1. Learn About Your Test

Learn about the specific test you will be taking

Chemistry (5246)

This advance copy of the Chemistry Test at a Glance is a preliminary document. A final version of the document is scheduled to be published on the *Praxis®* website as the Chemistry Study Companion in July 2022.

Test at a Glance

Test Name	Chemistry
Test Code	5246
Time	150 minutes
Number of Questions	125 selected-response questions
Format	The test consists of a variety of selected-response questions, where you select one or more answer choices; and other types of questions. You can review the possible question types in chapter 2.
Test Delivery	Computer Delivered

Content Categories	Approximate Number of Questions	Approximate Percentage of Examination
I. Nature and Impact of Science and Engineering	17	14%
II. Principles and Models of Matter and Energy	31	25%
III. Chemical Composition, Bonding, and Structure	25	20%
IV. Chemical Reactions and Periodicity	29	23%
V. Solutions and Acid-Base Chemistry	23	18%

All questions assess content from the above Chemistry domains. More than 40 percent of questions integrate a Science and Engineering Practice, and approximately 25 percent of questions assess content applied to a Task of Teaching of Science.

About This Test

Praxis Chemistry is designed to measure knowledge and competencies important for safe and effective beginning practice as a teacher of chemistry. Test takers have typically completed a bachelor's degree program with appropriate coursework in chemistry and education.

Content topics span the chemistry curriculum, including content related to (I) Nature and Impact of Science and Engineering, (II) Principles and Models of Matter and Energy, (III) Chemical Composition, Bonding, and Structure, (IV) Chemical Reactions and Periodicity, (V) Solutions and Acid Base Chemistry.

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

The 125 selected-response questions measure concepts, terms, phenomena, methods, applications, data analysis, and problem solving in science. A full list of the topics covered is provided in **Content Topics**.

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

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

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

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

Content Topics

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

I. Nature and Impact of Science and Engineering

A. Nature of Science

1. Nature of scientific knowledge
   a. Variety of investigation methods
   b. Based on experimental evidence that is reproducible
   c. How major concepts develop and change over time in light of new evidence
   d. Forming and testing hypotheses
   e. Use of models, laws, and theories to explain natural phenomena
   f. Development and application of models to explain natural phenomena
   g. Process skills, including observing, categorizing, comparing, generalizing, inferring, and concluding
2. Experimental design, data collection, and analysis
   a. Standard units of measurement, dimensional analysis, and unit conversion
   b. Scientific notation and use of significant figures
   c. Experimental design, including identifying variables, planning data collection, and how it supports testing of the hypothesis
   d. Processing, organizing, and reporting of data
   e. Error analysis, including accuracy and precision, mean, and percent error
   f. Identifying the sources and effects of error
   g. Interpreting, extrapolating, and drawing conclusions from data
3. Laboratory procedures
   a. Appropriate preparation, use, storage, and disposal of materials
   b. Appropriate use of laboratory equipment (including selection, calibration, and maintenance)
   c. Safety procedures and precautions for the laboratory

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

1. Interdependence of science, engineering, and technology
   a. Engineering advances that lead to important discoveries in science
   b. Science and technology that drive each other forward
2. Engineering Design
   a. Defining problems, including identifying the success criteria and the constraints
   b. Designing solutions, including proposing and evaluating in terms of criteria, constraints, and limitations
   c. Optimizing the design, including systematic modification and refinement
3. Using science and engineering to identify and address negative impacts on the environment and society
   a. Acid rain
   b. Air and water pollution
   c. Greenhouse gases
   d. Ozone layer depletion
   e. Polymers and plastics
   f. Waste disposal and recycling
4. Advantages and disadvantages associated with various types of energy production
   a. Conservation and recycling of energy
   b. Renewable and nonrenewable energy resources
   c. Pros and cons of power generation based on various sources such as fossil and nuclear fuel, hydropower, wind power, solar power, and geothermal power

5. Applications of chemistry and technology in daily life
    a. Water purification
    b. Plastics, soap, batteries, and other commercial products
    c. Mining and industrial processes
    d. Biological systems
    e. Radiation in medicine and technology

II. Principles and Models of Matter and Energy

A. Atomic and Nuclear Structure and Processes

1. Current model of atomic structure
    a. Description of basic model, including number and location of protons, neutrons, and electrons
    b. Quantum mechanical model of atom, including orbitals and subatomic particles
    c. Experimental basis of model, including gold foil experiment and atomic spectra
2. Electron configuration of the elements
    a. Aufbau principle, Hund’s rule, Pauli exclusion principle
    b. Correlation between electron configuration and the periodic table
    c. Relationship between electron configuration and chemical and physical properties of elements
3. Relationship between electronic absorption and emission spectra and electron energy levels in atoms
    a. Electronic energy transitions in atoms
    b. Relationship between energy, frequency, and wavelength of electromagnetic radiation
    c. Identification of atoms based on analysis of spectra
    d. Correlation of electronic transitions to spectral lines in electromagnetic spectrum
4. Radioactivity
    a. Characteristics of alpha particles, beta particles, and gamma radiation
    b. Radioactive decay, include the process, half-life, and applications
    c. Identifying fission and fusion reactions
    d. Balancing nuclear reactions and identifying products of nuclear reactions

B. Relationships Between Energy and Matter in Chemistry

1. Organization of matter
    a. Pure substances (elements and compounds)
    b. Mixtures (homogeneous, heterogeneous, solutions, suspensions)
    c. States of matter (solid, liquid, gas, and plasma)
    d. Atoms, ions, molecules
2. Difference between chemical and physical properties and changes
    a. Chemical versus physical properties
    b. Chemical versus physical changes
    c. Intensive versus extensive properties
    d. Conservation of matter in chemical processes
3. Conservation of energy
    a. Conservation of energy in chemical and physical processes
    b. Kinetic and potential energy concepts and particulate models
    c. Forms of energy including chemical, electrical, thermal, electromagnetic, and nuclear
    d. Conversion between different forms of energy
4. Temperature, thermal energy, and heat capacity, including calculations
    a. Temperature scales
    b. Heat transfer
    c. Heat capacity and specific heat
    d. Calorimetry

5. Energy concepts and calculations involving phase transitions, including particulate and mathematical models
   a. Phase transition diagrams
   b. Heats of vaporization, fusion, and sublimation
   c. Heating curves
6. Kinetic molecular theory, including particulate and mathematical models
   a. Assumptions and applications of the kinetic molecular theory
   b. Ideal gas behavior and the ideal gas laws
7. How thermodynamics relates to chemical and physical processes
   a. Laws of thermodynamics
   b. Spontaneous (favorable) and reversible processes
   c. Changes in enthalpy, entropy, and Gibbs energy
   d. Exothermic and endothermic processes
   e. Reaction progress diagrams based on potential energy of reactants and products.
   f. Energy involved in breaking and forming bonds

III. Chemical Composition, Bonding, and Structure

A. Chemical Composition

1. Mole concept and application to chemical systems
   a. Avogadro's number, molar mass, and mole conversions
   b. Calculation of empirical and molecular formulas
   c. Percent composition
2. Systematic names and chemical formulas for simple inorganic compounds
   a. Binary compounds
   b. Acids, bases, and salts
   c. Hydrates
3. Identification of common organic functional groups and compounds
   a. Alkanes, alkenes, and alkynes
   b. Alcohols, ethers, ketones, aldehydes, carboxylic acids, and amines

B. Bonding and Structure

1. Properties and models of bonding
   a. Ionic bonding
   b. Covalent bonding (polar, nonpolar, and hybridization)
   c. Metallic bonding
   d. Relative bond strengths and bond lengths
2. Molecular structure models
   a. Lewis structures, including formal charges
   b. Resonance structures
   c. Molecular geometry (shape and bond angles)
3. Identification of polar and nonpolar molecules
   a. Analysis of polarity of the bonds within a molecule
   b. Symmetry of molecular structure
4. Types of interparticle interactions
   a. London forces (instantaneous induced dipole-dipole attractions)
   b. Dipole-dipole attractive forces
   c. Dipole-induced dipole attractive forces
   d. Hydrogen bonding
5. How bonding, structure, and interparticle interactions are related to physical properties of pure substances
   a. Boiling points and melting points
   b. Solubility
   c. Equilibrium vapor pressure

IV. Chemical Reactions and Periodicity

A. Periodicity

1. The periodic table as a model
   a. Arranged in groups and periods
   b. Symbols of the element, atomic number, and atomic mass
   c. Location of metals, nonmetals, metalloids, and transition elements
2. Predicting and justifying patterns and trends in physical and chemical properties of the elements based on their position on the periodic table
   a. Atomic and ionic radius
   b. Ionization energy
   c. Electron affinity
   d. Electronegativity
   e. Physical properties
   f. Chemical properties and reactivity

B. Basic Principles of Chemical Reactions

1. Balancing equations for chemical reactions
   a. Simple chemical reactions
   b. Oxidation-reduction reactions
2. Stoichiometric calculations for chemical reactions
   a. Based on balanced equations involving moles, mass, or volume
   b. Limiting reagent calculations and percent yield
3. Predicting products of simple reaction types
   a. Combustion, neutralization, synthesis, decomposition, and dehydration reactions
   b. Single and double replacement reactions
4. Oxidation states and oxidation-reduction reactions
   a. Assigning oxidation numbers
   b. Identifying oxidation-reduction reactions and half-reactions
   c. Standard reduction potentials and the electrochemical reactivity series
5. Chemical kinetics: models based on collision theory
   a. Rate laws, rate constants, and reaction order
   b. Activation energy and catalysts
6. Equilibrium in chemical systems
   a. Equilibrium constants
   b. Le Chatelier's principle

V. Solutions and Acid-Base Chemistry

A. Solutions and Solubility

1. Analysis of types of solutions
   a. Dilute, concentrated, unsaturated, saturated, and supersaturated
   b. Identification of solute and solvent
   c. Representations of concentration in terms of various units, such as molarity, mole fraction, and percent by mass or volume
   d. Calculations needed to prepare solutions of varying concentrations
2. Factors affecting rate of dissolving and solubility
   a. Rate of dissolving (temperature, pressure, surface area, stirring)
   b. Solubility and solubility curves (temperature and pressure dependence)
3. Phenomena based on colligative properties of solutions
   a. Freezing point depression and boiling point elevation
   b. Vapor pressure effect
4. Equilibrium in ionic solutions
   a. Highly soluble and slightly soluble compounds
   b. Predictions of precipitation based on the solubility product (Ksp)
   c. Common ion effect when mixing ionic solutions
   d. Electrolytes, nonelectrolytes, and electrical conductivity of solutions

B. Acid-Base Chemistry

1. Models of acids and bases and their properties
   a. Arrhenius acids and bases
   b. Brønsted-Lowry acids and bases
   c. Lewis acids and bases
2. The concept of pH and calculations involving pH and pOH
   a. pH scale
   b. Calculation of pH and pOH
   c. Calculation of $[H^+]$ and $[OH^-]$
3. Concepts, representations, and calculations involving acid-base titrations
   a. Neutralization and equivalence point
   b. Use and selection of indicators
   c. End point determination
   d. Analysis of titrations curves
4. Equilibrium relationships in acid-base systems
   a. Strong and weak acids and bases
   b. Monoprotic and polyprotic acids
   c. K_a, K_b, K_w, and dissociation
   d. Buffer solutions

Science and Engineering Practices

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

1. Asking questions (for science) and defining problems (for engineering)
    - Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
    - Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
    - Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.
    - Ask questions to clarify and refine a model, an explanation, or an engineering problem.
    - Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
    - Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
    - Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
2. Developing and using models
    - Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.
    - Design a test of a model to ascertain its reliability.
    - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
    - Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
    - Develop a complex model that allows for manipulation and testing of a proposed process or system.
    - Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
3. Planning and carrying out investigations
    - Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
    - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
    - Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
    - Select appropriate tools to collect, record, analyze, and evaluate data.
    - Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

- Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

4. Analyzing and interpreting data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
- Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.
- Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
- Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.
- Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

5. Using mathematics and computational thinking

- Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
- Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
- Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
- Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world.
- Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

6. Constructing explanations (for science) and designing solutions (for engineering)

- Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.
- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

7. Engaging in argument from evidence

- Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
- Evaluate the claims, evidence, and/or reasoning behind currently accepted

explanations or solutions to determine the merits of arguments.
- Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.
- Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
- Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.
- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

8. Obtaining, evaluating, and communicating information

   - Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
   - Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.
   - Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
   - Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
   - Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Tasks of Teaching Science

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

Scientific Instructional Goals, Big Ideas, and Topics

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

Scientific Investigations and Demonstrations

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

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

10. Evaluating instructional materials and other resources for their ability to address scientific concepts; engage students with relevant phenomena; develop and use scientific ideas; promote students' thinking about phenomena, experiences, and knowledge; take account of students' ideas and background; and assess student progress
11. Choosing resources that support the selection of accurate, valid, and appropriate goals for science learning

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

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

Scientific Language, Discourse, Vocabulary, and Definitions

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

Scientific Explanations (includes claim, evidence, and reasoning)

19. Critiquing student-generated explanations or descriptions for their generalizability, accuracy, precision, or consistency with

scientific evidence

20. Selecting explanations of natural phenomena that are accurate and accessible to students

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

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