white dwarf, supernova, black holes)
   b. Characteristics of stars (e.g., mass, color, temperature, brightness, Hertzsprung-Russell diagram)
   c. Nuclear fusion and the formation of elements (e.g., carbon, iron)
   d. Characteristics of the universe and galaxies (e.g., Milky Way)
   e. Big Bang theory and evidence for the origin and evolution of the universe (e.g., redshift, cosmic background radiation)

B. Earth Science

1. Tectonics and internal Earth processes
   a. Theory of plate tectonics and its supporting evidence
      - Plate movement and potential driving forces (e.g., slab pull and ridge push; convection)
      - Types of plate boundaries (convergent, divergent, and transform)
      - Evidence for plate tectonics (e.g., seismic, geomagnetic reversals, fossil)
   b. Deformation of Earth's crust and resulting features (e.g., mountains, trenches)
   c. Characteristics of earthquakes and how they provide information about Earth's interior (e.g., distribution, magnitude, seismic waves)
   d. Types, features, and distribution of volcanoes (e.g., shield, hot spots, Ring of Fire)
   e. Layered structure of Earth and related processes
      - Characteristics and composition of the layers
      - Magnetic field
2. Earth's minerals and rocks
   a. Properties of minerals (e.g., density, streak, hardness, cleavage, luster, crystal structure)
   b. Rocks and the rock cycle
      - Types of rocks (i.e., igneous, metamorphic, sedimentary)
      - Rock-cycle processes (e.g., weathering, erosion, deposition, melting)
3. Evidence for the history of Earth
   a. Principles of relative dating (e.g., superposition, fossil succession)

b. Principles of absolute (radiometric) dating (e.g., radioactive decay, Earth's age)

4. Earth's hydrosphere
   a. Properties of water (e.g., density changes, polar solvent, high heat capacity)
   b. The water cycle
   c. Groundwater (e.g., water table, aquifers)
   d. Rivers and watersheds (e.g., deltas; erosion and deposition)
   e. Glaciers, ice sheets, and sea ice (e.g., features, change over time)
   f. Characteristics and processes of the oceans
      - Ocean circulation (e.g., Gulf Stream)
      - Waves (e.g., energy)
      - Seawater composition
   g. Hazards (e.g., flooding, sinkholes, storm surge, sea-level rise)
5. Earth's atmosphere
   a. Basic structure and composition of the atmosphere
      - Chemical composition
      - Layers and their physical properties (e.g., stratosphere, troposphere, thermosphere)
   b. Basic concepts in meteorology
      - Absolute and relative humidity
      - Cloud types and formation
      - Precipitation types and formation
      - Barometric pressure, wind (e.g., sea and land breezes)
      - Air masses, fronts, storms, and severe weather
      - Interpreting weather maps
   c. Factors and processes that influence climate
      - Latitude, geographical location, and elevation (e.g., climate belts, rain shadow effect)
      - Atmospheric circulation (e.g., global wind belts, Coriolis effect)
      - Characteristics and locations of climate zones (e.g., Tropics, Arctic)
      - Effects of natural phenomena on climate change (e.g., volcanic eruptions, asteroid impacts, variations in solar radiation)

Discussion Questions: Astronomy

- Why does the length of daylight change from day to day?
- Describe the temperature and length of the day at the North Pole, the mid-latitudes, and the equator on the summer solstice and the winter solstice.
- How do the Sun and the Moon influence tides?
- Why in general do two high tides occur every day even though the Moon is directly above any given portion of Earth's surface only once a day?
- Describe the orbits of the planets. What do they have in common?
- Compare the surface features and atmospheres of the other terrestrial planets to those of Earth.
- How do the Sun and other stars generate their energy?
- List the common astronomical units of length in order of increasing distance.

- Use the Hertzsprung-Russell (H-R) diagram to describe the life cycle of the Sun.

Discussion Questions: Earth Science

- What does the behavior of seismic waves reveal about the structure and physical characteristics of Earth's interior?
- Describe the different tectonic processes that lead to the formation of mountain ranges.
- Rift valleys are associated with what type of tectonic plate motion?
- What information is represented on a topographic map?
- What properties are most commonly used by geologists in the field to characterize minerals?
- What are the source materials for the ingredients of sedimentary rocks?
- What are the major agents of erosion?
- What factors determine the amount of surface runoff and soil infiltration?
- What are index fossils?
- What appeared first in the fossil record: angiosperms or insects?
- Transpiration is most closely related to what other process in the water cycle?
- What is the primary source of water in a lake?
- Why do waves break as they approach the shore?
- List the layers of the atmosphere and describe the temperature profile of each layer.
- How does the Sun influence global and local winds?
- What weather would you predict if you had observed a lowering sequence of stratiform clouds over the previous day or two?
- How are air masses classified?
- Why do tropical cyclones generally move in a westward direction?
- What is the Coriolis effect and how does it influence atmospheric and ocean circulation?
- How does a volcanic eruption affect both regional and worldwide climate conditions?

Science and Engineering Practices

The SEPs represent eight practices that scientists and engineers—and students and teachers—use to investigate the world and to design and build systems. Many test questions will integrate one or more of these practices.

1. Asking questions (for science) and defining problems (for engineering)
   - Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
   - Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
   - Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.
   - Ask questions to clarify and refine a model, an explanation, or an engineering problem.

- Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
- Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

2. Developing and using models
   - Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.
   - Design a test of a model to ascertain its reliability.
   - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
   - Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
   - Develop a complex model that allows for manipulation and testing of a proposed process or system.
   - Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
3. Planning and carrying out investigations
   - Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
   - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
   - Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
   - Select appropriate tools to collect, record, analyze, and evaluate data.

- Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
- Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

4. Analyzing and interpreting data
   - Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
   - Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
   - Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.
   - Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
   - Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.
   - Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
5. Using mathematics and computational thinking
   - Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
   - Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
   - Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
   - Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world.
   - Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3, acre-feet, etc.).
6. Constructing explanations (for science) and designing solutions (for engineering)
   - Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
   - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws

that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.
- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

7. Engaging in argument from evidence
   - Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
   - Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
   - Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.
   - Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
   - Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.
   - Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).
8. Obtaining, evaluating, and communicating information
   - Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
   - Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

- Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
- Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
- Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Tasks of Teaching Science

This list includes instructional tasks that teachers engage in that are essential for effective General Science teaching. Many test questions will measure content through application to one or more of these tasks

Scientific Instructional Goals, Big Ideas, and Topics

1. Selecting or sequencing appropriate instructional goals or big ideas for a topic
2. Identifying the big idea or instructional goal of an instructional activity
3. Choosing which science ideas or instructional activities are most closely related to a particular instructional goal
4. Linking science ideas to one another and to particular activities, models, and representations within and across units

Scientific Investigations and Demonstrations

5. Selecting investigations or demonstrations, including virtual, that facilitate understanding of disciplinary core ideas, scientific practices, or crosscutting concepts
6. Evaluating investigation questions for quality (e.g., testable, empirical)
7. Determining the variables, techniques, or tools that are appropriate for use by students to address a specific investigation question
8. Critiquing scientific procedures, data, observations, or results for their quality, accuracy, or appropriateness
9. Supporting students in generating questions for investigation or identifying patterns in data and observations

Scientific Resources (texts, curriculum materials, journals, and other print and media-based resources)

10. Evaluating instructional materials and other resources for their ability to address scientific concepts; engage students with relevant phenomena; develop and use scientific ideas; promote students' thinking about phenomena, experiences, and knowledge; take account of students' ideas and background; and assess student progress

11. Choosing resources that support the selection of accurate, valid, and appropriate goals for science learning

Student Ideas (including common misconceptions, alternate conceptions, and partial conceptions)

12. Analyzing student ideas for common misconceptions regarding intended scientific learning
13. Selecting diagnostic items and eliciting student thinking about scientific ideas and practices to identify common student misconceptions and the basis for those misconceptions
14. Developing or selecting instructional moves, approaches, or representations that provide evidence about common student misconceptions and help students move toward a better understanding of the idea, concept, or practice

Scientific Language, Discourse, Vocabulary, and Definitions

15. Selecting scientific language that is precise, accurate, grade-appropriate, and illustrates key scientific concepts
16. Anticipating scientific language and vocabulary that may be difficult for students
17. Modeling the use of appropriate verbal and written scientific language in critiquing arguments or explanations, in describing observations, or in using evidence to support a claim, etc.
18. Supporting and critiquing students' participation in and use of verbal and written scientific discourse and argumentation

Scientific Explanations (includes claim, evidence, and reasoning)

19. Critiquing student-generated explanations or descriptions for their generalizability, accuracy, precision, or consistency with scientific evidence
20. Selecting explanations of natural phenomena that are accurate and accessible to students

Scientific Models and Representations (analogies, metaphors, simulations, illustrations, diagrams, data tables, performances, videos, animations, graphs, and examples)

21. Evaluating or selecting scientific models and representations that predict or explain scientific phenomena or address instructional goals
22. Engaging students in using, modifying, creating, and critiquing scientific models and representations that are matched to an instructional goal
23. Evaluating student models or representations for evidence of scientific understanding
24. Generating or selecting diagnostic questions to evaluate student understanding of specific models or representations
25. Evaluating student ideas about what makes for good scientific models and representations

General Science (5436) Sample Test Questions

The sample questions that follow represent a number of the types of questions and topics that appear on 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 suggested answers or completions. Select the one that is best in each case.

Group	**Water Temperature** (°C)	**Average Rate of Gill Movement** (per min)
1	10	30
2	15	39
3	20	44
4	25	49

1. Students investigated the effect of water temperature on the gill movements of goldfish. A collection of goldfish was divided into four equal-sized groups. The average rate of gill movement was determined for each group at a different water temperature, as shown in the table. What are the independent and dependent variables in the investigation?

	Independent variable	Dependent variable
(A)	Group number	Number of goldfish per group
(B)	Number of goldfish per group	Water temperature
(C)	Water temperature	Average rate of gill movement
(D)	Average rate of gill movement	Water temperature

2. Which of the following is the electron dot structure of an N atom?

(A) 

(B) 

(C) 

(D) 

3. In humans, the concentration of iodine within thyroid gland cells is much higher than in any other cells of the body. Which of the following cell structures is most directly responsible for regulating and maintaining the iodine concentration in the thyroid cells?

   (A) Golgi apparatus
   (B) Lysosome
   (C) Nucleus
   (D) Plasma membrane

4. A rock is dropped from rest off a cliff that is $2{,}000\,\text{m}$ high. It takes $20\,\text{s}$ for the rock to reach the ground. What is the speed of the rock when it hits the ground? (Assume $g = 10\,\text{m/s}^2$ and air resistance is negligible.)

   (A) $2\,\text{m/s}$
   (B) $10\,\text{m/s}$
   (C) $100\,\text{m/s}$
   (D) $200\,\text{m/s}$

5. In an investigation, students hold a flashlight above a piece of graph paper at a $90°$ angle to the paper and shine the light on the paper. The students draw an outline of the light projected onto the paper and observe the brightness of the light on the paper. They repeat the process using angles of $67°$, $45°$, and $23°$ while keeping the distance between the flashlight and the paper the same. The area within each outline is determined and recorded in a data table along with the observations about brightness. The investigation best illustrates how

   (A) light is refracted as it passes from one type of material into another type of material
   (B) the observed wavelengths of stars are shifted because the stars are moving away from Earth
   (C) the tilt of Earth's axis affects the intensity of sunlight striking different locations on Earth at different times of year
   (D) shadows vary in length and direction throughout a day as the Sun moves from east to west across the sky

6. Which of the following is the highest energy orbital in the ground-state electron configuration of Si ?

   (A) 3*s*

   (B) 3*p*

   (C) 3*d*

   (D) 3*f*

7. Which **THREE** of the following resources are best used by a teacher to provide support for a claim that two species of animals share a recent common ancestor?

   (A) An extensive database with a search tool that indicates the percent identity of gene sequence between different organisms

   (B) A table that provides the amino acid sequences of mammalian hemoglobin proteins

   (C) A video that compares the structure and function of the wings of bats, insects, and birds

   (D) A diagram that is color coded to show the homologous bone structures in the forelimbs of mammals

8. Which of the following student comments made during a discussion about renewable resources identifies a drawback of using geothermal energy to generate electricity?

   (A) It produces pollution directly.

   (B) It increases the reliance on fossil fuels.

   (C) It is only suitable in certain regions on Earth.

   (D) It requires fuel to harness the energy.

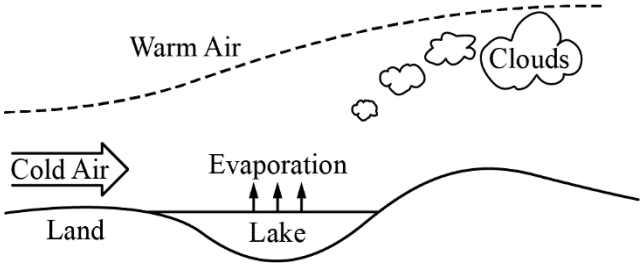
9. The first ionization energy is the minimum amount of energy required to remove one electron from an atom. Which of the following elements has the largest first ionization energy?

   (A) He

   (B) Ca

   (C) Zn

   (D) Br



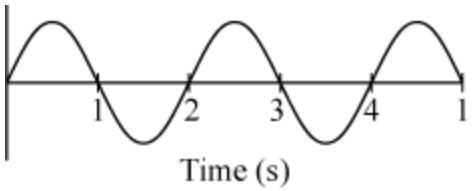
10. In December, subfreezing Arctic air is moving across the warm waters of a lake in the northern part of the United States. Water evaporates and rises, and cloud development occurs, as shown in the preceding diagram. Warm lake temperatures and the contour of the land along the shore enhance further cloud development. Which of the following would most likely result from the conditions described?

    (A) Thunderstorms

    (B) Hail

    (C) Intermittent rain

    (D) Lake-effect snow



11. What are the period and frequency for the wave represented in the figure above?

    (A) The period is $2\,s$ and the frequency is $0.5\,Hz$.

    (B) The period is $2\,s$ and the frequency is $0.25\,Hz$.

    (C) The period is $4\,s$ and the frequency is $0.5\,Hz$.

    (D) The period is $4\,s$ and the frequency is $0.25\,Hz$.

12. Which of the following best describes the mature sperm cells that form when one chromosome in a sperm-forming cell at meiosis I undergoes disjunction?

    (A) Only one sperm cell will form.

    (B) Four sperm cells will form, two with one extra chromosome and two with one less chromosome.

    (C) All sperm cells that form will be diploid.

    (D) All sperm cells that form will have two copies of the chromosome that underwent nondisjunction.

Solution	Initial pH	Final pH
A	12.0	10.1
B	10.0	9.8
C	7.0	4.7
D	5.0	3.1

13. Equal-volume samples of a hydrochloric acid solution were added to equal volumes of each solution listed in the table. Based on the initial pH of each solution and the final pH after the hydrochloric acid solution was added, which solution is most likely a buffer solution?

    (A) Solution A

    (B) Solution B

    (C) Solution C

    (D) Solution D

14. Which of the following is a true statement about the Sun's corona?

    (A) It is the innermost layer of the Sun.

    (B) It is where most nuclear fusion occurs.

    (C) It is the visible surface of the Sun.

    (D) It is visible during a total solar eclipse.

Distance (m)	**Gravitational Force** (N)
10	200
20	50
30	22.2
40	12.5

15. Using a simulation, students collected data by varying the distance d between two objects while keeping their masses constant. The distance and calculated gravitational force F_g are given in the preceding table. Which of the following student-generated mathematical expressions best models the relationship of gravitational force and the distance between the objects?

    (A) $F_g \propto \frac{1}{d^2}$

    (B) $F_g \propto \frac{1}{d}$

    (C) $F_g \propto d$

    (D) $F_g \propto d^2$

16. A student is exerting a force on a desk to keep it sliding at constant speed along a level floor. The desk's weight is $100\,\text{N}$, and the coefficient of kinetic friction is 0.2. Which of the following is equal to the magnitude of the force that the student is exerting on the desk?

    (A) 6 N

    (B) 20 N

    (C) 30 N

    (D) 100 N

Grasses → Grasshoppers → Toads → Snakes

17. A teacher shows students the preceding food chain for an ecosystem. Based on the food chain, which **TWO** of the following statements made by students about the organisms in the ecosystem are accurate?

    (A) Grasses are autotrophs.

    (B) Grasshoppers are producers.

    (C) Toads are predators.

    (D) Snakes have the greatest total biomass.

18. A teacher does a demonstration using two identical aluminum cans that are filled with equal amounts of soft drinks. Can 1 contains a soft drink sweetened with an artificial sweetener, while the soft drink in can 2 is sweetened with sugar. Which of the following best helps explain the observation that can 1 floats and can 2 sinks when the teacher places them in a tub of ice and water?

    (A) The solution in can 1 has a higher mass than the solution in can 2.

    (B) The solution in can 2 is denser than the solution in can 1.

    (C) Sugar has a lower heat capacity than the artificial sweetener has.

    (D) Sugar is more soluble than the artificial sweetener.

19. The buildup of stress along faults typically leads directly to which of the following?

    (A) Earthquakes

    (B) Magnetic reversals

    (C) Formation of hot spots

    (D) Mass wasting

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

20. A teacher presents students with the preceding balanced chemical equation. Which of the following student interpretations represents a misconception about the application of balanced chemical equations?

    (A) $1\,\text{mol}$ of N_2 can react with $3\,\text{mol}$ of H_2 to form $2\,\text{mol}$ of NH_3.

    (B) 1 molecule of N_2 can react with 3 molecules of H_2 to form 2 molecules of NH_3.

    (C) $1\,\text{L}$ of N_2 can react with $3\,\text{L}$ of H_2 to form $2\,\text{L}$ of NH_3.

    (D) $1\,\text{g}$ of N_2 can react with $3\,\text{g}$ of H_2 to form $2\,\text{g}$ of NH_3.

Time	**Carbon Dioxide Produced** (mL/min)	**Oxygen Consumed** (mL/min)
0 hours	1	1
3 hours	0.9	1
6 hours	0.8	1
9 hours	0.7	1

21. During aerobic respiration in animal cells, carbon dioxide is produced as oxygen is consumed. The ratio of carbon dioxide produced to oxygen consumed is known as the respiratory exchange ratio (RER). The RER is 1.0 when animals are using carbohydrates as fuel, 0.8 when animals are using proteins as fuel, and 0.7 when animals are using fats as fuel. The data shown in the table above were collected from an animal over 9 hours of fasting. Based on the data, during the period of fasting the animal most likely switched its fuel source from

    (A) carbohydrates to fats

    (B) fats to carbohydrates

    (C) proteins to carbohydrates

    (D) fats to protein

22. Two projectiles are launched with the same speed across a flat, horizontal field. One projectile is launched at an angle of $60°$ above the horizontal, and a second projectile is launched from the same launch point at an angle of $45°$ above the horizontal. In the absence of air resistance, which of the following statements correctly describes the flight of the two projectiles?

    (A) Both projectiles remain in the air for the same length of time and land the same distance away from the launch point.

    (B) The projectile that is fired at $60°$ remains in the air longer and lands farther away from the launch point.

    (C) The projectile that is fired at $45°$ remains in the air longer and lands farther away from the launch point.

    (D) The projectile that is fired at $60°$ remains in the air longer, while the projectile fired at $45°$ lands farther away from the launch point.

23. A material composed of long molecular chains of repeating structural units is called

    (A) a semiconductor

    (B) a plasma

    (C) an alloy

    (D) a polymer

24. A teacher is preparing a presentation about the classification of sedimentary rocks. Which of the following could a teacher use as an example of a sedimentary rock that is often classified as biochemical?

    (A) Shale

    (B) Conglomerate

    (C) Limestone

    (D) Sandstone

25. A small amount of heat is added to an ice-and-water mixture in an insulated container. If there is still ice remaining in the mixture, which of the following best describes the changes that take place in the temperature and energy content of the water as the heat is added?

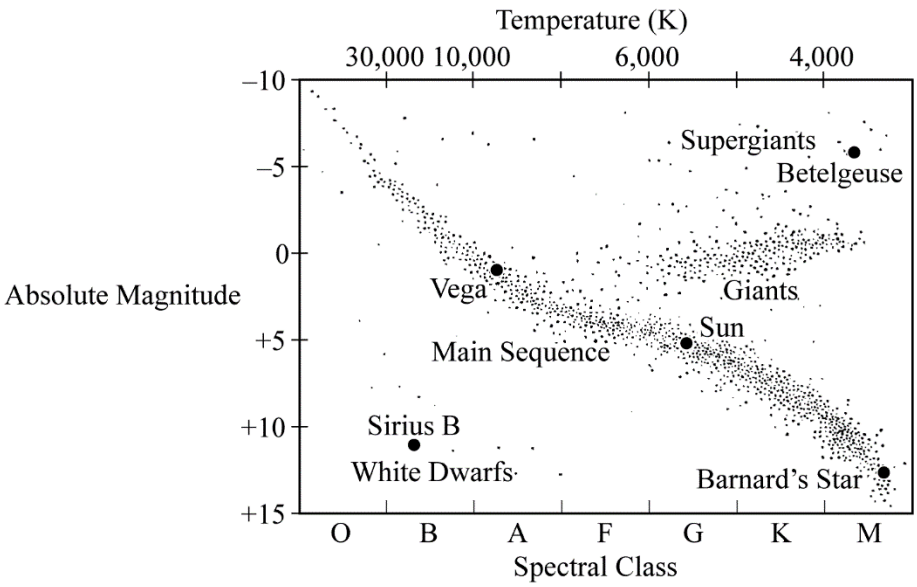
	Temperature	Energy Content
(A)	Decreases	Increases
(B)	No change	Increases
(C)	Increases	No change
(D)	Increases	Increases

26. An organism found in the soil has cell walls containing chitin and decomposes leaves by secreting enzymes into the leaves and then absorbing the small organic molecules released from the leaves. The organism most likely belongs to which of the following groups?

(A) Animalia
(B) Plantae
(C) Protista
(D) Fungi

27. Of the following, which has the highest electrical conductivity?

(A) $H_2O(l)$
(B) $1M\ CH_3COOH(aq)$
(C) $1M\ AlCl_3(aq)$
(D) $1M\ NH_3(aq)$

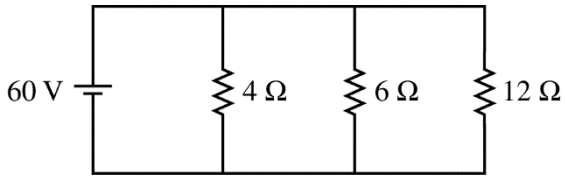


28. Based on the preceding Hertzsprung-Russell diagram, which of the following stars has the greatest luminosity?

    (A) Barnard's Star
    (B) Betelgeuse
    (C) Sirius B
    (D) Vega

29. Which **TWO** of the following are antigen-presenting cells that are used to stimulate the activity of helper T cells in the immune system?

    (A) Natural killer cells
    (B) Epithelial cells
    (C) B cells
    (D) Macrophages



30. What is the equivalent resistance of the resistors in the circuit represented by the preceding diagram?

    (A) 2 Ω
    (B) 4 Ω
    (C) 6 Ω
    (D) 22 Ω

31. Which of the following best describes the effect of guard cells closing the stomata they surround on leaf surfaces?

    (A) It maximizes the rate of photosynthesis.
    (B) It increases the uptake of atmospheric carbon dioxide.
    (C) It decreases the amount of water lost.
    (D) It ensures adequate oxygen availability for cellular respiration.

32. Which of the following should be heated only in a fume hood and never with an open flame?

    (A) Steel wool
    (B) Ethanol
    (C) A saltwater solution
    (D) Calcium carbonate

33. How does the chloride ion concentration of a sample of seawater compare with the salt concentration (salinity) of the same sample of seawater?

    (A) It is always greater than the salinity.

    (B) It is always less than the salinity.

    (C) It is always the same as the salinity.

    (D) It is not related to the salinity.

34. Cystic fibrosis is an autosomal recessive disorder. A female who is a genetic carrier for cystic fibrosis has a child with a male who is not a carrier and does not have the disorder. What is the probability that their child is a carrier?

    (A) 0

    (B) 0.25

    (C) 0.50

    (D) 1.0

General Science (5436) Answers

1. Option (C) is correct. The independent variable is manipulated by the investigator, and the dependent variable responds to the change in the independent variable. In the investigation, the independent variable is the water temperature and the dependent variable is the average rate of gill movement.

Content	1 A
Science and Engineering Practice	3
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2. Option (C) is correct. A neutral atom of nitrogen (N) has five valence electrons in its outer shell, as represented by the electron dot structure in option (C).

Content	II B
Science and Engineering Practice	2
Task of Teaching Science	23

3. Option (D) is correct. The plasma membrane regulates the movement of materials in and out of cells. The movement of ions across the membrane to a region of higher concentration inside a cell involves specialized membrane proteins and active transport. Dietary iodide (I^-) is converted in the cells to iodine (I).

Content	III A

4. Option (D) is correct. Because gravity is the only force acting on the rock, the rock's acceleration a equals g. Given the time it takes to reach the ground, the speed $v = gt = 10\,\text{m/s}^2 \times 20\,\text{s} = 200\,\text{m/s}$ when the rock hits the ground.

Content	II C
Science and Engineering Practice	5

5. Option (C) is correct. Earth's axis points in a fixed direction as Earth orbits the Sun. As a result, the angle at which the Sun's rays strike any given location on Earth varies throughout the year. The investigation illustrates that the intensity of light is greatest when the angle of incidence is $90°$. As the angle of incidence decreases, the light is spread over a larger area, but the intensity at any given point decreases. The variation in intensity of sunlight is an underlying cause of seasons.

Content	IV A
Science and Engineering Practice	2
Task of Teaching Science	2

6. Option (B) is correct. A neutral atom of Si has 14 electrons. Based on the Aufbau principle, the electron configuration for a ground-state atom of Si is $1s^2 2s^2 2p^6 3s^2 3p^2$. The Aufbau principle states that electrons fill the lowest available energy orbitals before higher energy orbitals; therefore, the highest energy orbital is $3p$.

Content	II A
Science and Engineering Practice	2

7. Options (A), (B), and (D) are correct. Extensive databases with search tools can be used to identify and compare homologous gene and amino acid sequences of proteins such as hemoglobin across different species. In general, the more conservation between a set of sequences, the more closely related two organisms are. Homologous structures, such as the bones in the forelimbs of mammals, are also used as evidence of a recent common ancestor. However, analogous structures, such as the wings of bats, birds, and insects, have similar functions but dissimilar structures, which is usually an indication that the structures evolved independently.

Content	III B
Science and Engineering Practice	7
Task of Teaching Science	10

8. Option (C) is correct. The use of geothermal energy typically involves drilling a well deep into the crust to harness Earth's internal heat. The drawback to the use of geothermal energy to generate electricity is that it is economically viable only in tectonically active locations where the heat is closer to the surface.

Content	I B
Science and Engineering Practice	1
Task of Teaching Science	19

9. Option (A) is correct. In the periodic table first ionization energies increase going across a column and decrease down a row. He , which is classified as a noble or inert gas, is in the last column of the periodic table. It has a filled outer electron shell; therefore, it has a high first ionization energy.

Content	II B
Science and Engineering Practice	2

10. Option (D) is correct. The lower layer of a cold air mass moving across the warmer waters of a lake warms and picks up water vapor. When the relatively warm, moist air rises into the colder air above, clouds form and precipitation occurs downwind from the lake. Near the Great Lakes, the winds often blow from the northwest. Regions to the south and east of the Great Lakes receive significant amounts of lake-effect snow during the winter.

Content	IV B
Science and Engineering Practice	7

11. Option (A) is correct. The period is the amount of time it takes for one complete wave cycle, and it can be determined by the time between crests or troughs. The frequency is equal to cycles per second (Hz), or the inverse of the period.

Content	II C
Science and Engineering Practice	2

12. Option (B) is correct. Nondisjunction during meiosis I in a gamete-forming cell occurs when a pair of homologous chromosomes fails to separate, initially resulting in one daughter cell with an extra pair of sister chromatids and the other daughter cell missing a pair of sister chromatids. After meiosis II, if the progenitor cell is a sperm-forming cell, two of the sperm cells will have one extra chromosome and the other two sperm cells will have one less chromosome.

Content	III A

13. Option (B) is correct. The buffer solution is the solution that had the smallest change in pH when the hydrochloric solution was added.

Content	III B
Science and Engineering Practice	6

14. Option (D) is correct. The corona is the outermost layer of the Sun. It has extremely low density and is much dimmer than the Sun's surface. Consequently, it is visible only during a total solar eclipse or when a coronagraph is used.

Content	IV A

15. Option (A) is correct. The data indicate that as the distance between the two objects is doubled, the gravitational force decreases exponentially. In other words, the gravitational force is inversely proportional to the square of the distance, as modeled by the expression $F_g \propto \frac{1}{d^2}$.

Content	I A
Science and Engineering Practice	5
Task of Teaching Science	23

16. Option (B) is correct. The desk is moving at constant speed, which means that the net force acting on the desk is zero. The frictional force is equal to $\mu_k mg$, where μ_k is the coefficient of kinetic friction, *m* is the mass, and *g* is the acceleration due to gravity. The expression mg is equal to the magnitude of weight or the normal force. The frictional force is equal to $(0.2)(100\,\text{N}) = 20\,\text{N}$; therefore, the magnitude of force that the student exerts on the desk is $20\,\text{N}$.

Content	II C
Science and Engineering Practice	5

17. Options (A) and (C) are correct. Autotrophs are organisms, such as grasses, that are capable of producing their food using energy from the Sun or chemical energy. Autotrophs are the producers, the first trophic level, in a food chain or web. In a terrestrial ecosystem, the producers typically have the greatest total biomass and energy. The grasshoppers are primary consumers, or herbivores. The frogs and snakes are secondary and tertiary consumers, and both are classified as carnivores and predators.

Content	III B
Science and Engineering Practice	2
Task of Teaching Science	22

18. Option (B) is correct. Can 2 sinks because the density of the can plus its contents is greater than the density of the ice-water mixture, and can 1 floats because the density of the can plus its contents is less than the density of the ice-water mixture. The difference in the densities is due to the different densities of the solutions in the cans. Therefore, the solution in can 2 is denser than the solution in can 1.

Content	II A
Science and Engineering Practice	6
Task of Teaching Science	20

19. Option (A) is correct. Earthquakes are the abrupt release of energy that occurs when a rock under stress fractures and displacement occurs.

Content	IV B

20. Option (D) is correct. Balanced chemical equations are based on molar ratios. Both the number of molecules and the volume of a gas are directly related to the number of moles. The masses of the reactants and products must first be divided by their molar masses to determine the molar quantities. In the scenario represented by choice (D), $1\,g$ of N_2 is equal to $0.036\,mol$ and $3\,g$ of H_2 is equal to $1.5\,mol$. N_2 is the limiting reactant, and based on the balanced chemical equation, the maximum amount of the NH_3 that can be produced is approximately $0.072\,mol$, or $1.2\,g$.

Content	II B
Science and Engineering Practice	2
Task of Teaching Science	12

21. Option (A) is correct. During the 9 hours of fasting, the animal switched from using carbohydrates as fuel to using fats as fuel. At the start of the fasting period, the respiratory exchange ratio is equal to 1, which corresponds to using carbohydrates as fuel. At the end of the fasting period, the respiratory exchange ratio is equal to 0.70, which corresponds to using fats as fuels.

Content	III A
Science and Engineering Practice	7

22. Option (D) is correct. In the absence of air resistance, a projectile achieves its maximum horizontal distance when launched at a $45°$ angle and its maximum vertical distance (height) and flight time when launched at a $90°$ degree angle (straight up), assuming the same launch speed. Therefore, the projectile fired at $60°$ remains in the air longer, while the projectile fired at $45°$ lands farther away from the launch point.

Content	II C
Science and Engineering Practice	6

23. Option (D) is correct. A polymer is composed of long molecular chains. The molecules are made of repeating structural units known as monomers.

Content	I B
Task of Teaching Science	15

24. Option (C) is correct. Limestone is composed mainly of calcium carbonate. Calcium carbonate is secreted by marine organisms such as algae and coral, and it is also a component in the shells of other marine organisms.

Content	IV B
Task of Teaching Science	21

25. Option (B) is correct. During a phase change of a sample of a substance, the energy content of the sample increases, but the temperature of the sample remains constant. In this example, the added heat mainly is used to disrupt the intermolecular (hydrogen) bonding between the water molecules in the solid phase.

Content	II A

26. Option (D) is correct. Organisms in the kingdom fungi are characterized by cell walls containing chitin. Fungi are heterotrophs that obtain their food by secreting digestive enzymes and absorbing the small organic molecules that are produced.

Content	III B
Science and Engineering Practice	7

27. Option (C) is correct. The ability of an aqueous solution to conduct electricity depends on the concentration of ions in solution. When $AlCl_3$ is dissolved in water to make a $1M$ solution, it dissociates to produce Al^{3+} and Cl^- ions, such that the ion concentration is $4M$. Pure water, CH_3COOH (a weak acid), and NH_3 (a weak base) only partially dissociate; thus, they are considered weak electrolytes.

Content	II B

28. Option (B) is correct. Luminosity is the total amount of energy emitted by a star or other astronomical object per unit of time. The absolute magnitude is a measure of luminosity on a logarithmic scale. On the Hertzsprung-Russell diagram, the lower, or more negative, the value of the absolute magnitude, the more luminous the star. Based on its position on the diagram, Betelgeuse is the star with the greatest luminosity.

Content	IV A
Science and Engineering Practice	4

29. Options (C) and (D) are correct. B cells and macrophages present antigens to helper T cells, which activates an adaptive immune response that is specific to a particular pathogen.

Content	III B

30. Option (A) is correct. The diagram represents a circuit with three resistors connected in parallel. The formula for calculating the equivalent resistance in ohms for a parallel circuit is $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$. For this circuit, $\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12} = \frac{6}{12}$, which gives $R_{eq} = 2\,\Omega$.

Content	II C
Science and Engineering Practice	5

31. Option (C) is correct. The major function of guard cells is to regulate the exchange of gases through the stomata. When water is scarce, the guard cells close the stomata, limiting the amount of water lost through transpiration. The closing of the stomata also results in decreased rates of photosynthesis and cellular respiration by limiting the amount of carbon dioxide and oxygen available.

Content	III B
Science and Engineering Practice	6

32. Option (B) is correct. Ethanol is a volatile, flammable liquid. It should be heated only in a fume hood with a water bath to limit exposure to the vapor and minimize the chance of the vapor igniting. Flammable organic solvents should never be heated with or near an open flame.

Content	I A
Science and Engineering Practice	3
Task of Teaching Science	8

33. Option (B) is correct. The salinity of seawater is typically reported as grams of dissolved salts per kilogram of seawater. When dissolved, the salts are dissociated into ions, including chloride ions. The concentration of chloride ions is always less than the salt concentration.

Content	IV B

34. Option (C) is correct. The female parent who is a carrier has the genotype Cc, and the male parent has the genotype CC. The cross $Cc \times CC$ is expected to produce the $F1$ genotypes CC and Cc in a $1:1$ ratio. Thus, the probability that the child is a carrier is 0.5.

Content	III A
Science and Engineering Practice	5

Understanding Question Types

The *Praxis*® assessments include a variety of question types: constructed response (for which you write a response of your own); selected response, for which you select one or more answers from a list of choices or make another kind of selection (e.g., by selecting a sentence in a text or by selecting part of a graphic); and numeric entry, for which you enter a numeric value in an answer field. You may be familiar with these question formats from taking other standardized tests. If not, familiarize yourself with them so you don't spend time during the test figuring out how to answer them.

Understanding Selected-Response and Numeric-Entry Questions

For most questions, you respond by selecting an oval to select a single answer from a list of answer choices.

However, interactive question types may also ask you to respond by:

- Selecting more than one choice from a list of choices.
- Typing in a numeric-entry box. When the answer is a number, you may be asked to enter a numerical answer. Some questions may have more than one entry box to enter a response. Numeric-entry questions typically appear on mathematics-related tests.
- Selecting parts of a graphic. In some questions, you will select your answers by selecting a location (or locations) on a graphic such as a map or chart, as opposed to choosing your answer from a list.
- Selecting sentences. In questions with reading passages, you may be asked to choose your answers by selecting a sentence (or sentences) within the reading passage.
- Dragging and dropping answer choices into targets on the screen. You may be asked to select answers from a list of choices and to drag your answers to the appropriate location in a table, paragraph of text or graphic.
- Selecting answer choices from a drop-down menu. You may be asked to choose answers by selecting choices from a drop-down menu (e.g., to complete a sentence).

Remember that with every question you will get clear instructions.

Understanding Constructed-Response Questions

Some tests include constructed-response questions, which require you to demonstrate your knowledge in a subject area by writing your own response to topics. Essays and short-answer questions are types of constructed-response questions.

For example, an essay question might present you with a topic and ask you to discuss the extent to which you agree or disagree with the opinion stated. You must support your position with specific reasons and examples from your own experience, observations, or reading.

Review a few sample essay topics:

- *Brown v. Board of Education of Topeka*

  "We come then to the question presented: Does segregation of children in public schools solely on the basis of race, even though the physical facilities and other 'tangible' factors may be equal, deprive the children of the minority group of equal educational opportunities? We believe that it does."

  A. What legal doctrine or principle, established in *Plessy v. Ferguson* (1896), did the Supreme Court reverse when it issued the 1954 ruling quoted above?
  B. What was the rationale given by the justices for their 1954 ruling?

- *In his self-analysis, Mr. Payton says that the better-performing students say small-group work is boring and that they learn more working alone or only with students like themselves. Assume that Mr. Payton wants to continue using cooperative learning groups because he believes they have value for all students.*

  - Describe **TWO** strategies he could use to address the concerns of the students who have complained.
  - Explain how each strategy suggested could provide an opportunity to improve the functioning of cooperative learning groups. Base your response on principles of effective instructional strategies.

- *"Minimum-wage jobs are a ticket to nowhere. They are boring and repetitive and teach employees little or nothing of value. Minimum-wage employers take advantage of people because they need a job."*

  - Discuss the extent to which you agree or disagree with this opinion. Support your views with specific reasons and examples from your own experience, observations, or reading.

Keep these things in mind when you respond to a constructed-response question:

1. **Answer the question accurately.** Analyze what each part of the question is asking you to do. If the question asks you to describe or discuss, you should provide more than just a list.
2. **Answer the question completely.** If a question asks you to do three distinct things in your response, you should cover all three things for the best score. Otherwise, no matter how well you write, you will not be awarded full credit.
3. **Answer the question that is asked.** Do not change the question or challenge the basis of the question. You will receive no credit or a low score if you answer another question or if you state, for example, that there is no possible answer.
4. **Give a thorough and detailed response.** You must demonstrate that you have a thorough understanding of the subject matter. However, your response should be straightforward and not filled with unnecessary information.
5. **Take notes on scratch paper** so that you don't miss any details. Then you'll be sure to have all the information you need to answer the question.
6. **Reread your response.** Check that you have written what you thought you wrote. Be sure not to leave sentences unfinished or omit clarifying information.

General Assistance For The Test

Praxis® Interactive Practice Test

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- Correct answers with detailed explanations
- Practice test results for each content category

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Develop Your Study Plan

Planning your study time is important to help ensure that you review all content areas covered on the test. View a sample plan and learn how to create your own. Learn more at Develop a Study Plan.

Helpful Links

Ready to Register – How to register and the information you need to know to do so.

Disability Accommodations – Testing accommodations are available for test takers who meet ETS requirements.

PLNE Accommodations (ESL) – If English is not your primary language, you may be eligible for extended testing time.

What To Expect on Test Day – Knowing what to expect on test day can make you feel more at ease.

Getting Your Scores – Find out where and when you will receive your test scores.

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Other Praxis Tests – Learn about other *Praxis* tests and how to prepare for them.

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