

The Praxis® Study Companion

Pennsylvania Grades 4–8 Subject Concentration: Science

5159



Welcome to the *Praxis*® Study Companion

Prepare to Show What You Know

You have been working to acquire the knowledge and skills you need for your teaching career. Now you are ready to demonstrate your abilities by taking a *Praxis*® test.

Using *The Praxis Series*® Study Companion is a smart way to prepare for the test so you can do your best on test day. This guide can help keep you on track and make the most efficient use of your study time.

The Study Companion contains practical information and helpful tools, including:

- An overview of the *Praxis* tests
- Specific information on the *Praxis* test you are taking
- A template study plan
- Study topics
- Practice questions and explanations of correct answers
- Test-taking tips and strategies
- Frequently asked questions
- Links to more detailed information

So where should you start? Begin by reviewing this guide in its entirety and note those sections that you need to revisit. Then you can create your own personalized study plan and schedule based on your individual needs and how much time you have before test day.

Keep in mind that study habits are individual. There are many different ways to successfully prepare for your test. Some people study better on their own, while others prefer a group dynamic. You may have more energy early in the day, but another test taker may concentrate better in the evening. So use this guide to develop the approach that works best for you.

Your teaching career begins with preparation. Good luck!

Know What to Expect

Which tests should I take?

Each state or agency that uses the *Praxis* tests sets its own requirements for which test or tests you must take for the teaching area you wish to pursue.

Before you register for a test, confirm your state or agency's testing requirements at www.ets.org/praxis/states.

How are the *Praxis* tests given?

Praxis tests are given on computer. Other formats are available for test takers approved for accommodations (see page 43).

What should I expect when taking the test on computer?

When taking the test on computer, you can expect to be asked to provide proper identification at the test center. Once admitted, you will be given the opportunity to learn how the computer interface works (how to answer questions, how to skip questions, how to go back to questions you skipped, etc.) before the testing time begins. Watch the [What to Expect on Test Day](#) video to see what the experience is like.

Where and when are the *Praxis* tests offered?

You can select the test center that is most convenient for you. The *Praxis* tests are administered through an international network of test centers, which includes Prometric® Testing Centers, some universities, and other locations throughout the world.

Testing schedules may differ, so see the *Praxis* Web site for more detailed test registration information at www.ets.org/praxis/register.

Table of Contents

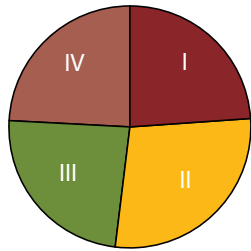
The Praxis® Study Companion guides you through the steps to success

1. Learn About Your Test	5
<i>Learn about the specific test you will be taking</i>	
2. Familiarize Yourself with Test Questions	13
<i>Become comfortable with the types of questions you'll find on the Praxis tests</i>	
3. Practice with Sample Test Questions	17
<i>Answer practice questions and find explanations for correct answers</i>	
4. Determine Your Strategy for Success	22
<i>Set clear goals and deadlines so your test preparation is focused and efficient</i>	
5. Develop Your Study Plan	25
<i>Develop a personalized study plan and schedule</i>	
6. Review Study Topics	29
<i>Review detailed study topics with questions for discussion</i>	
7. Review Smart Tips for Success	41
<i>Follow test-taking tips developed by experts</i>	
8. Check on Testing Accommodations	43
<i>See if you qualify for accommodations that may make it easier to take the Praxis test</i>	
9. Do Your Best on Test Day	44
<i>Get ready for test day so you will be calm and confident</i>	
10. Understand Your Scores	46
<i>Understand how tests are scored and how to interpret your test scores</i>	
Appendix: Other Questions You May Have	48

1. Learn About Your Test

Learn about the specific test you will be taking

Pennsylvania Grades 4–8 Subject Concentration: Science (5159)

Test at a Glance			
Test Name	Pennsylvania Grades 4-8 Subject Concentration: Science		
Test Code	5159		
Time	1 hour and 30 minutes		
Number of Questions	90		
Format	Selected-response questions; scientific or four-function calculator use permitted		
Test Delivery	Computer delivered		
	Content Categories	Approximate Number of Questions	Approximate Percentage of Examination
	I. Basic Principles and Processes	21	24%
	II. Physical Sciences	25	28%
	III. Life Sciences	22	24%
	IV. Earth and Space Sciences	22	24%

About This Test

The purpose of the Pennsylvania Grades 4–8 Subject Concentration: Science test is to assess whether the entry-level middle school teacher has the content knowledge that is important, necessary, and needed at the time of entry to the profession in order to teach science.

Scientific or four-function calculator use is permitted.

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

Test Specifications

Test specifications in this chapter describe the knowledge and skills measured by the test. Study topics that help you prepare to answer test questions are in “6. Review Study Topics” on page 29. Not every subtopic in a content area appears on any one test form, but every test form contains questions on a broad range of subtopics

I. Basic Principles and Processes

A. Scientific Inquiry, Methodology, Techniques, and History

1. Understands methods of scientific inquiry and how they are used in basic problem solving
 - a. observations, hypotheses, experiments, conclusions, theories, models, and laws
 - b. experimental design, including independent and dependent variables, controls, and sources of error
 - c. nature of scientific knowledge
 - consistent with evidence, based on reproducible evidence, subject to change based on new evidence
 - includes unifying concepts and processes (e.g., systems, models, constancy and change, equilibrium, form and function)
2. Understands the processes involved in scientific data collection and manipulation
 - a. common units of measurement (e.g., units of length, time, mass, volume, pressure, energy, force), including prefixes such as milli and kilo
 - b. scientific notation and significant figures
 - c. organization and presentation of data (e.g., graphs, tables, charts)
 - d. basic error analysis (e.g., accuracy, precision)
 - e. basic descriptive statistics (e.g., calculate averages, distinguish between mean, mode, and median)
3. Knows how to interpret and draw conclusions from data presented in tables, graphs, maps, and charts
 - a. trends in data
 - b. relationships between variables
 - c. predictions based on data
 - d. conclusions based on the evidence
4. Is familiar with the procedures for safe and correct preparation, storage, use, and disposal of laboratory materials
 - a. safe storage
 - b. appropriate and safe disposal (e.g., chemicals, biohazards)
 - c. appropriate preparation and handling
5. Understands safety and emergency procedures in the laboratory
 - a. equipment (e.g., fire extinguishers, eyewash stations, safety showers, fire blanket)
 - b. appropriate student apparel and behavior (e.g., goggles, clothing)
 - c. emergency procedures for minor burns and other injuries
 - d. emergency procedures for mishaps (e.g., fires, chemical spills)
 - e. evacuation procedures
6. Is familiar with how to use standard equipment in the laboratory
 - a. appropriate use of equipment (e.g., thermometers, microscopes, barometers, graduated cylinders, Bunsen burners, balances, pH meters)
 - b. basic care, preparation, and maintenance of equipment
7. Is familiar with the historical developments of science and the contributions of major historical figures
 - a. how major concepts developed over time (e.g., atomic models, genetics, plate tectonics)
 - b. key historical figures and their contributions

B. Basic Principles of Matter and Energy

1. Is familiar with the structure and properties of matter
 - a. solids, liquids, gases, and plasmas
 - b. elements, atoms, compounds, molecules, and mixtures
 - c. elements and their isotopes
2. Knows the basic relationships between energy and matter
 - a. conservation of energy (first law of thermodynamics)
 - b. entropy changes (second law of thermodynamics)
 - c. conservation of matter in chemical processes
 - d. forms of kinetic and potential energy (e.g., thermal, chemical, radiant, mechanical)
 - e. energy transformations (e.g., light to heat, potential to kinetic)
 - f. chemical and physical properties/changes
 - g. temperature scales (e.g., Celsius, Fahrenheit, and Kelvin; comparisons between the scales)
 - h. difference between heat and temperature
 - i. effect of thermal energy on matter and the measurement of thermal energy (e.g., specific heat capacity)
 - j. methods of heat transfer (e.g., convection, radiation, conduction)
 - k. interdisciplinary applications of energy and matter relationships
 - trophic levels
 - matter cycling and energy flow in ecosystems
 - convection currents in atmosphere, ocean, and mantle
 - conservation of mass in the rock cycle
 - nitrogen cycle
 - chemical and physical changes in rocks
 - impact of solar radiation on Earth and life
 - photosynthesis and cellular respiration
 - energy transformations in living systems

3. Knows the basic structure of the atom
 - a. atomic models
 - b. atomic structure including electrons, protons, and neutrons
 - c. atomic number and mass
 - d. ions
 - e. electron arrangements
 - f. radioisotopes, radioactive decay, half-life, fission, and fusion

C. Science, Technology, and Society

1. Understands the impact of science and technology on the environment and society
 - a. air and water pollution
 - b. greenhouse gases
 - c. global climate and sea level change
 - d. waste disposal and recycling
 - e. acid rain
 - f. loss of biodiversity (e.g., habitat destruction, invasive species)
 - g. ozone depletion
2. Knows major issues associated with energy production and the management of natural resources
 - a. conservation and recycling
 - b. renewable and nonrenewable resources
 - c. pros and cons of power generation based on various sources (e.g., fossil, nuclear, water, wind, solar, biomass, geothermal)
 - d. use and extraction of Earth's resources (e.g., mining, reclamation, deforestation, drilling)

3. Is familiar with applications of science and technology in daily life
 - a. chemical properties of household products
 - b. batteries, wireless devices, microchips, lasers, and fiber optics
 - c. communication satellites
 - d. contributions of space technology (e.g., GPS)
 - e. common agricultural practices (e.g., genetically modified crops, use of pesticides, fertilizers)
 - f. DNA evidence in forensic investigations
4. Is familiar with the impact of science on public-health issues
 - a. nutrition, disease, and medicine (e.g., food preservation, vitamins, vaccines, viruses)
 - b. biotechnology (e.g., genetic engineering, human genome project)
 - c. medical technologies (e.g., MRIs, X-rays, radiation therapy)
5. Analyzes motion and forces in a physical situation, including basic problems
 - e. analyze motion and forces in a physical situation, including basic problems
 - Newton’s first law: inertia
 - Newton’s second law: $F = ma$
 - Newton’s third law: action-reaction forces
 - Inclined planes
 - Projectile motion
 - Periodic motion (e.g., pendulums, springs, planetary orbits)
 - Conservation of energy and conservation of momentum (e.g., collisions)
 - f. simple and compound machines and mechanical advantage
 - g. physical properties of fluids (e.g., buoyancy, density, pressure)
2. Knows electricity and magnetism
 - a. electrical nature of materials
 - electric charges
 - electrostatic attraction and repulsion
 - conductivity, conductors, and insulators
 - b. analyze basic series and parallel electrical circuits
 - DC and AC current
 - current, resistance, voltage, and power
 - Ohm’s law
 - voltage sources (batteries, generators)
 - c. magnetic fields and forces
 - magnetic materials
 - magnetic forces and fields (e.g., magnetic poles, attractive and repulsive forces)
 - electromagnets

II. Physical Sciences

A. Physics

1. Understands mechanics
 - a. describe linear and circular motion in one and two dimensions
 - speed
 - velocity
 - acceleration
 - momentum
 - b. friction
 - c. work, energy, and power
 - d. mass, weight, and gravity
 - characteristics of gravitation (e.g., gravitational attraction, acceleration due to gravity, mass, distance)
 - distinguish between mass and weight
3. Understands basic waves and optics
 - a. characteristics of light and the electromagnetic spectrum
 - nature of light
 - visible spectrum and color
 - ultraviolet, infrared, microwave, and gamma
 - b. basic characteristics and types of waves
 - transverse and longitudinal
 - amplitude, frequency, wavelength, speed, intensity

- c. basic wave phenomena
 - reflection, refraction, diffraction, scattering
 - absorption and transmission
 - interference and polarization
 - Doppler effect
- d. basic characteristics and phenomena of sound
 - pitch/frequency and loudness/intensity
 - sound-wave production, air vibrations, and resonance (e.g., tuning forks)
- e. basic optics
 - mirrors
 - lenses and their applications (e.g., the human eye, microscope, telescope)
 - prisms

B. Chemistry

1. Is familiar with how to use the periodic table to predict the physical and chemical properties of elements
 - a. organization of the periodic table
 - arranged in columns and rows (e.g., groups/families, periods)
 - includes symbol, atomic number, and atomic mass for each element
 - b. general trends in chemical reactivity based on position of elements in the periodic table (e.g., metallic and nonmetallic elements, noble gases)
 - c. general trends in physical properties based on position of elements in the periodic table (e.g., atomic radius, ionization energy)
2. Knows types of chemical bonding and the composition of simple chemical compounds
 - a. covalent and ionic bonding
 - b. names of simple chemical compounds
 - ionic
 - covalent compounds involving two elements
 - acids and bases
 - common names (e.g., methane, glucose, ammonia)
 - c. interpret chemical formulas
 - describe formulas in terms of moles of atoms
 - percent composition
 - empirical/molecular formulas
 - electron dot and structural formulas
3. Understands states of matter and phase changes between them
 - a. basic assumptions of the kinetic molecular theory of matter (e.g., particles in constant motion, speed and energy of gas particles are related to temperature)
 - b. ideal gas laws (e.g., volume is directly proportional to temperature, pressure and volume are inversely proportional)
 - c. phase changes
 - melting/freezing
 - vaporization/condensation
 - sublimation
 - heating/cooling curves (e.g., heat of vaporization, heat of fusion)
4. Knows how to balance and use simple chemical equations
 - a. balance simple chemical reactions
 - b. simple stoichiometric calculations involving balanced equations
 - c. use chemical formulas and equations to identify and describe simple chemical reactions
 - combustion
 - oxidation (e.g., iron rusting)
 - neutralization
 - single or double replacement
 - d. energy relationships (e.g., endothermic reactions, exothermic reactions)
 - e. factors that affect reaction rates (e.g., concentration, temperature, pressure, catalysts/enzymes)
5. Understands basic concepts in acid-base chemistry
 - a. chemical and physical properties of acids and bases
 - b. pH scale
 - c. neutralization
 - d. buffers

6. Is familiar with solutions and solubility
 - a. solution terminology and identification of different types of solutions
 - dilute and concentrated solutions
 - saturated, unsaturated, and supersaturated solutions
 - solvents and solutes
 - concentrations of solutions (e.g., molarity, and percent by mass)
 - b. factors affecting the dissolving process and solubility of substances
 - effect of temperature and particle size on dissolving
 - effect of temperature on solubility
 - polar versus non-polar solvents and solutes (e.g., like dissolving like)
 - ionic compounds dissociate in water and form ions (e.g., electrolytes)

III. Life Sciences

1. Understands the basic structure and function of cells and their organelles
 - a. structure and function of cell membranes (e.g., passive and active transport, osmosis)
 - b. structure and function of cell organelles (e.g., chloroplasts, mitochondria)
 - c. levels of organization (cells, tissues, organs, organ systems)
 - d. identify specialized cell types (e.g., muscle, nerve, epithelial)
 - e. prokaryotes and eukaryotes
2. Understands basic cell reproduction
 - a. cell cycle
 - b. mitosis
 - c. meiosis
 - d. cytokinesis
3. Is familiar with the basic biochemistry of life
 - a. cellular respiration
 - b. photosynthesis
 - c. fermentation
 - d. biological molecules (e.g., DNA, carbohydrates, proteins, lipids, enzymes)
4. Understands basic genetics
 - a. DNA structure
 - b. replication, transcription, and translation
 - c. dominant, co-dominant, and recessive alleles
 - d. Mendelian inheritance (e.g., genotype, phenotype, pedigree, sex-linked traits, use of Punnett squares)
 - e. mutations, chromosomal abnormalities, and common human genetic disorders
5. Understands the theory and key mechanisms of evolution
 - a. mechanisms of evolution (e.g., natural selection, punctuated equilibrium)
 - b. isolation mechanisms and speciation
 - c. supporting evidence (e.g., fossil record, comparative genetics, homologous structures)
6. Knows the elements of the hierarchical classification scheme and the characteristics of the major groups of organisms
 - a. classification schemes (e.g., domain, kingdom, phylum/division, class, order, family, genus, species)
 - b. characteristics of animals, plants, fungi, protists, and bacteria
7. Knows the major structures and functions of plant organs and systems
 - a. characteristics of vascular and nonvascular plants
 - b. characteristics of gymnosperms and angiosperms
 - c. responses to stimuli
 - d. structure and function of leaves, roots, and stems
 - e. asexual and sexual reproduction
 - f. uptake and transport of nutrients and water
 - g. growth

8. Knows the basic anatomy and physiology of animals, including structure and function of human body systems and the major differences between humans and other animals
 - a. homeostasis
 - b. exchange with the environment (e.g., respiratory, excretory, digestive systems)
 - c. internal transport and exchange (e.g., circulatory system)
 - d. movement and support (e.g., skeletal system, muscular systems)
 - e. reproduction and development
 - f. immune systems
 - g. control systems (e.g., nervous system, endocrine system)
 - h. physiological effects on behavior (e.g., bird migration)
9. Knows key aspects of ecology
 - a. population dynamics (e.g., growth curves, carrying capacity, mating systems, and social systems, behavior such as territoriality)
 - b. community ecology (e.g., niche, succession, species diversity, symbiosis, interspecific relationships such as predator-prey)
 - c. ecosystems
 - biomes – terrestrial and aquatic
 - stability and disturbances (e.g., glaciations, effect of global warming)
 - energy flow (e.g., trophic levels, food webs)
 - biogeochemical cycles (e.g., water, nitrogen, and carbon cycles, biotic and abiotic interaction)
- b. classification of minerals and their formation processes (e.g., crystal form, hardness, streak)
2. Is familiar with processes involved in erosion, weathering, and deposition of Earth's surface materials and soil formation
 - a. erosion and deposition (e.g., agents of erosion)
 - b. chemical and physical (mechanical) weathering
 - c. characteristics of soils (e.g., types, soil profile)
 - d. porosity and permeability
 - e. runoff and infiltration
3. Knows Earth's basic structure and internal processes
 - a. Earth's layers (e.g., lithosphere, asthenosphere, crust, mantle, core)
 - b. Earth's shape and size
 - c. geographical features (e.g., mountains, plateaus, mid-ocean ridges)
 - d. topographic, cross-sectional, and structural maps
 - e. Earth's magnetic field
 - f. plate tectonics theory and evidence
 - folding and faulting
 - continental drift
 - magnetic reversals
 - characteristics of volcanoes and their formation (e.g., types, lava, eruptions)
 - characteristics of earthquakes and reasons they occur (e.g., epicenters, faults, tsunamis)
 - seismic waves and triangulation

IV. Earth and Space Sciences

A. Physical Geology

1. Is familiar with types and characteristics of rocks, minerals, and their formation processes
 - a. characteristics of rocks and their formation processes (e.g., igneous, metamorphic, and sedimentary rocks, the rock cycle)

B. Historical Geology

1. Is familiar with historical geology
 - a. principle of uniformitarianism
 - b. basic principles of stratigraphy (e.g., law of superposition)
 - c. relative and absolute time (e.g., index fossils, radioactive dating)
 - d. geologic time scale (e.g., eras, periods)
 - e. fossil formation and the fossil record
 - f. important events in Earth's geologic history (e.g., Pangaea, mass extinctions, Cambrian explosion, ice ages, meteor impacts)

C. Earth's Hydrosphere and Atmosphere

1. Is familiar with the water cycle
 - a. evaporation and transpiration
 - b. condensation
 - c. precipitation
 - d. runoff
2. Is familiar with Earth's oceans and other bodies of water and their geologic features
 - a. tides, waves, and currents
 - b. estuaries and barrier islands
 - c. island, reef, and atoll formation
 - d. polar ice caps, icebergs, and glaciers
 - e. lakes, ponds, streams, rivers, and river deltas
 - f. groundwater, water table, wells, and aquifers
 - g. properties of water that affect Earth systems (e.g., density changes when freezing, high heat capacity, polar solvent)
3. Knows basic meteorology
 - a. structure of Earth's atmosphere (e.g., troposphere, stratosphere)
 - b. composition of Earth's atmosphere (e.g., percent composition of oxygen and nitrogen)
 - c. atmospheric pressure and temperature
 - d. wind
 - e. cloud types and cloud formation
 - f. frontal systems, weather maps, storms, and severe weather
 - g. humidity, dew point, and frost point
 - h. forms of precipitation
4. Knows major factors that affect climate and seasons
 - a. climate zones (e.g., Tropics, Arctic)
 - b. proximity to mountains and oceans
 - c. global winds and ocean circulation
 - d. latitude, geographical location, and elevation
 - e. natural phenomena (e.g., volcanic eruptions, solar radiation)
 - f. effect of Earth's tilt on seasons

D. Astronomy

1. Is familiar with the major features of the solar system
 - a. structure of the solar system (e.g., orbits of the planets)
 - b. characteristics of planets (e.g., composition, unique features)
 - c. characteristics of the Sun
 - d. asteroids, meteoroids, and comets
 - e. origin of the solar system
2. Is familiar with the interactions of the Earth-Moon-Sun system
 - a. Earth's rotation and orbital revolution around the Sun
 - b. effect on seasons
 - c. phases of the Moon
 - d. effect on tides
 - e. solar and lunar eclipses
3. Is familiar with the major features of the universe and its origin
 - a. galaxies (e.g., types, Milky Way)
 - b. stars and their life cycle (e.g., Hertzsprung-Russell diagram, types, nebulae, black holes)
 - c. units of celestial distance (e.g., light-year, astronomical unit)
 - d. Big Bang theory
4. Is familiar with contributions of space exploration and technology to astronomy
 - a. remote-sensing devices (e.g., optical/radio telescopes, Hubble telescope, satellites, space probes)
 - b. search for life and water on other planets

2. Familiarize Yourself with Test Questions

Become comfortable with the types of questions you'll find on the Praxis tests

The *Praxis Series* 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 clicking on a sentence in a text or by clicking on 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 Computer-Delivered Questions

Questions on computer-delivered tests are interactive in the sense that you answer by selecting an option or entering text on the screen. If you see a format you are not familiar with, read the directions carefully. The directions always give clear instructions on how you are expected to respond.

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

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

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

Remember that with every question you will get clear instructions.

Perhaps the best way to understand computer-delivered questions is to view the [Computer-delivered Testing Demonstration](#) on the Praxis Web site to learn how a computer-delivered test works and see examples of some types of questions you may encounter.

Understanding Selected-Response Questions

Many selected-response questions begin with the phrase “which of the following.” Take a look at this example:

Which of the following is a flavor made from beans?

- (A) Strawberry
- (B) Cherry
- (C) Vanilla
- (D) Mint

How would you answer this question?

All of the answer choices are flavors. Your job is to decide which of the flavors is the one made from beans.

Try following these steps to select the correct answer.

- 1) **Limit your answer to the choices given.** You may know that chocolate and coffee are also flavors made from beans, but they are not listed. Rather than thinking of other possible answers, focus only on the choices given (“which of the following”).
- 2) **Eliminate incorrect answers.** You may know that strawberry and cherry flavors are made from fruit and that mint flavor is made from a plant. That leaves vanilla as the only possible answer.
- 3) **Verify your answer.** You can substitute “vanilla” for the phrase “which of the following” and turn the question into this statement: “Vanilla is a flavor made from beans.” This will help you be sure that your answer is correct. If you’re still uncertain, try substituting the other choices to see if they make sense. You may want to use this technique as you answer selected-response questions on the practice tests.

Try a more challenging example

The vanilla bean question is pretty straightforward, but you’ll find that more challenging questions have a similar structure. For example:

Entries in outlines are generally arranged according to which of the following relationships of ideas?

- (A) Literal and inferential
- (B) Concrete and abstract
- (C) Linear and recursive
- (D) Main and subordinate

You’ll notice that this example also contains the phrase “which of the following.” This phrase helps you determine that your answer will be a “relationship of ideas” from the choices provided. You are supposed to find the choice that describes how entries, or ideas, in outlines are related.

Sometimes it helps to put the question in your own words. Here, you could paraphrase the question in this way: “How are outlines usually organized?” Since the ideas in outlines usually appear as main ideas and subordinate ideas, the answer is (D).

QUICK TIP: Don't be intimidated by words you may not understand. It might be easy to be thrown by words like "recursive" or "inferential." Read carefully to understand the question and look for an answer that fits. An outline is something you are probably familiar with and expect to teach to your students. So slow down, and use what you know.

Watch out for selected-response questions containing "NOT," "LEAST," and "EXCEPT"

This type of question asks you to select the choice that does not fit. You must be very careful because it is easy to forget that you are selecting the negative. This question type is used in situations in which there are several good solutions or ways to approach something, but also a clearly wrong way.

How to approach questions about graphs, tables, or reading passages

When answering questions about graphs, tables, or reading passages, provide only the information that the questions ask for. In the case of a map or graph, you might want to read the questions first, and then look at the map or graph. In the case of a long reading passage, you might want to go ahead and read the passage first, noting places you think are important, and then answer the questions. Again, the important thing is to be sure you answer the questions as they refer to the material presented. So read the questions carefully.

How to approach unfamiliar formats

New question formats are developed from time to time to find new ways of assessing knowledge. Tests may include audio and video components, such as a movie clip or animation, instead of a map or reading passage. Other tests may allow you to zoom in on details in a graphic or picture.

Tests may also include interactive questions. These questions take advantage of technology to assess knowledge and skills in ways that standard selected-response questions cannot. If you see a format you are not familiar with, **read the directions carefully**. The directions always give clear instructions on how you are expected to respond.

QUICK TIP: Don't make the questions more difficult than they are. Don't read for hidden meanings or tricks. There are no trick questions on *Praxis* tests. They are intended to be serious, straightforward tests of your knowledge.

Understanding Constructed-Response Questions

Constructed-response questions require you to demonstrate your knowledge in a subject area by creating your own response to particular 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.

Take a look at a few sample essay topics:

- "Celebrities have a tremendous influence on the young, and for that reason, they have a responsibility to act as role models."
- "We are constantly bombarded by advertisements—on television and radio, in newspapers and magazines, on highway signs, and the sides of buses. They have become too pervasive. It's time to put limits on advertising."
- "Advances in computer technology have made the classroom unnecessary, since students and teachers are able to communicate with one another from computer terminals at home or at work."

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) **Reread your response.** Check that you have written what you thought you wrote. Be sure not to leave sentences unfinished or omit clarifying information.

QUICK TIP: You may find that it helps to 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.

For tests that have constructed-response questions, more detailed information can be found in "Understanding Constructed-Response Questions" on page 15.

3. Practice with Sample Test Questions

Answer practice questions and find explanations for correct answers

Sample Test Questions

The sample questions that follow illustrate the kinds of questions 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.



- 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

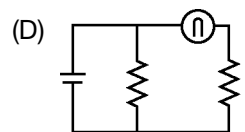
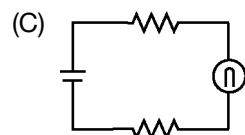
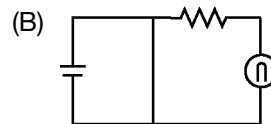
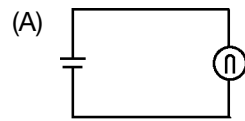
Consider the atoms described above. Which of the following are isotopes of each other?

 - 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

8. 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?
- (A) The presence of cells in the sample
 - (B) The presence of hydrogen in the sample
 - (C) Diffusion of material out of the sample
 - (D) 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

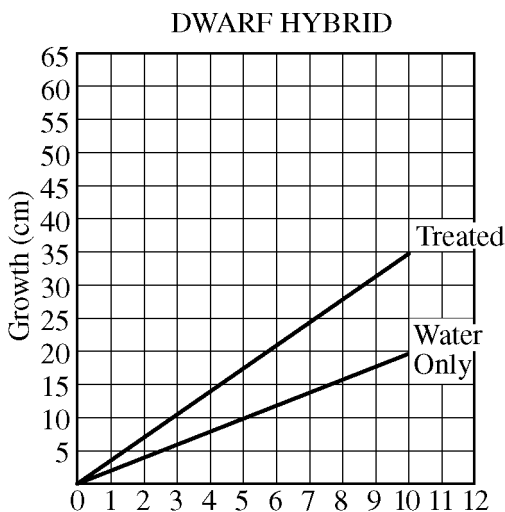
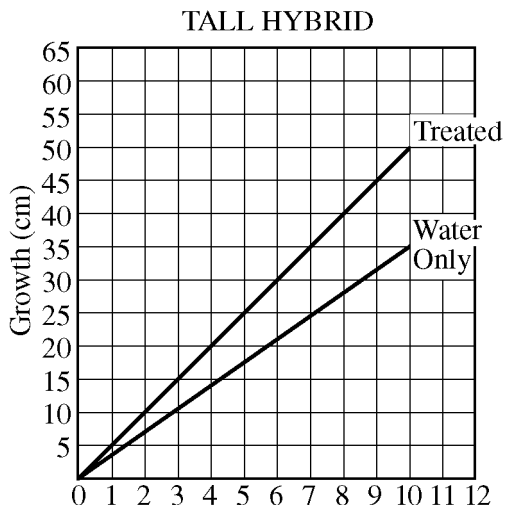
10. In which of the following is the battery short-circuited?

= – 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 gram
 - (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?
- The new fertilizer influences the growth of both corn varieties tested.
 - The new fertilizer causes faster growth rate for both varieties than do other fertilizers.
 - The new fertilizer improves the root system of the tall hybrid to a greater extent than it does that of the dwarf hybrid.
 - 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?
- The tilt of the Earth's axis of rotation relative to the ecliptic
 - The varying amount of sunspot activity
 - The Earth's orbit about the Sun as an ellipse rather than a circle
 - The rotation of the Earth during a 24-hour day
15. Of the following, which atom has the smallest atomic radius?
- S
 - Al
 - Na
 - Ba
16. Animals in which of the following groups may have a backbone and a spinal cord?
- Mollusks
 - Chordates
 - Invertebrates
 - Echinoderms
17. Which of the following parts of the Sun is easily visible only during a total solar eclipse?
- Core
 - Photosphere
 - Sunspots
 - Corona
18. The true length of a block of wood is 1.010 cm. Three measurements of this block produced the following values: 1.4 cm, 1.2 cm, and 0.9 cm. Which of the following statements is true concerning these measurements?
- They are precise and accurate.
 - They are precise but not accurate.
 - They are accurate but not precise.
 - They are neither precise nor accurate.

Answers to Sample Questions

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 (2×18.0 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 2×32.0 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.

15. The correct answer is (A). S has the smallest atomic radius. The relative atomic radii of the atoms of various elements can be predicted from the position of the element on the periodic table. Going across a row of the periodic table from left to right, the radii get smaller, and going down a column, the radii get larger. The correct order of atomic radii for elements in this question is $Ba > Na > Al > S$.

16. The correct answer is (B). Most chordates possess a vertebral column (backbone) that surrounds a dorsal nerve cord. Mollusks (e.g., clams and mussels) and echinoderms (e.g., sea stars and sea urchins) are invertebrates that lack a vertebral column and dorsal nerve cord.

17. The correct answer is (D). The Sun's corona has extremely low density and is visible only during a total solar eclipse.

18. The correct answer is (D). The measurements differ from the true length by 0.39 cm, 0.19 cm, and -0.11 cm. Thus, the measurements are quite different in value from the true value, which means that they are not accurate. The measurements are also quite different in value from one another (not repeatable), which means that they are not precise.

4. Determine Your Strategy for Success

Set clear goals and deadlines so your test preparation is focused and efficient

Effective *Praxis* test preparation doesn't just happen. You'll want to set clear goals and deadlines for yourself along the way. Otherwise, you may not feel ready and confident on test day.

1) Learn what the test covers.

You may have heard that there are several different versions of the same test. It's true. You may take one version of the test and your friend may take a different version a few months later. Each test has different questions covering the same subject area, but both versions of the test measure the same skills and content knowledge.

You'll find specific information on the test you're taking in "1. Learn About Your Test" on page 5, which outlines the content categories that the test measures and what percentage of the test covers each topic. Visit www.ets.org/praxis/testprep for information on other *Praxis* tests.

2) Assess how well you know the content.

Research shows that test takers tend to overestimate their preparedness—this is why some test takers assume they did well and then find out they did not pass.

The *Praxis* tests are demanding enough to require serious review of likely content, and the longer you've been away from the content, the more preparation you will most likely need. If it has been longer than a few months since you've studied your content area, make a concerted effort to prepare.

3) Collect study materials.

Gathering and organizing your materials for review are critical steps in preparing for the *Praxis* tests. Consider the following reference sources as you plan your study:

- Did you take a course in which the content area was covered? If yes, do you still have your books or your notes?
- Does your local library have a high school-level textbook in this area? Does your college library have a good introductory college-level textbook in this area?

Practice materials are available for purchase for many *Praxis* tests at www.ets.org/praxis/testprep. Test preparation materials include sample questions and answers with explanations.

4) Plan and organize your time.

You can begin to plan and organize your time while you are still collecting materials. Allow yourself plenty of review time to avoid cramming new material at the end. Here are a few tips:

- Choose a test date far enough in the future to leave you plenty of preparation time. Test dates can be found at www.ets.org/praxis/register/centers_dates.
- Work backward from that date to figure out how much time you will need for review.
- Set a realistic schedule—and stick to it.

5) Practice explaining the key concepts.

Praxis tests with constructed-response questions assess your ability to explain material effectively. As a teacher, you'll need to be able to explain concepts and processes to students in a clear, understandable way. What are the major concepts you will be required to teach? Can you explain them in your own words accurately, completely, and clearly? Practice explaining these concepts to test your ability to effectively explain what you know.

6) Understand how questions will be scored.

Scoring information can be found in "10. Understand Your Scores" on page 46.

7) Develop a study plan.

A study plan provides a road map to prepare for the *Praxis* tests. It can help you understand what skills and knowledge are covered on the test and where to focus your attention. Use the study plan template on page 27 to organize your efforts.

And most important—get started!

Would a Study Group Work for You?

Using this guide as part of a study group

People who have a lot of studying to do sometimes find it helpful to form a study group with others who are working toward the same goal. Study groups give members opportunities to ask questions and get detailed answers. In a group, some members usually have a better understanding of certain topics, while others in the group may be better at other topics. As members take turns explaining concepts to one another, everyone builds self-confidence.

If the group encounters a question that none of the members can answer well, the group can go to a teacher or other expert and get answers efficiently. Because study groups schedule regular meetings, members study in a more disciplined fashion. They also gain emotional support. The group should be large enough so that multiple people can contribute different kinds of knowledge, but small enough so that it stays focused. Often, three to six members is a good size.

Here are some ways to use this guide as part of a study group:

- **Plan the group's study program.** Parts of the study plan template, beginning on page 27, can help to structure your group's study program. By filling out the first five columns and sharing the worksheets, everyone will learn more about your group's mix of abilities and about the resources, such as textbooks, that members can share with the group. In the sixth column ("Dates I will study the content"), you can create an overall schedule for your group's study program.
- **Plan individual group sessions.** At the end of each session, the group should decide what specific topics will be covered at the next meeting and who will present each topic. Use the topic headings and subheadings in the Test at a Glance table on page 5 to select topics, and then select practice questions, beginning on page 17.
- **Prepare your presentation for the group.** When it's your turn to present, prepare something that is more than a lecture. Write two or three original questions to pose to the group. Practicing writing actual questions can help you better understand the topics covered on the test as well as the types of questions you will encounter on the test. It will also give other members of the group extra practice at answering questions.

- **Take a practice test together.** The idea of a practice test is to simulate an actual administration of the test, so scheduling a test session with the group will add to the realism and may also help boost everyone's confidence. Remember, complete the practice test using only the time that will be allotted for that test on your administration day.
- **Learn from the results of the practice test.** Review the results of the practice test, including the number of questions answered correctly in each content category. For tests that contain constructed-response questions, look at the Sample Test Questions section, which also contain sample responses to those questions and shows how they were scored. Then try to follow the same guidelines that the test scorers use.
- **Be as critical as you can.** You're not doing your study partner(s) any favors by letting them get away with an answer that does not cover all parts of the question adequately.
- **Be specific.** Write comments that are as detailed as the comments about the sample responses. Indicate where and how your study partner(s) are doing an inadequate job of answering the question. Writing notes in the margins of the answer sheet may also help.
- **Be supportive.** Include comments that point out what your study partner(s) got right.

Then plan one or more study sessions based on aspects of the questions on which group members performed poorly. For example, each group member might be responsible for rewriting one paragraph of a response in which someone else did an inadequate job.

Whether you decide to study alone or with a group, remember that the best way to prepare is to have an organized plan. The plan should set goals based on specific topics and skills that you need to learn, and it should commit you to a realistic set of deadlines for meeting those goals. Then you need to discipline yourself to stick with your plan and accomplish your goals on schedule.

5. Develop Your Study Plan

Develop a personalized study plan and schedule

Planning your study time is important because it will help ensure that you review all content areas covered on the test. Use the sample study plan below as a guide. It shows a plan for the *Core Academic Skills for Educators: Reading* test. Following that is a study plan template that you can fill out to create your own plan. Use the "Learn about Your Test" and "Test Specifications" information beginning on page 5 to help complete it.

Use this worksheet to:

1. **Define Content Areas:** List the most important content areas for your test as defined in chapter 1.
2. **Determine Strengths and Weaknesses:** Identify your strengths and weaknesses in each content area.
3. **Identify Resources:** Identify the books, courses, and other resources you plan to use for each content area.
4. **Study:** Create and commit to a schedule that provides for regular study periods.

Praxis Test Name (Test Code): Core Academic Skills for Educators: Reading (5712)

Test Date: 9/15/15

Content covered	Description of content	How well do I know the content? (scale 1–5)	What resources do I have/need for the content?	Where can I find the resources I need?	Dates I will study the content	Date completed
Key Ideas and Details						
Close reading	Draw inferences and implications from the directly stated content of a reading selection	3	Middle school English textbook	College library, middle school teacher	7/15/15	7/15/15
Determining Ideas	Identify summaries or paraphrases of the main idea or primary purpose of a reading selection	3	Middle school English textbook	College library, middle school teacher	7/17/15	7/17/15
Determining Ideas	Identify summaries or paraphrases of the supporting ideas and specific details in a reading selection	3	Middle and high school English textbook	College library, middle and high school teachers	7/20/15	7/21/15
Craft, Structure, and Language Skills						
Interpreting tone	Determine the author's attitude toward material discussed in a reading selection	4	Middle and high school English textbook	College library, middle and high school teachers	7/25/15	7/26/15
Analysis of structure	Identify key transition words and phrases in a reading selection and how they are used	3	Middle and high school English textbook, dictionary	College library, middle and high school teachers	7/25/15	7/27/15
Analysis of structure	Identify how a reading selection is organized in terms of cause/effect, compare/contrast, problem/solution, etc.	5	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/1/15	8/1/15
Author's purpose	Determine the role that an idea, reference, or piece of information plays in an author's discussion or argument	5	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/1/15	8/1/15

(continued on next page)

Content covered	Description of content	How well do I know the content? (scale 1–5)	What resources do I have/need for the content?	Where can I find the resources I need?	Dates I will study the content	Date completed
Language in different contexts	Determine whether information presented in a reading selection is presented as fact or opinion	4	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/1/15	8/1/15
Contextual meaning	Identify the meanings of words as they are used in the context of a reading selection	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/1/15	8/1/15
Figurative Language	Understand figurative language and nuances in word meanings	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/8/15	8/8/15
Vocabulary range	Understand a range of words and phrases sufficient for reading at the college and career readiness level	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/15/15	8/17/15
Integration of Knowledge and Ideas						
Diverse media and formats	Analyze content presented in diverse media and formats, including visually and quantitatively, as well as in words	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/22/15	8/24/15
Evaluation of arguments	Identify the relationship among ideas presented in a reading selection	4	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/24/15	8/24/15
Evaluation of arguments	Determine whether evidence strengthens, weakens, or is relevant to the arguments in a reading selection	3	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/27/15	8/27/15
Evaluation of arguments	Determine the logical assumptions upon which an argument or conclusion is based	5	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/28/15	8/30/15
Evaluation of arguments	Draw conclusions from material presented in a reading selection	5	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/30/15	8/31/15
Comparison of texts	Recognize or predict ideas or situations that are extensions of or similar to what has been presented in a reading selection	4	High school textbook, college course notes	College library, course notes, high school teacher, college professor	9/3/15	9/4/15
Comparison of texts	Apply ideas presented in a reading selection to other situations	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	9/5/15	9/6/15

My Study Plan

Use this worksheet to:

1. **Define Content Areas:** List the most important content areas for your test as defined in chapter 1.
2. **Determine Strengths and Weaknesses:** Identify your strengths and weaknesses in each content area.
3. **Identify Resources:** Identify the books, courses, and other resources you plan to use for each content area.
4. **Study:** Create and commit to a schedule that provides for regular study periods.

Praxis Test Name (Test Code): _____

Test Date: _____

Content covered	Description of content	How well do I know the content? (scale 1–5)	What resources do I have/need for this content?	Where can I find the resources I need?	Dates I will study this content	Date completed

(continued on next page)

Content covered	Description of content	How well do I know the content? (scale 1–5)	What resources do I have/need for the content?	Where can I find the resources I need?	Dates I will study the content	Date completed

6. Review Study Topics

Review detailed study topics with questions for discussion

Using the Study Topics That Follow

The Pennsylvania Grades 4-8 Subject Concentration: Science test is designed to measure the knowledge and skills necessary for a beginning teacher.

This chapter is intended to help you organize your preparation for the test and to give you a clear indication of the depth and breadth of the knowledge required for success on the test.

Virtually all accredited programs address the topics covered by the test; however, you are not expected to be an expert on all aspects of the topics that follow.

You are likely to find that the topics below are covered by most introductory textbooks. Consult materials and resources, including lecture and laboratory notes, from all your coursework. You should be able to match up specific topics and subtopics with what you have covered in your courses.

Try not to be overwhelmed by the volume and scope of content knowledge in this guide. Although a specific term may not seem familiar as you see it here, you might find you can understand it when applied to a real-life situation. Many of the items on the actual test will provide you with a context to apply to these topics or terms.

Discussion Areas

Interspersed throughout the study topics are discussion areas, presented as open-ended questions or statements. These discussion areas are intended to help test your knowledge of fundamental concepts and your ability to apply those concepts to situations in the classroom or the real world. Most of the areas require you to combine several pieces of knowledge to formulate an integrated understanding and response. If you spend time on these areas, you will gain increased understanding and facility with the subject matter covered on the test. You may want to discuss these areas and your answers with a teacher or mentor.

Note that this study companion *does not provide answers for the discussion area questions*, but thinking about the answers to them will help improve your understanding of fundamental concepts and will probably help you answer a broad range of questions on the test.

Study Topics

An overview of the areas covered on the test, along with their subareas, follows.

I. Basic Principles and Processes

A. Scientific Inquiry, Methodology, Techniques, and History

1. Understands methods of scientific inquiry and how they are used in basic problem solving
 - a. observations, hypotheses, experiments, conclusions, theories, models, and laws
 - b. experimental design, including independent and dependent variables, controls, and sources of error
 - c. nature of scientific knowledge
 - consistent with evidence, based on reproducible evidence, subject to change based on new evidence
 - includes unifying concepts and processes (e.g., systems, models, constancy and change, equilibrium, form and function)
2. Understands the processes involved in scientific data collection and manipulation
 - a. common units of measurement (e.g., units of length, time, mass, volume, pressure, energy, force), including prefixes such as milli and kilo
 - b. scientific notation and significant figures
 - c. organization and presentation of data (e.g., graphs, tables, charts)
 - d. basic error analysis (e.g., accuracy, precision)
 - e. basic descriptive statistics (e.g., calculate averages, distinguish between mean, mode, and median)
3. Knows how to interpret and draw conclusions from data presented in tables, graphs, maps, and charts
 - a. trends in data
 - b. relationships between variables
 - c. predictions based on data
 - d. conclusions based on the evidence

4. Is familiar with the procedures for safe and correct preparation, storage, use, and disposal of laboratory materials
 - a. safe storage
 - b. appropriate and safe disposal (e.g., chemicals, biohazards)
 - c. appropriate preparation and handling
5. Understands safety and emergency procedures in the laboratory
 - a. equipment (e.g., fire extinguishers, eyewash stations, safety showers, fire blanket)
 - b. appropriate student apparel and behavior (e.g., goggles, clothing)
 - c. emergency procedures for minor burns and other injuries
 - d. emergency procedures for mishaps (e.g., fires, chemical spills)
 - e. evacuation procedures
6. Is familiar with how to use standard equipment in the laboratory
 - a. appropriate use of equipment (e.g., thermometers, microscopes, barometers, graduated cylinders, Bunsen burners, balances, pH meters)
 - b. basic care, preparation, and maintenance of equipment
7. Is familiar with the historical developments of science and the contributions of major historical figures
 - a. how major concepts developed over time (e.g., atomic models, genetics, plate tectonics)
 - b. key historical figures and their contributions

B. Basic Principles of Matter and Energy

1. Is familiar with the structure and properties of matter
 - a. solids, liquids, gases, and plasmas
 - b. elements, atoms, compounds, molecules, and mixtures
 - c. elements and their isotopes

2. Knows the basic relationships between energy and matter
 - a. conservation of energy (first law of thermodynamics)
 - b. entropy changes (second law of thermodynamics)
 - c. conservation of matter in chemical processes
 - d. forms of kinetic and potential energy (e.g., thermal, chemical, radiant, mechanical)
 - e. energy transformations (e.g., light to heat, potential to kinetic)
 - f. chemical and physical properties/changes
 - g. temperature scales (e.g., Celsius, Fahrenheit, and Kelvin; comparisons between the scales)
 - h. difference between heat and temperature
 - i. effect of thermal energy on matter and the measurement of thermal energy (e.g., specific heat capacity)
 - j. methods of heat transfer (e.g., convection, radiation, conduction)
 - k. interdisciplinary applications of energy and matter relationships
 - trophic levels
 - matter cycling and energy flow in ecosystems
 - convection currents in atmosphere, ocean, and mantle
 - conservation of mass in the rock cycle
 - nitrogen cycle
 - chemical and physical changes in rocks
 - impact of solar radiation on Earth and life
 - photosynthesis and cellular respiration
 - energy transformations in living systems
 3. Knows the basic structure of the atom
 - a. atomic models
 - b. atomic structure including electrons, protons, and neutrons
 - c. atomic number and mass
 - d. ions
 - e. electron arrangements
 - f. radioisotopes, radioactive decay, half-life, fission, and fusion
- C. Science, Technology, and Society**
1. Understands the impact of science and technology on the environment and society
 - a. air and water pollution
 - b. greenhouse gases
 - c. global climate and sea level change
 - d. waste disposal and recycling
 - e. acid rain
 - f. loss of biodiversity (e.g., habitat destruction, invasive species)
 - g. ozone depletion
 2. Knows major issues associated with energy production and the management of natural resources
 - a. conservation and recycling
 - b. renewable and nonrenewable resources
 - c. pros and cons of power generation based on various sources (e.g., fossil, nuclear, water, wind, solar, biomass, geothermal)
 - d. use and extraction of Earth's resources (e.g., mining, reclamation, deforestation, drilling)
 3. Is familiar with applications of science and technology in daily life
 - a. chemical properties of household products
 - b. batteries, wireless devices, microchips, lasers, and fiber optics
 - c. communication satellites
 - d. contributions of space technology (e.g., GPS)
 - e. common agricultural practices (e.g., genetically modified crops, use of pesticides, fertilizers)
 - f. DNA evidence in forensic investigations
 4. Is familiar with the impact of science on public-health issues
 - a. nutrition, disease, and medicine (e.g., food preservation, vitamins, vaccines, viruses)
 - b. biotechnology (e.g., genetic engineering, human genome project)
 - c. medical technologies (e.g., MRIs, X-rays, radiation therapy)

Discussion areas: Scientific Inquiry, Methodology, Techniques, and History

- What is a scientific hypothesis?
- What unit is equivalent to 1/1,000th of a gram?
- What is the area, to the correct number of significant figures, of a rectangle having a width of 2 cm and a length of 6.7 cm?
- How would you prepare 500 mL of a 3 M NaCl solution?
- What is a graduated cylinder used for?

Discussion areas: Basic Principles of Matter and Energy

- When a reaction in solution produces energy, what happens to the temperature of the solution?
- What entropy changes occur when a substance melts?
- How are kinetic energy and potential energy different?
- What energy changes occur to a mass that starts from rest and slides without friction from the top to the bottom of an inclined plane? What additional energy changes occur when there is friction between the mass and the inclined plane?
- How are physical changes in a substance different from chemical changes?
- If 100 g of water at 20°C absorbs 5 kJ of heat, by what amount will the temperature of the water increase?
- What changes in an atom produce an atomic spectrum?
- How many neutrons are in $^{14}_6\text{C}$?
- What is an example of a nuclear reaction involving beta decay? Alpha decay?
- If a 100 g sample of a radioactive element decays to 25 g in 4 days, what is the half-life of the element?

Discussion areas: Science, Technology, and Society

- Give examples of how events, such as the clear-cutting of the tropical rain forests and building of nuclear energy plants, have had both positive and negative impacts on humans and the environment.
- What is the effect of the presence of chlorofluorocarbons in the stratosphere?
- Since plastic products do not readily decompose in waste sites, what is an alternative for plastic disposal?
- Compare the availability and limitations of the following sources of power: geothermal, nuclear, hydroelectric, solar, and fossil fuel.
- Compare and contrast the depletion of mineral resources with that of fossil fuels.
- How has recombinant DNA technology been used to solve criminal cases?
- How has recombinant DNA technology been used to treat diabetes?

II. Physical Sciences**A. Physics**

1. Understands mechanics
 - a. describe linear and circular motion in one and two dimensions
 - speed
 - velocity
 - acceleration
 - momentum
 - b. friction
 - c. work, energy, and power
 - d. mass, weight, and gravity
 - characteristics of gravitation (e.g., gravitational attraction, acceleration due to gravity, mass, distance)
 - distinguish between mass and weight

- e. analyze motion and forces in a physical situation, including basic problems
 - Newton’s first law: inertia
 - Newton’s second law: $F = ma$
 - Newton’s third law: action-reaction forces
 - Inclined planes
 - Projectile motion
 - Periodic motion (e.g., pendulums, springs, planetary orbits)
 - Conservation of energy and conservation of momentum (e.g., collisions)
 - f. simple and compound machines and mechanical advantage
 - g. physical properties of fluids (e.g., buoyancy, density, pressure)
2. Knows electricity and magnetism
- a. electrical nature of materials
 - electric charges
 - electrostatic attraction and repulsion
 - conductivity, conductors, and insulators
 - b. analyze basic series and parallel electrical circuits
 - DC and AC current
 - current, resistance, voltage, and power
 - Ohm’s law
 - voltage sources (batteries, generators)
 - c. magnetic fields and forces
 - magnetic materials
 - magnetic forces and fields (e.g., magnetic poles, attractive and repulsive forces)
 - electromagnets
3. Understands basic waves and optics
- a. characteristics of light and the electromagnetic spectrum
 - nature of light
 - visible spectrum and color
 - ultraviolet, infrared, microwave, and gamma
 - b. basic characteristics and types of waves
 - transverse and longitudinal
 - amplitude, frequency, wavelength, speed, intensity
 - c. basic wave phenomena
 - reflection, refraction, diffraction, scattering
 - absorption and transmission
 - interference and polarization
 - Doppler effect
 - d. basic characteristics and phenomena of sound
 - pitch/frequency and loudness/intensity
 - sound-wave production, air vibrations, and resonance (e.g., tuning forks)
 - e. basic optics
 - mirrors
 - lenses and their applications (e.g., the human eye, microscope, telescope)
 - prisms
- B. Chemistry**
1. Is familiar with how to use the periodic table to predict the physical and chemical properties of elements
- a. organization of the periodic table
 - arranged in columns and rows (e.g., groups/families, periods)
 - includes symbol, atomic number, and atomic mass for each element
 - b. general trends in chemical reactivity based on position of elements in the periodic table (e.g., metallic and nonmetallic elements, noble gases)
 - c. general trends in physical properties based on position of elements in the periodic table (e.g., atomic radius, ionization energy)
2. Knows types of chemical bonding and the composition of simple chemical compounds
- a. covalent and ionic bonding
 - b. names of simple chemical compounds
 - ionic
 - covalent compounds involving two elements
 - acids and bases
 - common names (e.g., methane, glucose, ammonia)
 - c. interpret chemical formulas
 - describe formulas in terms of moles of atoms
 - percent composition
 - empirical/molecular formulas
 - electron dot and structural formulas

3. Understands states of matter and phase changes between them
 - a. basic assumptions of the kinetic molecular theory of matter (e.g., particles in constant motion, speed and energy of gas particles are related to temperature)
 - b. ideal gas laws (e.g., volume is directly proportional to temperature, pressure and volume are inversely proportional)
 - c. phase changes
 - melting/freezing
 - vaporization/condensation
 - sublimation
 - heating/cooling curves (e.g., heat of vaporization, heat of fusion)
4. Knows how to balance and use simple chemical equations
 - a. balance simple chemical reactions
 - b. simple stoichiometric calculations involving balanced equations
 - c. use chemical formulas and equations to identify and describe simple chemical reactions
 - combustion
 - oxidation (e.g., iron rusting)
 - neutralization
 - single or double replacement
 - d. energy relationships (e.g., endothermic reactions, exothermic reactions)
 - e. factors that affect reaction rates (e.g., concentration, temperature, pressure, catalysts/enzymes)
5. Understands basic concepts in acid-base chemistry
 - a. chemical and physical properties of acids and bases
 - b. pH scale
 - c. neutralization
 - d. buffers
6. Is familiar with solutions and solubility
 - a. solution terminology and identification of different types of solutions
 - dilute and concentrated solutions
 - saturated, unsaturated, and supersaturated solutions
 - solvents and solutes
 - concentrations of solutions (e.g., molarity, and percent by mass)
 - b. factors affecting the dissolving process and solubility of substances
 - effect of temperature and particle size on dissolving
 - effect of temperature on solubility
 - polar versus non-polar solvents and solutes (e.g., like dissolving like)
 - ionic compounds dissociate in water and form ions (e.g., electrolytes)

Discussion areas: Physics

- How does mass affect the acceleration of a falling object?
- What is the direction of the centripetal force acting on an object moving in uniform circular motion?
- If the momentum of a 2,500 kg car is equal to the momentum of a 1,500 kg car moving at 5 m/s, what must be the speed of the 2,500 kg car?
- Why is it more difficult to slide a crate starting from rest than it is to keep it moving once it is sliding?
- If the speed of an object is doubled, by what factor does its kinetic energy change?
- Which requires more work: lifting a 100 kg sack a vertical distance of 2 m or lifting a 50 kg sack a vertical distance of 4 m?
- If the distance between two masses is doubled, what happens to the gravitational force between the two masses?
- What forces act on an air puck as it moves across a frictionless surface at constant speed in a straight line?
- A ball is dropped and another ball of smaller mass is fired horizontally from the same height at the same time. Which ball has a greater acceleration when it hits the ground? Which ball hits the ground first?

- What variables affect the period of a pendulum?
- When a moving object collides with an object at rest, is it possible for both objects to be at rest after the collision?
- What is the difference between an elastic and an inelastic collision?
- What type of simple machine is a wheelbarrow?
- What affects the buoyant force acting on an object?
- If the distance between two charges is halved, what happens to the electrostatic force between the two charges?
- What happens to the electric potential between two positive charges when the distance between the charges decreases?
- What is the current flowing through a $10\ \Omega$ resistor that is connected in series to a $50\ \text{V}$ source?
- If three $10\ \Omega$ resistors are connected in parallel, what is the equivalent resistance of the parallel combination? What is the equivalent resistance if the same resistors are connected in series?
- Describe the orientation of the magnetic field lines of a bar magnet.
- What is the range of wavelengths of visible light?
- Why does the sky appear blue when viewed from the surface of Earth?
- Under what condition does constructive interference occur? Destructive interference?
- How do polarized sunglasses reduce the glare from reflective surfaces, such as the surface of a lake?
- When you blow over a bottle, what happens to the frequency of the sound produced as you fill the bottle with water?
- Describe image formation in a plane mirror.
- Does the size of the image in a plane mirror change as the object moves away from the mirror?

- What is always true of the images formed by concave lenses?

Discussion areas: Chemistry

- What is the relationship between the position of an element on the periodic table and the distribution of electrons in the atoms of the element?
- Of the elements K, Fe, Cu, and Ag, which will react most readily with Cl?
- Of the atoms He, H, Li, and Be, which is the smallest?
- Of the elements Na, Mg, Al, P, S, and Cl, which has the highest first ionization energy?
- What types of bonding are exhibited by KCl, MgO, CO_2 , and H_2 ?
- Of the compounds Na_2S , Na_2SO_4 , and Na_2SO_3 , which is called sodium sulfate?
- What is the formula for cupric oxide, also known as copper(II) oxide?
- How many oxygen atoms are in 3 moles of CO_2 ?
- How many H atoms are in calcium hydroxide, $\text{Ca}(\text{OH})_2$?
- What are the molecular formulas for ethanol, ethanal, and butane?
- What are both the electron dot and structural formulas for methane, CH_4 ?
- If a sample of gas is heated at a constant pressure, what will happen to the volume of the gas?
- Balance the following equation:

$$\text{Na} + \text{MgSO}_4 \rightarrow \text{Mg} + \text{Na}_2\text{SO}_4$$
- In general terms, what will happen to the chemical equilibrium

$$2\ \text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g}) + 58\ \text{kJ}$$
if the temperature, pressure, or concentration of one of the reactants is changed?
- What will happen to the pH of an aqueous solution of HCl when a base such as NaOH is added?
- What is the general function of buffer mixtures?

- If a solute is completely dissolved in a solvent, is the solution saturated or unsaturated?
- Why is ammonia gas very soluble in water while oxygen, O_2 , is only slightly soluble?
- Will a substance dissolve faster if it is ground into a powder first?
- Will increasing temperature always increase solubility?

III. Life Sciences

1. Understands the basic structure and function of cells and their organelles
 - a. structure and function of cell membranes (e.g., passive and active transport, osmosis)
 - b. structure and function of cell organelles (e.g., chloroplasts, mitochondria)
 - c. levels of organization (cells, tissues, organs, organ systems)
 - d. identify specialized cell types (e.g., muscle, nerve, epithelial)
 - e. prokaryotes and eukaryotes
2. Understands basic cell reproduction
 - a. cell cycle
 - b. mitosis
 - c. meiosis
 - d. cytokinesis
3. Is familiar with the basic biochemistry of life
 - a. cellular respiration
 - b. photosynthesis
 - c. fermentation
 - d. biological molecules (e.g., DNA, carbohydrates, proteins, lipids, enzymes)
4. Understands basic genetics
 - a. DNA structure
 - b. replication, transcription, and translation
 - c. dominant, co-dominant, and recessive alleles
 - d. Mendelian inheritance (e.g., genotype, phenotype, pedigree, sex-linked traits, use of Punnett squares)
 - e. mutations, chromosomal abnormalities, and common human genetic disorders
5. Understands the theory and key mechanisms of evolution
 - a. mechanisms of evolution (e.g., natural selection, punctuated equilibrium)
 - b. isolation mechanisms and speciation
 - c. supporting evidence (e.g., fossil record, comparative genetics, homologous structures)
6. Knows the elements of the hierarchical classification scheme and the characteristics of the major groups of organisms
 - a. classification schemes (e.g., domain, kingdom, phylum/division, class, order, family, genus, species)
 - b. characteristics of animals, plants, fungi, protists, and bacteria
7. Knows the major structures and functions of plant organs and systems
 - a. characteristics of vascular and nonvascular plants
 - b. characteristics of gymnosperms and angiosperms
 - c. responses to stimuli
 - d. structure and function of leaves, roots, and stems
 - e. asexual and sexual reproduction
 - f. uptake and transport of nutrients and water
 - g. growth
8. Knows the basic anatomy and physiology of animals, including structure and function of human body systems and the major differences between humans and other animals
 - a. homeostasis
 - b. exchange with the environment (e.g., respiratory, excretory, digestive systems)
 - c. internal transport and exchange (e.g., circulatory system)
 - d. movement and support (e.g., skeletal system, muscular systems)
 - e. reproduction and development
 - f. immune systems
 - g. control systems (e.g., nervous system, endocrine system)
 - h. physiological effects on behavior (e.g., bird migration)

9. Knows key aspects of ecology
- population dynamics (e.g., growth curves, carrying capacity, mating systems, and social systems, behavior such as territoriality)
 - community ecology (e.g., niche, succession, species diversity, symbiosis, interspecific relationships such as predator-prey)
 - ecosystems
 - biomes – terrestrial and aquatic
 - stability and disturbances (e.g., glaciations, effect of global warming)
 - energy flow (e.g., trophic levels, food webs)
 - biogeochemical cycles (e.g., water, nitrogen, and carbon cycles, biotic and abiotic interaction)

Discussion areas

- If you were stranded in a lifeboat on the ocean, why would drinking the ocean water be more harmful than not drinking the water?
- What structures would you expect to find in a typical plant cell but not in an animal cell? What function do these unique structures carry out for the plant?
- What are the major differences between “normal” cells and cancerous cells? Chemotherapy is the use of chemicals to kill rapidly dividing cells. In addition to killing many types of cancer cells, why does chemotherapy treatment cause side effects such as anemia, gastrointestinal distress, and hair loss?
- At the cellular level, what is the benefit of exercising aerobically? Why do muscles become “sore” after excessive exercise?
- What makes yeast bread “rise” before it is baked?
- Describe Watson and Crick’s model for DNA structure.
- What percentage of offspring will have blood type A if the parents have blood types AB and O? What percentage will have blood type O?
- Why are there more color-blind males than color-blind females?
- How are Mendel’s laws related to the behavior of chromosomes during the formation of gametes?
- A small percentage of individuals with Down syndrome possess a chromosomal translocation in which a copy of chromosome 21 becomes attached to chromosome 14. How does this translocation occur?
- 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.
- A radioactive meteorite falls to Earth and kills 90 percent of a secluded population of salamander. What mechanisms are in action changing allelic frequency in this population’s gene pool?
- Discuss the significance of Darwin’s finches.
- What are the limitations of the five-kingdom system? Current debates about revising the five-kingdom system center mainly on which groups of organisms?
- Under what environmental conditions would you expect the transpiration rate to be the highest in an average-sized oak tree? The lowest?
- Consider a seed planted upside down three inches under the soil. When the seed germinates, why does the root grow downward into the soil while the shoot grows upward?
- Why are insulin and glucagon considered “antagonistic” hormones? Are there other such hormone pairs in the human body?
- Why must the human body digest large macromolecules into small monomers before it can use them? What enzymes does the human body use to digest these macromolecules?
- Of proteins, carbohydrates and fats, which type of nutrient has the highest caloric value per gram?
- What are the structural and functional differences between the three muscle types, i.e., skeletal, smooth, and cardiac?

- What are some genetic, lifestyle, and internal physiological factors that can lead to hypertension (high blood pressure)? If hypertension is uncontrolled, what health problems can occur? What types of treatments exist to help control hypertension?
 - Explain J-shaped and S-shaped population growth curves in terms of biotic potential and carrying capacity.
 - What is the principle of competitive exclusion?
 - Compare the types of vegetation encountered with increasing altitude (e.g., traveling up a mountainside) and with increasing latitude (e.g., traveling from the Equator toward the North Pole).
 - How have humans accelerated the process of the greenhouse effect? What is the environmental impact of this accelerated greenhouse effect?
 - Create a food web, with organisms placed within an appropriate trophic level, with the following organisms: zooplankton, eagle, freshwater shrimp, green algae, goose, mouse, beetle, bacteria, trout, bear, and mushroom. What would the pyramids of number, biomass, and energy look like for this ecosystem? Describe the levels of DDT you would find in the tissues of the members of the community, if the pesticide DDT were introduced into this food web.
2. Is familiar with processes involved in erosion, weathering, and deposition of Earth's surface materials and soil formation
 - a. erosion and deposition (e.g., agents of erosion)
 - b. chemical and physical (mechanical) weathering
 - c. characteristics of soils (e.g., types, soil profile)
 - d. porosity and permeability
 - e. runoff and infiltration
 3. Knows Earth's basic structure and internal processes
 - a. Earth's layers (e.g., lithosphere, asthenosphere, crust, mantle, core)
 - b. Earth's shape and size
 - c. geographical features (e.g., mountains, plateaus, mid-ocean ridges)
 - d. topographic, cross-sectional, and structural maps
 - e. Earth's magnetic field
 - f. plate tectonics theory and evidence
 - folding and faulting
 - continental drift
 - magnetic reversals
 - characteristics of volcanoes and their formation (e.g., types, lava, eruptions)
 - characteristics of earthquakes and reasons they occur (e.g., epicenters, faults, tsunamis)
 - seismic waves and triangulation

IV. Earth and Space Sciences

A. Physical Geology

1. Is familiar with types and characteristics of rocks, minerals, and their formation processes
 - a. characteristics of rocks and their formation processes (e.g., igneous, metamorphic, and sedimentary rocks, the rock cycle)
 - b. classification of minerals and their formation processes (e.g., crystal form, hardness, streak)

B. Historical Geology

1. Is familiar with historical geology
 - a. principle of uniformitarianism
 - b. basic principles of stratigraphy (e.g., law of superposition)
 - c. relative and absolute time (e.g., index fossils, radioactive dating)
 - d. geologic time scale (e.g., eras, periods)
 - e. fossil formation and the fossil record
 - f. important events in Earth's geologic history (e.g., Pangaea, mass extinctions, Cambrian explosion, ice ages, meteor impacts)

C. Earth's Hydrosphere and Atmosphere

1. Is familiar with the water cycle
 - a. evaporation and transpiration
 - b. condensation
 - c. precipitation
 - d. runoff
2. Is familiar with Earth's oceans and other bodies of water and their geologic features
 - a. tides, waves, and currents
 - b. estuaries and barrier islands
 - c. island, reef, and atoll formation
 - d. polar ice caps, icebergs, and glaciers
 - e. lakes, ponds, streams, rivers, and river deltas
 - f. groundwater, water table, wells, and aquifers
 - g. properties of water that affect Earth systems (e.g., density changes when freezing, high heat capacity, polar solvent)
3. Knows basic meteorology
 - a. structure of Earth's atmosphere (e.g., troposphere, stratosphere)
 - b. composition of Earth's atmosphere (e.g., percent composition of oxygen and nitrogen)
 - c. atmospheric pressure and temperature
 - d. wind
 - e. cloud types and cloud formation
 - f. frontal systems, weather maps, storms, and severe weather
 - g. humidity, dew point, and frost point
 - h. forms of precipitation
4. Knows major factors that affect climate and seasons
 - a. climate zones (e.g., Tropics, Arctic)
 - b. proximity to mountains and oceans
 - c. global winds and ocean circulation
 - d. latitude, geographical location, and elevation
 - e. natural phenomena (e.g., volcanic eruptions, solar radiation)
 - f. effect of Earth's tilt on seasons

D. Astronomy

1. Is familiar with the major features of the solar system
 - a. structure of the solar system (e.g., orbits of the planets)
 - b. characteristics of planets (e.g., composition, unique features)
 - c. characteristics of the Sun
 - d. asteroids, meteoroids, and comets
 - e. origin of the solar system
2. Is familiar with the interactions of the Earth-Moon-Sun system
 - a. Earth's rotation and orbital revolution around the Sun
 - b. effect on seasons
 - c. phases of the Moon
 - d. effect on tides
 - e. solar and lunar eclipses
3. Is familiar with the major features of the universe and its origin
 - a. galaxies (e.g., types, Milky Way)
 - b. stars and their life cycle (e.g., Hertzsprung-Russell diagram, types, nebulae, black holes)
 - c. units of celestial distance (e.g., light-year, astronomical unit)
 - d. Big Bang theory
4. Is familiar with contributions of space exploration and technology to astronomy
 - a. remote-sensing devices (e.g., optical/radio telescopes, Hubble telescope, satellites, space probes)
 - b. search for life and water on other planets

Discussion areas: Physical Geology

- What are the source materials for the ingredients of sedimentary rocks?
- What is the Mohs hardness scale?
- What are the major agents of erosion?
- What does the behavior of seismic waves reveal about the structure and physical characteristics of Earth's interior?

- What makes a topographic map different from any other map? Why is a topographic map useful to a geologist?
- What processes occur at plate boundaries?
- What is seafloor spreading? Explain the origin of the rift valley in the center of the mid-oceanic ridge.
- What evidence exists for “continental drift” and how is continental drift different from plate tectonics?
- What are black smokers and how do they form?

Discussion areas: Historical Geology

- What is radioactive dating and how is it used to provide dates for the geologic time scale?
- How can fossils be useful to a geologist in correlating the north and south walls of the Grand Canyon?

Discussion areas: Earth’s Hydrosphere and Atmosphere

- How do the Sun and Moon influence tides? Why, in general, do two high tides occur at a given location every day?
- Why do waves break as they approach the shore?
- List the layers of the atmosphere and discuss the temperature changes within each.
- How does the Sun influence global and local winds?
- What weather would you predict for the next day if you observed a lowering sequence of stratiform clouds over a day or two?
- Why do weather systems generally move across the United States from west to east?
- Compare and contrast tornadoes and hurricanes.
- What influence does one or more of the following have on the climate of a region: ocean currents, landforms, and global wind belts?
- How does a volcanic eruption affect both regional and worldwide climate conditions?

Discussion areas: Astronomy

- Describe the shape of a planet’s orbit about the Sun.
- At what point in its orbit about the Sun is the speed of a planet the greatest?
- What are the characteristics of the terrestrial planets? The Jovian planets?
- How do the Sun and other stars generate their energy?
- Why does the length of daylight change from day to day?
- What is the relationship between a time zone, longitude, and Earth’s rotation?
- Compare the temperature and length of the day at the North Pole, the midlatitudes, and the Equator on June 21 and on December 21.
- Why do lunar and solar eclipses not occur every month?
- What type of galaxy is the Milky Way?
- What information about stars and their life cycles can be obtained from a Hertzsprung-Russell (H-R) diagram
- How far does light travel in a light-year?
- What limitation of Earth-based telescopes has been solved by the Hubble space telescope?

7. Review Smart Tips for Success

Follow test-taking tips developed by experts

Learn from the experts. Take advantage of the following answers to questions you may have and practical tips to help you navigate the *Praxis* test and make the best use of your time.

Should I Guess?

Yes. Your score is based on the number of questions you answer correctly, with no penalty or subtraction for an incorrect answer. When you don't know the answer to a question, try to eliminate any obviously wrong answers and then guess at the correct one. Try to pace yourself so that you have enough time to carefully consider every question.

Can I answer the questions in any order?

You can answer the questions in order or skip questions and come back to them later. If you skip a question, you can also mark it so that you can remember to return and answer it later. Remember that questions left unanswered are treated the same as questions answered incorrectly, so it is to your advantage to answer every question.

Are there trick questions on the test?

No. There are no hidden meanings or trick questions. All of the questions on the test ask about subject matter knowledge in a straightforward manner.

Are there answer patterns on the test?

No. You might have heard this myth: the answers on tests follow patterns. Another myth is that there will never be more than two questions in a row with the correct answer in the same position among the choices. Neither myth is true. Select the answer you think is correct based on your knowledge of the subject.

Can I write on the scratch paper I am given?

Yes. You can work out problems on the scratch paper, make notes to yourself, or write anything at all. Your scratch paper will be destroyed after you are finished with it, so use it in any way that is helpful to you. But make sure to select or enter your answers on the computer.

Smart Tips for Taking the Test

- 1. Skip the questions you find extremely difficult.** Rather than trying to answer these on your first pass through the test, you may want to leave them blank and mark them so that you can return to them later. Pay attention to the time as you answer the rest of the questions on the test, and try to finish with 10 or 15 minutes remaining so that you can go back over the questions you left blank. Even if you don't know the answer the second time you read the questions, see if you can narrow down the possible answers, and then guess. Your score is based on the number of right answers, so it is to your advantage to answer every question.

2. **Keep track of the time.** The on-screen clock will tell you how much time you have left. You will probably have plenty of time to answer all of the questions, but if you find yourself becoming bogged down, you might decide to move on and come back to any unanswered questions later.
3. **Read all of the possible answers before selecting one.** For questions that require you to select more than one answer, or to make another kind of selection, consider the most likely answers given what the question is asking. Then reread the question to be sure the answer(s) you have given really answer the question. Remember, a question that contains a phrase such as “Which of the following does NOT . . .” is asking for the one answer that is NOT a correct statement or conclusion.
4. **Check your answers.** If you have extra time left over at the end of the test, look over each question and make sure that you have answered it as you intended. Many test takers make careless mistakes that they could have corrected if they had checked their answers.
5. **Don’t worry about your score when you are taking the test.** No one is expected to answer all of the questions correctly. Your score on this test is not analogous to your score on the *GRE*[®] or other tests. It doesn’t matter on the *Praxis* tests whether you score very high or barely pass. If you meet the minimum passing scores for your state and you meet the state’s other requirements for obtaining a teaching license, you will receive a license. In other words, what matters is meeting the minimum passing score. You can find passing scores for all states that use *The Praxis Series* tests at http://www.ets.org/s/praxis/pdf/passing_scores.pdf or on the Web site of the state for which you are seeking certification/licensure.
6. **Use your energy to take the test, not to get frustrated by it.** Getting frustrated only increases stress and decreases the likelihood that you will do your best. Highly qualified educators and test development professionals, all with backgrounds in teaching, worked diligently to make the test a fair and valid measure of your knowledge and skills. Your state painstakingly reviewed the test before adopting it as a licensure requirement. The best thing to do is concentrate on answering the questions.

8. Check on Testing Accommodations

See if you qualify for accommodations that may make it easier to take the Praxis test

What if English is not my primary language?

Praxis tests are given only in English. If your primary language is not English (PLNE), you may be eligible for extended testing time. For more details, visit www.ets.org/praxis/register/accommodations/plne.

What if I have a disability or other health-related need?

The following accommodations are available for *Praxis* test takers who meet the Americans with Disabilities Act (ADA) Amendments Act disability requirements:

- Extended testing time
- Additional rest breaks
- Separate testing room
- Writer/recorder of answers
- Test reader
- Sign language interpreter for spoken directions only
- Perkins Braille
- Braille slate and stylus
- Printed copy of spoken directions
- Oral interpreter
- Audio test
- Braille test
- Large print test book
- Large print answer sheet
- Listening section omitted

For more information on these accommodations, visit www.ets.org/praxis/register/disabilities.

Note: Test takers who have health-related needs requiring them to bring equipment, beverages, or snacks into the testing room or to take extra or extended breaks must request these accommodations by following the procedures described in the *Bulletin Supplement for Test Takers with Disabilities or Health-Related Needs* (PDF), which can be found at http://www.ets.org/s/disabilities/pdf/bulletin_supplement_test_takers_with_disabilities_health_needs.pdf.

You can find additional information on available resources for test takers with disabilities or health-related needs at www.ets.org/disabilities.

9. Do Your Best on Test Day

Get ready for test day so you will be calm and confident

You followed your study plan. You prepared for the test. Now it's time to prepare for test day.

Plan to end your review a day or two before the actual test date so you avoid cramming. Take a dry run to the test center so you're sure of the route, traffic conditions, and parking. Most of all, you want to eliminate any unexpected factors that could distract you from your ultimate goal—passing the *Praxis* test!

On the day of the test, you should:

- be well rested
- wear comfortable clothes and dress in layers
- eat before you take the test
- bring an acceptable and valid photo identification with you
- bring an approved calculator only if one is specifically permitted for the test you are taking (see Calculator Use, at http://www.ets.org/praxis/test_day/policies/calculators)
- be prepared to stand in line to check in or to wait while other test takers check in

You can't control the testing situation, but you can control yourself. Stay calm. The supervisors are well trained and make every effort to provide uniform testing conditions, but don't let it bother you if the test doesn't start exactly on time. You will have the allotted amount of time once it does start.

You can think of preparing for this test as training for an athletic event. Once you've trained, prepared, and rested, give it everything you've got.

What items am I restricted from bringing into the test center?

You cannot bring into the test center personal items such as:

- handbags, knapsacks, or briefcases
- water bottles or canned or bottled beverages
- study materials, books, or notes
- pens, pencils, scrap paper, or calculators, unless specifically permitted for the test you are taking (see Calculator Use, at http://www.ets.org/praxis/test_day/policies/calculators)
- any electronic, photographic, recording, or listening devices

Personal items are not allowed in the testing room and will not be available to you during the test or during breaks. You may also be asked to empty your pockets. At some centers, you will be assigned a space to store your belongings, such as handbags and study materials. Some centers do not have secure storage space available, so please plan accordingly.

Test centers assume no responsibility for your personal items.

If you have health-related needs requiring you to bring equipment, beverages or snacks into the testing room or to take extra or extended breaks, you need to request accommodations in advance. Procedures for requesting accommodations are described in the [Bulletin Supplement for Test Takers with Disabilities or Health-related Needs \(PDF\)](#).

Note: All cell phones, smart phones (e.g., Android® devices, iPhones®, etc.), and other electronic, photographic, recording, or listening devices are strictly prohibited from the test center. If you are seen with such a device, you will be dismissed from the test, your test scores will be canceled, and you will forfeit your test fees. If you are seen *using* such a device, the device will be confiscated and inspected. For more information on what you can bring to the test center, visit www.ets.org/praxis/test_day/bring.

Are You Ready?

Complete this checklist to determine whether you are ready to take your test.

- Do you know the testing requirements for the license or certification you are seeking in the state(s) where you plan to teach?
- Have you followed all of the test registration procedures?
- Do you know the topics that will be covered in each test you plan to take?
- Have you reviewed any textbooks, class notes, and course readings that relate to the topics covered?
- Do you know how long the test will take and the number of questions it contains?
- Have you considered how you will pace your work?
- Are you familiar with the types of questions for your test?
- Are you familiar with the recommended test-taking strategies?
- Have you practiced by working through the practice questions in this study companion or in a study guide or practice test?
- If constructed-response questions are part of your test, do you understand the scoring criteria for these questions?
- If you are repeating a *Praxis* test, have you analyzed your previous score report to determine areas where additional study and test preparation could be useful?

If you answered “yes” to the questions above, your preparation has paid off. Now take the *Praxis* test, do your best, pass it—and begin your teaching career!

10. Understand Your Scores

Understand how tests are scored and how to interpret your test scores

Of course, passing the *Praxis* test is important to you so you need to understand what your scores mean and what your state requirements are.

What are the score requirements for my state?

States, institutions, and associations that require the tests set their own passing scores. Visit www.ets.org/praxis/states for the most up-to-date information.

If I move to another state, will my new state accept my scores?

The Praxis Series tests are part of a national testing program, meaning that they are required in many states for licensure. The advantage of a national program is that if you move to another state that also requires *Praxis* tests, you can transfer your scores. Each state has specific test requirements and passing scores, which you can find at www.ets.org/praxis/states.

How do I know whether I passed the test?

Your score report will include information on passing scores for the states you identified as recipients of your test results. If you test in a state with automatic score reporting, you will also receive passing score information for that state.

A list of states and their passing scores for each test are available online at www.ets.org/praxis/states.

What your *Praxis* scores mean

You received your score report. Now what does it mean? It's important to interpret your score report correctly and to know what to do if you have questions about your scores.

Visit http://www.ets.org/s/praxis/pdf/sample_score_report.pdf to see a sample score report.

To access *Understanding Your Praxis Scores*, a document that provides additional information on how to read your score report, visit www.ets.org/praxis/scores/understand.

Put your scores in perspective

Your score report indicates:

- Your score and whether you passed
- The range of possible scores
- The raw points available in each content category
- The range of the middle 50 percent of scores on the test

If you have taken the same test or other tests in *The Praxis Series* over the last 10 years, your score report also lists the highest score you earned on each test taken.

Content category scores and score interpretation

Questions on the *Praxis* tests are categorized by content. To help you in future study or in preparing to retake the test, your score report shows how many raw points you earned in each content category. Compare your “raw points earned” with the maximum points you could have earned (“raw points available”). The greater the difference, the greater the opportunity to improve your score by further study.

Score scale changes

ETS updates *Praxis* tests on a regular basis to ensure they accurately measure the knowledge and skills that are required for licensure. When tests are updated, the meaning of the score scale may change, so requirements may vary between the new and previous versions. All scores for previous, discontinued tests are valid and reportable for 10 years, provided that your state or licensing agency still accepts them.

These resources may also help you interpret your scores:

- *Understanding Your Praxis Scores* (PDF), found at www.ets.org/praxis/scores/understand
- *The Praxis Series Passing Scores* (PDF), found at www.ets.org/praxis/scores/understand
- State requirements, found at www.ets.org/praxis/states

Appendix: Other Questions You May Have

Here is some supplemental information that can give you a better understanding of the *Praxis* tests.

What do the *Praxis* tests measure?

The *Praxis* tests measure the specific knowledge and skills that beginning teachers need. The tests do not measure an individual's disposition toward teaching or potential for success, nor do they measure your actual teaching ability. The assessments are designed to be comprehensive and inclusive but are limited to what can be covered in a finite number of questions and question types. Teaching requires many complex skills that are typically measured in other ways, including classroom observation, video recordings, and portfolios.

Ranging from Agriculture to World Languages, there are more than 80 *Praxis* tests, which contain selected-response questions or constructed-response questions, or a combination of both.

Who takes the tests and why?

Some colleges and universities use the *Praxis* Core Academic Skills for Educators tests (Reading, Writing, and Mathematics) to evaluate individuals for entry into teacher education programs. The assessments are generally taken early in your college career. Many states also require Core Academic Skills test scores as part of their teacher licensing process.

Individuals entering the teaching profession take the *Praxis* content and pedagogy tests as part of the teacher licensing and certification process required by many states. In addition, some professional associations and organizations require the *Praxis* Subject Assessments (formerly the *Praxis II*® tests) for professional licensing.

Do all states require these tests?

The *Praxis Series* tests are currently required for teacher licensure in approximately 40 states and United States territories. These tests are also used by several professional licensing agencies and by several hundred colleges and universities. Teacher candidates can test in one state and submit their scores in any other state that requires *Praxis* testing for licensure. You can find details at www.ets.org/praxis/states.

What is licensure/certification?

Licensure in any area—medicine, law, architecture, accounting, cosmetology—is an assurance to the public that the person holding the license possesses sufficient knowledge and skills to perform important occupational activities safely and effectively. In the case of teacher licensing, a license tells the public that the individual has met predefined competency standards for beginning teaching practice.

Because a license makes such a serious claim about its holder, licensure tests are usually quite demanding. In some fields, licensure tests have more than one part and last for more than one day. Candidates for licensure in all fields plan intensive study as part of their professional preparation. Some join study groups, others study alone. But preparing to take a licensure test is, in all cases, a professional activity. Because a licensure exam surveys a broad body of knowledge, preparing for a licensure exam takes planning, discipline, and sustained effort.

Why does my state require *The Praxis Series* tests?

Your state chose *The Praxis Series* tests because they assess the breadth and depth of content—called the “domain”—that your state wants its teachers to possess before they begin to teach. The level of content knowledge, reflected in the passing score, is based on recommendations of panels of teachers and teacher

educators in each subject area. The state licensing agency and, in some states, the state legislature ratify the passing scores that have been recommended by panels of teachers.

How were the tests developed?

ETS consulted with practicing teachers and teacher educators around the country during every step of *The Praxis Series* test development process. First, ETS asked them which knowledge and skills a beginning teacher needs to be effective. Their responses were then ranked in order of importance and reviewed by hundreds of teachers.

After the results were analyzed and consensus was reached, guidelines, or specifications, for the selected-response and constructed-response tests were developed by teachers and teacher educators. Following these guidelines, teachers and professional test developers created test questions that met content requirements and [ETS Standards for Quality and Fairness](#).*

When your state adopted the research-based *Praxis* tests, local panels of teachers and teacher educators evaluated each question for its relevance to beginning teachers in your state. During this “validity study,” the panel also provided a passing-score recommendation based on how many of the test questions a beginning teacher in your state would be able to answer correctly. Your state’s licensing agency determined the final passing-score requirement.

ETS follows well-established industry procedures and standards designed to ensure that the tests measure what they are intended to measure. When you pass the *Praxis* tests your state requires, you are proving that you have the knowledge and skills you need to begin your teaching career.

How are the tests updated to ensure the content remains current?

Praxis tests are reviewed regularly. During the first phase of review, ETS conducts an analysis of relevant state and association standards and of the current test content. State licensure titles and the results of relevant job analyses are also considered. Revised test questions are then produced following the standard test development methodology. National advisory committees may also be convened to review and revise existing test specifications and to evaluate test forms for alignment with the specifications.

How long will it take to receive my scores?

Scores for tests that do not include constructed response questions are available on screen immediately after the test. Scores for tests that contain constructed-response questions or essays aren’t available immediately after the test because of the scoring process involved. Official score reports are available to you and your designated score recipients approximately two to three weeks after the test date for tests delivered continuously, or two to three weeks after the testing window closes for other tests. See the test dates and deadlines calendar at www.ets.org/praxis/register/centers_dates for exact score reporting dates.

Can I access my scores on the Web?

All test takers can access their test scores via My *Praxis* Account free of charge for one year from the posting date. This online access replaces the mailing of a paper score report.

The process is easy—simply log into My *Praxis* Account at www.ets.org/praxis and click on your score report. If you do not already have a *Praxis* account, you must create one to view your scores.

Note: You must create a *Praxis* account to access your scores, even if you registered by mail or phone.

*[ETS Standards for Quality and Fairness](#) (2014, Princeton, N.J.) are consistent with the “[Standards for Educational and Psychological Testing](#),” industry standards issued jointly by the American Educational Research Association, the American Psychological Association, and the National Council on Measurement in Education (2014, Washington, D.C.).

Your teaching career is worth preparing for, so start today!
Let the *Praxis*® Study Companion guide you.



To search for the *Praxis* test prep resources
that meet your specific needs, visit:

www.ets.org/praxis/testprep

To purchase official test prep made by the creators
of the *Praxis* tests, visit the ETS Store:

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