



The *PRAXIS*® Study Companion

Chemistry: Content Knowledge (5245)



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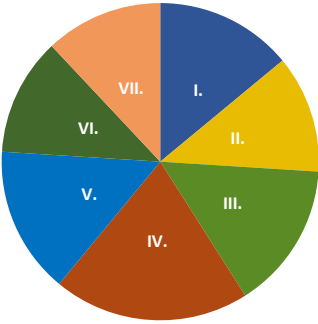
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Chemistry: Content Knowledge (5245)

Test at a Glance

The *Praxis*® Chemistry Content Knowledge test is designed to measure knowledge and competencies that are important for safe and effective beginning practice as a Chemistry content knowledge specialist.

| | | | |
|---|---|---------------------------------|---------------------------------------|
| Test Name | Chemistry: Content Knowledge | | |
| Test Code | 5245 | | |
| Time | 2.5 hours | | |
| 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. You can review the possible question types in Understanding Question Types. | | |
| Test Delivery | Computer Delivered | | |
|  | Content Categories | Approximate Number of Questions | Approximate Percentage of Examination |
| | I. Basic Principles of Matter and Energy Thermodynamics | 17 | 14% |
| | II. Atomic and Nuclear Structure | 15 | 12% |
| | III. Nomenclature; Chemical Composition Structure | 19 | 15% |
| | IV. Chemical Reactions; Periodicity | 25 | 20% |
| | V. Solutions and Solubility; Acid-Base Chemistry | 19 | 15% |
| | VI. Scientific Inquiry and Social Perspectives Science | 15 | 12% |
| | VII. Scientific Procedures and Techniques | 15 | 12% |

About The Test

The Chemistry: Content Knowledge test is designed to measure the knowledge and competencies necessary for a beginning teacher of secondary school Chemistry. Examinees have typically completed or nearly completed a bachelor's degree program with appropriate coursework in chemistry and education. This test may contain some questions that will not count toward your score.

The development of the test questions and the construction of the test reflect the National Science Education Standards (NSES) and the National Science Teacher Association (NSTA) standards and recognize that there are conceptual and procedural schemes that unify the various scientific disciplines. These fundamental concepts and processes (systems; models; constancy and change; equilibrium; form and function) are useful in understanding the natural world. Insofar as possible, then, the test questions will have the primary objective of evaluating the content areas by using questions that focus on conceptual understanding, critical thinking, and problem solving in science. The test content is developed and reviewed in collaboration with practicing high school chemistry teachers, teacher-educators, and higher education content specialists to keep the test updated and representative of current standards.

The 125 selected-response questions include concepts, terms, phenomena, methods, applications, data analysis, and problem solving in Chemistry, and include an understanding of the impact of science and technology on the environment and human affairs. The topics are typically those covered in introductory college-level chemistry courses, although some questions of a more advanced nature are included, because secondary school teachers must understand the subject matter from a more advanced viewpoint than that presented to their students.

Examinees 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.

Content Topics

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

Note: The use of “e.g.” to start a list of examples implies that only a few examples are offered and the list is not exhaustive, whereas the use of “i.e.” to start a list of examples implies that the given list of examples is complete.

Discussion Questions

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

I. Basic Principles of Matter and Energy; Thermodynamics

A. Matter and Energy

1. Organization of matter
 - a. pure substances (elements and compounds)
 - b. mixtures (homogeneous, heterogeneous, solutions, suspensions)
 - c. states of matter (solid, liquid, gas, plasma)
2. Particulate structure of matter
 - a. atoms, ions, molecules
3. Differences between chemical and physical properties and chemical and physical changes
 - a. chemical versus physical properties
 - b. chemical versus physical changes
intensive versus extensive properties
4. Conservation of energy and the conservation of matter in chemical processes
 - a. law of conservation of energy
 - b. law of conservation of matter
5. Different forms of energy
 - a. kinetic and potential
 - b. chemical, electrical, electromagnetic, nuclear, and thermal energy
 - c. conversions between different forms of energy within chemical systems

Discussion Questions: Matter and Energy

- Test tubes contain three colorless liquids: alcohol, water, and a weak solution of ammonia. What properties could be used to identify the liquids?
- What are some examples of the different types of mixtures?
- What is a cation?
- In their standard state, which of the following elements are diatomic: bromine, chlorine, argon, and helium?
- What are some examples of chemical properties?
- Describe a process that involves both a chemical change and a physical change?
- Is balancing a chemical equation an application of the law of conservation of energy or the law of conservation of matter?
- List in order of increasing energy (or decreasing wavelength) the following forms of electromagnetic radiation: gamma rays, microwaves, x-rays, visible light, ultraviolet, and infrared).
- What is an example of the conversion of chemical energy to electrical energy?

B. Thermodynamics in Chemistry

1. Temperature, thermal energy, and heat capacity, including temperature scales, units of energy, and calculations involving these concepts
 - a. temperature and temperature scales
 - b. thermal energy and units of energy
 - c. heat transfer
 - d. heat capacity and specific heat
 - e. calorimetry calculations
2. Concepts and calculations involving phase transitions between the various states of matter
 - a. phase transitions and diagrams
 - b. heats of vaporization, fusion, and sublimation
 - c. heating curves
3. Kinetic molecular theory and ideal gas laws
 - a. assumptions of the kinetic molecular theory
 - b. ideal gases and the ideal gas laws (e.g., applications, calculations)
 - c. real gas behavior
4. Energetics of chemical reactions
 - a. exothermic and endothermic reactions
 - b. bond energy; Hess's law

5. How the laws of thermodynamics relate to chemical reactions and phase changes
 - a. laws of thermodynamics
 - b. spontaneous/reversible processes
 - c. change in enthalpy, entropy, and Gibbs energy in chemical/physical processes

Discussion Questions:**Thermodynamics in Chemistry**

- Convert 350 K to degrees Celsius.
- Which of the following are units of energy: ergs, joules, electron volts, ohms?
- If a substance has high heat capacity, will its temperature increase faster as heat is absorbed than for a substance with lower heat capacity absorbing the same amount of heat?
- How much heat is absorbed as 10 g of ice melts at the freezing point?
- What is the boiling point of water at high altitudes compared to sea level and why is it different?
- When a gas expands from 5 L to 10 L as its temperature increases from 300 K to 500 K, what is the change in the pressure of the gas?
- What are the major differences between an ideal gas and a real gas?
- Given the heats of formation of H_2O , CO_2 , and CH_4 , calculate the heat of combustion of CH_4 .
- Is the combustion of CH_4 an exothermic or endothermic process?
- Based on the first and second laws of thermodynamics, predict whether a reaction is spontaneous.

- Describe some processes in which the entropy of the system is increasing.

II. Atomic and Nuclear Structure

1. Current model of atomic structure
 - a. description of atomic model (e.g., subatomic particles, orbitals, quantum numbers)
 - b. experimental basis (e.g., cathode ray tube, gold foil experiment, spectral lines)
 - c. isotopes (mass number, average atomic mass)
2. Electron configuration of the elements based on the periodic table
 - a. Aufbau principle, Hund's rule, Pauli exclusion principle
 - b. correlation between electron configuration and periodic table
 - c. relationship between electron configuration and chemical and physical properties
3. Radioactivity
 - a. characteristics of alpha particles, beta particles, and gamma radiation
 - b. radioactive decay processes; half life
 - c. fission, fusion, and other nuclear reactions
 - d. balancing nuclear reactions and identifying products of nuclear reactions

4. How the electronic absorption and emission spectra of elements are related to electron energy levels
 - a. electronic energy transitions in atoms (e.g., ground state, excited states, emission/absorption of energy)
 - b. energy of electronic absorption/emission spectral lines in various regions of the electromagnetic spectrum
 - c. relationship between energy, frequency, and wavelength

Discussion Questions: Atomic and Nuclear Structure

- How are isotopes of the same element alike? How are they different?
- An element has three isotopes, each with a different mass. Explain why the mass number for the element that is listed on the periodic table is not equal to the mass of any of the isotopes.
- What are the electron configurations for atoms of sodium and sulfur?
- Based on their electron configurations, what is the formula of the compound that forms in the reaction of sodium and sulfur?
- Give an example of Hund's rule.
- Given that the half-life of carbon-14 is 5,730 years, estimate the age of a piece of charcoal that has a carbon-14 content equal to 12.5% of that in living matter.
- How is fission different than fusion or radioactive decay?
- What is the wavelength of the energy emitted for an electronic transition in a hydrogen atom from $n = 3$ to $n = 2$ electronic energy level?
- What part of the electromagnetic spectrum are electron emission spectral lines?

III. Nomenclature; Chemical Composition; Bonding and Structure

A. Nomenclature and Chemical Composition

1. Systematic names and chemical formulas of simple inorganic compounds
 - a. binary compounds
 - b. acids, bases, and salts
 - c. hydrates
2. Names of common organic compounds based on their functional groups
 - a. alkanes, alkenes, and alkynes
 - b. alcohols, ethers, ketones, aldehydes, amines
3. Mole concept and how it applies to chemical composition
 - a. Avogadro's number, molar mass, and mole conversions
 - b. calculation of empirical and molecular formulas
 - c. percent composition

B. Bonding and Structure

1. Common properties of bonds
 - a. relative bond lengths
 - b. relative bond strengths
2. Bond types
 - a. ionic bonding
 - b. covalent bonding (polar, nonpolar, hybridization)
 - c. metallic bonding
3. Structural formulas and molecular geometry (shape)
 - a. Lewis structures including formal charges
 - b. resonance structures
 - c. molecular geometry (shape and approximate bond angles)
4. Identify polar and nonpolar molecules
 - a. analysis of bonding in the molecule
 - b. symmetry of molecular structure
5. Intermolecular interactions
 - a. hydrogen bonding
 - b. London forces (instantaneous induced dipole-dipole)
 - c. dipole-dipole
 - d. dipole-induced dipole
6. How bonding and structure correlate with physical properties
 - a. boiling points and melting points
 - b. solubility
 - c. equilibrium vapor pressure

Discussion Questions: Nomenclature; Chemical Composition; Bonding and Structure

- What are the IUPAC names for the following compounds: HClO_4 , $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, and CuCl_2 ?
- Write the molecular formula for each of the following compounds: acetone, ethanol, ethanal, and formic acid.
- What is the number of moles of oxygen atoms in 5 moles of $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$?
- What is the molecular formula of a compound that has the empirical formula $\text{C}_2\text{H}_4\text{O}$ and a molar mass of 88 g?
- Which of the following molecules has the shortest bond length: HF, HCl, N_2 , or O_2 ?
- Which type of bonding is found in each of the following solids: KCl, NaSO_4 , and Cu?
- What is the difference between a pi bond and a sigma bond?
- Why is the geometry of NH_3 trigonal pyramidal?
- What are the Lewis dot and the structural formulas for CH_4 ?
- What are the resonance structures for the carbonate ion?
- Does CO_2 have any polar bonds? Is it a polar molecule? Why?
- What is the predominate intermolecular force involved between two PCl_3 molecules?

- Correlate the relative boiling points of the following compounds with their molecular structure and intermolecular interactions: H_2O , Cl_2 , Br_2 , HCl , and H_2 .

IV. Chemical Reactions; Periodicity

A. Periodicity

1. Basis of the periodic table and general layout
 - a. arranged in groups and periods
 - b. atomic number and mass
 - c. symbols of the elements
 - d. metals, nonmetals, metalloids
 - e. transition elements
2. Periodic trends in physical and chemical properties of the elements
 - a. atomic/ionic radius
 - b. ionization energy
 - c. electron affinity
 - d. electronegativity
 - e. physical properties (e.g., boiling/melting points, conductivity)
 - f. chemical reactivity

B. Chemical Reactions and Basic Principles

1. Balancing chemical equations
 - a. simple chemical equations
 - b. chemical equations involving oxidation- reduction

2. Stoichiometric calculations
 - a. simple calculations based on balanced chemical equations involving moles, mass, and volume
 - b. limiting reagent calculations and percent yield
3. Identify, write, and predict products of simple reaction types
 - a. combustion, neutralization
 - b. decomposition, dehydration
 - c. single and double replacement
 - d. oxidation-reduction
4. Chemical kinetics
 - a. rate laws, rate constants, and reaction order
 - b. activation energy and reaction mechanisms including catalysts
 - c. factors affecting reaction rate such as concentration, surface area, and temperature
5. Chemical reaction equilibrium
 - a. equilibrium constants
 - b. Le Châtelier's principle
6. Oxidation-reduction reactions and how to determine oxidation states
 - a. oxidation states
 - b. identify oxidation-reduction reactions and half reactions
 - c. standard reduction potentials
 - d. electrochemical reactivity series
 - e. electrochemical cells

C. Biochemistry and Organic Chemistry

1. Important biochemical compounds
 - a. carbohydrates, including simple sugars
 - b. lipids
 - c. proteins and amino acids
 - d. DNA and RNA
 - e. products of photosynthesis and respiration
2. Common organic compounds (i.e., identify functional groups)
 - a. alcohols
 - b. ketones and aldehydes
 - c. alkanes, alkenes, and alkynes
 - d. ethers
 - e. carboxylic acids
 - f. amines
 - g. benzene

Discussion Questions: Chemical reactions; Periodicity

- In what location of the periodic table are nonmetals generally found?
- List some examples of transition elements
- How do the atomic radii, ionization energies, and melting points change across period and down columns in the periodic table?
- Using the location of the elements on the periodic table, predict the formula of the compound that would exist containing Mg and O.

- What needs to be considered when balancing oxidation-reduction reactions that does not need to be accounted for when balancing a standard formation reaction such as:

$$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}?$$
- At standard temperature and pressure, what is the ratio of the volumes of hydrogen gas and oxygen gas that react to form water?
- What is the limiting reagent in the reaction to form water, when 10 g of hydrogen is mixed with 32 g of oxygen?
- How is a decomposition reaction different from a dehydration reaction?
- What is the effect of temperature and catalysts on reaction rates?
- How are simple rate equations determined based on experimental data?
- What changes will occur to chemical systems that are at equilibrium when pressure or concentration of one of the reactants or products is changed?
- What is the effect of temperature on equilibrium constants?
- Based on a table of standard reduction potentials, predict whether the following reaction will occur spontaneously:

$$\text{Cu} + \text{FeCl}_2 \rightarrow \text{CuCl}_2 + \text{Fe}?$$
- What is the oxidation state of Mn in KMnO_2 ?

- What are the structures in the following types of molecules that distinguish them from other biochemical compounds: Carbohydrates, amino acids, and DNA?
- Identify the functional group in each of the following compounds: CH_3OCH_3 , CH_3NH_2 , CH_3OH , and CH_3COOH

V. Solutions and Solubility; Acid-Base Chemistry

A. Solutions and Solubility

1. Solution terminology and calculations
 - a. dilute, concentrated
 - b. saturated, unsaturated, supersaturated
 - c. solvent, solute
 - d. concentration units (e.g., molarity, molality, mole fraction, parts per million (ppm), parts per billion (ppb), percent by mass or volume)
 - e. preparation of solutions of varying concentrations
2. Factors affecting solubility and dissolution rate
 - a. dissolution rate (i.e., temperature, pressure, surface area, agitation)
 - b. solubility and solubility curves (temperature and pressure dependent)

3. Solution phenomena based on colligative properties
 - a. freezing point depression
 - b. boiling point elevation
 - c. vapor pressure effects
 - d. osmotic pressure
4. Common applications of equilibrium in ionic solutions
 - a. solubility of ionic compounds (e.g., solubility rules, slightly soluble compounds)
 - b. K_{sp} calculations including percent dissociation and precipitation
 - c. common ion effect
 - d. electrolytes, nonelectrolytes, and electrical conductivity

B. Acid-Base Chemistry

1. Define and identify acids and bases and know their properties
 - a. Arrhenius acids and bases
 - b. Brønsted-Lowry acids and bases
 - c. Lewis acids and bases
 - d. neutralization and equivalence point
2. The pH scale and calculations involving pH and pOH
 - a. pH scale
 - b. calculation of pH and pOH
 - c. calculation of $[\text{H}^+]$ and $[\text{OH}^-]$
 - d. knows the meaning of K_w
3. Concepts and calculations involving acid-base titrations
 - a. use and selection of indicators (e.g., phenolphthalein, litmus paper)
 - b. endpoint determination
 - c. calculations based on titrations

4. Equilibrium relationships in acid-base chemistry
 - a. strong/weak acids and bases, including common examples
 - b. monoprotic and polyprotic acids
 - c. K_{b1} , K_{b2} , and percent dissociation
 - d. hydrolysis (acidic and basic salts)
 - e. buffer solutions

Discussion Questions: Solutions and Solubility; Acids-Base Chemistry

- How many grams of solute are present in 1.5 L of 0.30 M KNO_3 ?
- What is the difference between a 1 molar NaCl solution and a 1 molal NaCl solution?
- Is a very concentrated solution saturated, supersaturated, or unsaturated? What else do you need to know to answer the question?
- Why is ammonia gas very soluble in water while oxygen is only slightly soluble?
- What is the relationship between surface area and dissolution rate?
- Will increasing temperature increase the solubility of any substance?
- How will the vapor pressure, boiling point, and freezing point of water change when a nonvolatile solute is added to water?
- Compare the degree of dissociation of HCl and H_2S in water.
- Write a chemical equation that illustrates the common ion effect.
- Is CCl_4 an electrolyte?
- When an aqueous solution of NaCl is mixed with an aqueous solution of AgNO_3 the precipitate AgCl forms. Why?
- Select an acid that is both a Brønsted-Lowry acid and a Lewis acid and explain why it fits both definitions.
- What is $[\text{H}^+]$ in an aqueous solution with $\text{pH} = 5.5$?
- What is the pOH of a solution with $[\text{H}^+] = 1 \times 10^{-8} \text{ M}$?
- Based on a titration curve, determine the pK_a of the acid and the volume of base required to neutralize the acid.
- What indicator would be used in a titration involving a strong acid and a weak base and why?
- Is HF a strong acid? Why or why not?
- If Na_2CO_3 is dissolved in water, will the solution be acidic, basic, or neutral?
- For an acid HA, $K_a = 1 \times 10^{-8}$, what is the pH of 0.001 M HA?

VI. Scientific Inquiry and Social Perspectives of Science

A. History and Nature of Scientific Inquiry

1. Processes involved in scientific inquiry
 - a. formulating problems
 - b. forming and testing hypotheses
 - c. development of theories, models, and laws (postulates, assumptions)
 - d. process skills including observing, concluding, comparing, inferring, categorizing, and generalizing

2. Experimental design
 - a. testing hypotheses
 - b. significance of controls
 - c. use and identification of variables
 - d. data collection planning
3. Nature of scientific knowledge
 - a. subject to change
 - b. consistent with experimental evidence
 - c. reproducibility
 - d. unifying concepts and processes (e.g., systems, models, constancy and change, equilibrium, form and function)
4. Major historical developments in chemistry and the contributions of major historical figures
 - a. how current chemical principles and models developed over time
 - b. major developments in chemistry (e.g., atomic model, ideal gas behavior) including major historical figures

B. Science, Technology, Society, and the Environment

1. Impact of chemistry and technology on society and the environment
 - a. pharmaceuticals
 - b. acid rain
 - c. medical imaging
 - d. air and water pollution
 - e. greenhouse gases
 - f. ozone layer depletion
 - g. waste disposal and recycling
 - h. nanotechnology

2. Applications of chemistry in daily life
 - a. plastics, soap, batteries, fuel cells, and other consumer products
 - b. water purification
 - c. chemical properties of household products
3. Advantages and disadvantages associated with various types of energy production
 - a. renewable and nonrenewable energy resources
 - b. conservation and recycling
 - 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

Discussion Questions: Scientific Inquiry and Social Perspectives of Science

- What are the similarities and differences between laws, hypotheses, and theories?
- What is the difference between independent and dependent variables? Describe an experiment and identify the independent and the dependent variables.
- Describe something in chemistry that illustrates the relationship between form and function.
- What is Boyle's law and what is Charles's law?
- What was the role of Bohr's model of the atom in the development of modern atomic theory?
- What are the major contributors of acid rain?

- What are some of the reactions in the stratosphere that lead to ozone depletion?
- What are the acid-base properties of commonly used consumer products such as ammonia cleaner, vinegar, and orange juice?
- Describe the reverse osmosis process that is sometimes used for water purification.
- What settings is solar power most effective?
- What are some examples of nonrenewable energy resources?

VII. Scientific Procedures and Techniques

1. Collect, evaluate, manipulate, interpret, and report data
 - a. significant figures in collected data and calculations
 - b. organization and presentation of data
 - c. knows how to interpret and draw conclusions from data presented in tables, graphs, and charts (e.g., trends in data, relationships between variables, predictions and conclusions based on data)
2. Units of measurement, notation systems, conversions, and mathematics used in chemistry
 - a. standard units of measurement
 - b. unit conversion
 - c. scientific notation
 - d. measurement equipment
3. Basic error analysis
 - a. determining mean
 - b. accuracy and precision
 - c. identifying sources and effects of error
 - d. percent error
4. Appropriate preparation, use, storage, and disposal of materials in the laboratory
 - a. appropriate use and storage
 - b. safe disposal
 - c. preparation for classroom use
 - d. safe procedures and safety precautions
5. Appropriate use, maintenance, and calibration of laboratory equipment
 - a. appropriate use and storage
 - b. maintenance and calibration
 - c. preparation for classroom use
 - d. safety procedures and precautions when using equipment
6. Safety procedures and precautions for the high school chemistry laboratory
 - a. location and use of standard safety equipment such as eyewash and shower
 - b. laboratory safety rules for students
 - c. appropriate apparel and conduct in the laboratory, such as wearing goggles
 - d. emergency procedures

Discussion Questions: Scientific Procedures and Techniques

- What is the uncertainty in volume measurements made when using a buret and how many significant figures should be included in the recorded volume?
- How many significant figures are in 0.1360 g?
- Determine the endpoint in an acid-base titration using a plot of pH versus the volume of base added to an acid.
- What is the mass in grams of a sample that has a mass of 20 mg ?
- Express the number 0.000450 in scientific notation.
- What is the difference between the accuracy and the precision of a data set?
- How do you prepare 200 mL of 0.5 M CaSO_4 from a stock solution of 2.0 M CaSO_4 ?
- Can a very dilute solution of HCl acid be disposed of in a sink with running water?
- What are the following pieces of equipment used for in the laboratory: buret, pipet, Erlenmeyer flask, and volumetric flask?
- When and why is a fume hood needed in a chemistry laboratory?

Chemistry: Content Knowledge (5245) Sample Test Questions

Sample Questions

The sample questions that follow represent a number of the types of questions and topics that appear on the test. They are not, however, representative of the entire scope of the test in either content or difficulty. Answers with explanations follow the questions.

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

1. Which of the following is the correct IUPAC name for $\text{Ca}_3(\text{PO}_4)_2$?
 - (A) Calcium phosphide
 - (B) Calcium(III) phosphite
 - (C) Calcium phosphate
 - (D) Calcium biphosphate
2. Based on its position on the periodic table, which of the following has the largest atomic radius?
 - (A) Cs
 - (B) Mg
 - (C) I
 - (D) Se
3. If 50 mL of 0.02 M Na_2SO_4 is diluted with sufficient water to make a total volume of 200 mL, which of the following is the concentration of Na^+ ions in the diluted solution?
 - (A) 0.005 M
 - (B) 0.1 M
 - (C) 0.2 M
 - (D) 0.4 M

4. Which of the following is the number of significant figures in a mass that was recorded as 0.00100 g ?
(A) 1
(B) 3
(C) 4
(D) 6
5. Of the following, which best describes smoke?
(A) A suspension
(B) An alloy
(C) A solution
(D) A homogeneous mixture
6. Which of the following scientists is known for developing a model of the atom?
(A) Rosalind Franklin
(B) George Washington Carver
(C) John Dalton
(D) Louis Pasteur
7. Which of the following is the ground-state electron configuration of Mg^{2+} ?
(A) $1s^2 2s^2 2p^6 3s^2$
(B) $1s^2 2s^2 2p^6$
(C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
(D) $1s^2 2s^2 2p^6 3s^2 3p^6$
8. How many oxygen atoms are in 2 moles of CuSO_4 ?
(A) 4
(B) 8
(C) 6.02×10^{23}
(D) 4.82×10^{24}

9. At standard temperature and pressure (STP), what volume of CO_2 is produced when 1.000 mol of C_8H_{18} undergoes complete combustion?
- (A) 179.2 L
 - (B) 89.6 L
 - (C) 22.4 L
 - (D) 8.00 L
10. Which of the following is the approximate pH of a $1.0 \times 10^{-3} \text{ M}$ NaOH solution?
- (A) pH = 3.0
 - (B) pH = 4.0
 - (C) pH = 10.0
 - (D) pH = 11.0
11. A well-designed experiment always includes which of the following?
- (A) A scientific law
 - (B) A well-written conclusion
 - (C) Multiple independent variables
 - (D) A plan about how to measure the dependent variable
12. Which of the following is a unit that is used to describe bond lengths?
- (A) Erg
 - (B) Bar
 - (C) Nanometer
 - (D) Coloumb
13. If a 20 g sample of a substance is compared to a 10 g sample of the same substance, both at 25°C , the 20 g sample will have a higher
- (A) density
 - (B) thermal heat content
 - (C) temperature
 - (D) boiling point

14. Naturally occurring Ce has four stable isotopes, one of which is much more abundant than the others. The atomic weight for Ce is listed on the periodic table as 140.1. Based on the data, which is the most abundant isotope?
- (A) ^{136}Ce
 - (B) ^{138}Ce
 - (C) ^{140}Ce
 - (D) ^{142}Ce
15. What is the empirical formula for $\text{CH}_3\text{CH}_2\text{COOH}$?
- (A) $\text{C}_4\text{H}_8\text{O}_2$
 - (B) $\text{C}_2\text{H}_4\text{O}$
 - (C) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^- + \text{H}^+$
 - (D) $\text{CH}_3\text{C}^+ + \text{OH}^-$
16. $\text{A}(\text{g}) + \text{B}(\text{g}) \rightarrow \text{C}(\text{g})$
- For the reaction represented above, when the concentrations of the starting materials A and B are both doubled, the initial rate of the reaction is doubled. Which of the following is a possible initial rate law for the reaction? ($[\text{A}]$ is the concentration of A and $[\text{B}]$ is the concentration of B.)
- (A) $\text{Rate} = k[\text{A}]^2[\text{B}]^2$
 - (B) $\text{Rate} = k[\text{A}]^2[\text{B}]$
 - (C) $\text{Rate} = k[\text{A}][\text{B}]$
 - (D) $\text{Rate} = k[\text{A}]$
17. If the concentration of H^+ in an aqueous solution at 25°C is 0.0002 M , what is the concentration of OH^- in the solution?
- (A) $5 \times 10^{-9}\text{ M}$
 - (B) $2 \times 10^{-10}\text{ M}$
 - (C) $5 \times 10^{-11}\text{ M}$
 - (D) $1 \times 10^{-14}\text{ M}$

18. $A(g) \rightleftharpoons B(g)$

Which of the following is a clear indication that the reaction represented above is at equilibrium?

- (A) All of A has been converted to B.
- (B) The mass of B equals the initial mass of A.
- (C) The concentration of A equals the concentration of B.
- (D) The rate of formation of B equals the rate of formation of A.

19. Of the following molecules, which has the most polar covalent bonds?

- (A) HBr
- (B) CH_4
- (C) Cl_2
- (D) H_2

20. $2 KMnO_4 + 3 Na_2SO_3 + H_2O \rightarrow 2 MnO_2 + 3 Na_2SO_4 + 2 KOH$

Which of the following species is reduced in the oxidation-reduction reaction represented above?

- (A) K^+
- (B) Mn^{7+}
- (C) Na^+
- (D) S^{4+}

21. If a weak acid is titrated with a strong base, which of the following could be the pH at the equivalence point?

- (A) pH = 2.0
- (B) pH = 6.0
- (C) pH = 7.0
- (D) pH = 8.0

22. Which of the following must be done under a fume hood?
- (A) Heating a sample of HgO
 - (B) Dissolving KMnO_4 in water
 - (C) Dissolving sugar crystals in an ethanol- water mixture
 - (D) Diluting a solution of CH_3OH with water
23. Two moles of an ideal gas in a freely expandable piston are heated from $T_1 = 300 \text{ K}$ to $T_2 = 400 \text{ K}$, and the gas expands from $V_1 = 2 \text{ L}$ to $V_2 = 4 \text{ L}$. What is the pressure after the expansion?
- (A) $P_2 = P_1$
 - (B) $P_2 = \frac{1}{2}P_1$
 - (C) $P_2 = 2P_1$
 - (D) $P_2 = \frac{2}{3}P_1$
24. Ozone in the atmosphere is most closely related to which of the following?
- (A) Acid rain production
 - (B) Water pollution
 - (C) Absorption of ultraviolet radiation in the stratosphere
 - (D) Nuclear-power plant waste
25. Which of the following represents a positron emission?
- (A) ${}^8_5\text{B} \rightarrow {}^8_4\text{Be} + {}^0_{+1}\text{e}$
 - (B) ${}^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + {}^4_2\text{He}$
 - (C) ${}^{144}_{58}\text{Ce} \rightarrow {}^{144}_{59}\text{Pr} + {}^0_{-1}\text{e}$
 - (D) ${}^{13}_6\text{C} + {}^4_2\text{He} \rightarrow {}^{16}_8\text{O} + {}^1_0\text{n}$

26. Br_2 has a lower boiling point than H_2O because of hydrogen bonding between H_2O molecules in liquid water. Which of the following intermolecular interactions exist between Br_2 molecules in the liquid phase?
- (A) London dispersion forces
 - (B) Dipole-dipole forces
 - (C) Ionic bonding
 - (D) Covalent bonding
27. Which of the following is a carboxylic acid?
- (A) $\text{CH}_3\text{CH}_2\text{COOH}$
 - (B) CH_3OCH_3
 - (C) H_2CO_3
 - (D) CH_3NH_2
28. For $\text{Mg}(\text{OH})_2$ at room temperature, the solubility product K_{sp} is approximately 1×10^{-11} . The magnitude of the solubility constant indicates which of the following about $\text{Mg}(\text{OH})_2$?
- (A) If sufficient $\text{Mg}(\text{OH})_2$ is mixed with water, it can form 11 M $\text{Mg}(\text{OH})_2$ (aq).
 - (B) It is a weak acid.
 - (C) It cannot form a saturated solution.
 - (D) It is only slightly soluble.
29. Of the following materials, which is most biodegradable?
- (A) Glass bottle
 - (B) Petroleum
 - (C) Aluminum can
 - (D) Flashlight battery

30. Dry crystals of an unknown inorganic compound were heated in a dry glass test tube. The mass of the test tube and its solid contents was observed to be less after heating. Which TWO of the following could explain the observation?
- (A) The crystals were a hydrate, and at least some of the water vaporized and escaped.
 - (B) The crystals were a compound that decomposed into two different solid compounds.
 - (C) A reaction occurred in which one of the products was a gas that escaped.
 - (D) The crystals were a compound that reacted with oxygen in the air to form a compound of lower mass than the original compound.
31. Which THREE of the following processes involve an increase in entropy?
- (A) Ice melting
 - (B) Snow sublimating
 - (C) Dew forming on grass
 - (D) Sugar dissolving in water

Answers

- Option (C) is correct. Calcium phosphate is the correct name. Three calcium ions are bonded to two phosphate polyatomic ions.
- Option (A) is correct. An atom of Cs has a larger radius than an atom of Mg, I, or Se based on its location on the periodic table. Going down the column, the atom radius generally increases, and going from left to right across a row, the atomic radius generally decreases. Cs is located near the lower corner on the left side of the periodic table.

- Option (B) is correct. The concentration of Na^+ ions is 0.01 M :

$$[\text{Na}^+] = \frac{(0.05\text{ L})(0.2\text{ M Na}_2\text{SO}_4)}{(0.2\text{ L})} \times \frac{2\text{ Na}^+}{\text{Na}_2\text{SO}_4} = 0.01\text{ M}$$

Note that 50 mL is 0.05 L and 200 mL is 0.2 L.

- Option (B) is correct. The numeral one and the two zeros following it are significant figures that reflect the precision of the measuring instrument that was used to determine the mass. The last zero is an estimate beyond the smallest increment that the instrument shows.
- Option (A) is correct. Smoke is a suspension. Tiny particles are suspended by Brownian motion in the air (collisions with the molecules of nitrogen, oxygen, and other gases). Eventually, the particles may settle and collect on surfaces.
- Option (C) is correct. John Dalton proposed an atomic theory in the 1800s, although he did scientific work in a number of other areas of science.
- Option (B) is correct. The electron configuration for the Mg^{2+} ion based on the Aufbau principle is: $1s^2 2s^2 2p^6$. Mg atoms each have 12 electrons, but Mg^{2+} ions each have 10 electrons.

8. Option (D) is correct. Two moles of CuSO_4 contain 8 moles of oxygen atoms. The number of oxygen atoms is 8 times Avogadro's number:
 $8 \times 6.2 \times 10^{23} = 4.82 \times 10^{24}$ atoms.
9. Option (A) is correct. The balanced equation for the reaction is:
 $2 \text{C}_8\text{H}_{18} + 25 \text{O}_2 \rightarrow 16 \text{CO}_2 + 18 \text{H}_2\text{O}$
 Based on the balanced equation, 8 mol of CO_2 would be produced. This volume of 8 mol of CO_2 at STP is: $8 \times 22.4 \text{ L} = 179.2 \text{ L}$
10. Option (D) is correct. The concentration of the correct name. Three calcium ions are bonded to two phosphate polyatomic ions. H^+ in the solution is:
 $[\text{H}^+] = 1 \times 10^{-14} / [\text{OH}^-]$
 Since $[\text{OH}^-] = 1 \times 10^{-3}$, then $[\text{H}^+] = 1 \times 10^{-11}$. The pH of the solution is equal to: \log
 $[\text{H}^+] = -\log(1.0 \times 10^{-11}) = 11.0$.
11. Option (D) is correct. The experimental design should include a plan to measure the dependent variable and should have only one independent variable. Laws and conclusions are not part of an experimental design.
12. Option (C) is correct. Bond lengths are very small and are often described in terms of nanometers. A nanometer is 1×10^{-9} meter. An erg is an energy unit, a bar is a pressure unit, and a coulomb is an electrical-charge unit.
13. Option (B) is correct. The 20 gram sample will have a higher thermal heat content because heat content depends on both the temperature and amount of the substance. Both samples will have the same density, temperature, and boiling point.
14. Option (C) is correct. The natural abundance of ^{140}Ce is 88.4%. The atomic mass list on the periodic table is a weighted average of the naturally occurring isotopes. Without doing calculations, it is clear that ^{140}Ce is most abundant, since the weighted average of the four isotopes is close to the atomic mass of ^{140}Ce .

15. Option (B) is correct. The empirical formula is the smallest whole-number ratio of the atoms in the chemical compound. The empirical formula is C_2H_4O .
16. Option (D) is correct. $\text{Rate} = k[A]$ is a possible initial rate law that fits the data, because doubling A only would result in doubling the initial rate of reaction which agrees with the observed experimental results. Similarly, $\text{rate} = k[B]$ is also a possible initial rate law that fits the data, but it is not one of the answer choices. The other answer choices would result in a larger increase in reaction rate than what was observed.
17. Option (C) is correct. At 298 K, $K_w = 1 \times 10^{-14} = [H^+][OH^-]$. Based on this equilibrium, $[OH^-] = 1 \times 10^{-14} / (0.0002) = 5 \times 10^{-11} M$.
18. Option (D) is correct. At equilibrium, the rates of the forward and reverse reactions are equal. The concentrations of A and B can be found using the equilibrium constant.
19. Option (A) is correct. Since the difference in electronegativity between H and Br is greater than the electronegativity difference between C and H, the covalent bond between H and Br in HBr is more polar than the covalent bonds between C and H in CH_4 . There is a nonpolar covalent bond in Cl_2 and in H_2 .
20. Option (B) is correct. Reduction involves a reduction of the formal oxidation number of the species. Mn^{7+} in $KMnO_4$ is reduced to Mn^{4+} in MnO_2 . S^{4+} in Na_2SO_3 is oxidized to S^{6+} in Na_2SO_4 . K^+ , Na^+ , and O^{2-} and do not undergo a change in oxidation number.
21. Option (D) is correct. The pH of titration of a weak acid with a strong base will not be at 7.0 but will be at a basic pH, since the hydrolysis of the salt of the weak acid will provide OH^- ions in solutions, resulting in a pH above 7.0. An example is the titration of the weak acid CH_3COOH with the strong base $NaOH$. At the equivalence point of the titration, $Na^+ + CH_3COO^- + H_2O$ have been produced. But there is a hydrolysis equilibrium that exists: $H_2O + CH_3COO^- \rightarrow CH_3COOH + OH^-$. Hence the pH will be above 7.0.

22. Option (A) is correct. When heated, mercuric oxide decomposes to liquid Hg and O₂. It should be done under a fume hood. Mercuric oxide is toxic by inhalation or contact with skin and liquid Hg may form some Hg vapor. The other answer choices are safe to do without a fume hood.
23. Option (D) is correct. The pressure after the expansion (P_1) is two-thirds the original pressure (P_2). The relationship between the pressure, volume, and temperature before and after the process is: $P_2 = P_1 \times \frac{V_1}{V_2} \times \frac{T_2}{T_1}$.
24. Option (C) is correct. Ozone absorbs harmful ultraviolet radiation in the stratosphere. It is not related to the other answer choices.
25. Option (A) is correct. It represents a positron emission.
26. Option (A) is correct. There are London forces of attraction between Br₂ molecules in the liquid phase. Covalent bonding is an intramolecular interaction in Br₂, not an intermolecular interaction. Ionic bonding and dipole-dipole interactions do not exist in Br₂ molecules. Dipole-dipole interactions exist between polar molecules.
27. Option (A) is correct. Carboxylic acids contain the carboxyl functional group (—COOH), which contains a carbonyl group bonded to a hydroxyl group.
28. Option (D) is correct. A very low K_{sp} indicates that Mg(OH)₂ is only slightly soluble and will form a saturated solution with a very small concentration of Mg²⁺ and OH⁻ ions present in solution. Hence, a 11M solution cannot be prepared. It is a base, not an acid.

29. Option (B) is correct. Of the answer choices, petroleum is most biodegradable. Glass and aluminum can biodegrade but over very long time periods. Many of the components of the flashlight battery will not biodegrade.
30. Options (A) and (C) are correct. Inorganic hydrates are compounds that in their solid state contain some H_2O molecules within their crystal lattice. When heated the water can vaporize, resulting in a lower mass for the remaining solid. An example of a hydrate is $\text{MgCO}_3 \cdot 5\text{H}_2\text{O}$. When a reaction occurs in an open vessel in which one of the products is a gas, the gas can escape, resulting in a loss of mass. A decomposition reaction that produced two solid compounds would not result in a loss of mass. If an oxide had been produced in a reaction with oxygen, the mass of the contents would have increased, not decreased.
31. Options (A) (B) and (D) are correct. Entropy increases as solid ice becomes liquid water, as snow changes to gaseous water as it sublimates, and as sugar dissolves in water. Entropy decreases as gas water vapor condenses as a liquid on grass.

Understanding Question Types

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

Understanding Selected-Response and Numeric-Entry Questions

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

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

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

Remember that with every question you will get clear instructions.

Understanding Constructed-Response Questions

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

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

Review a few sample essay topics:

- *Brown v. Board of Education of Topeka*
 “We come then to the question presented: Does segregation of children in public schools solely on the basis of race, even though the physical facilities and other ‘tangible’ factors may be equal, deprive the children of the minority group of equal educational opportunities? We believe that it does.”
 - A. What legal doctrine or principle, established in *Plessy v. Ferguson* (1896), did the Supreme Court reverse when it issued the 1954 ruling quoted above?
 - B. What was the rationale given by the justices for their 1954 ruling?
- *In his self-analysis, Mr. Payton says that the better-performing students say small-group work is boring and that they learn more working alone or only with students like themselves. Assume that Mr. Payton wants to continue using cooperative learning groups because he believes they have value for all students.*
 - Describe **TWO** strategies he could use to address the concerns of the students who have complained.
 - Explain how each strategy suggested could provide an opportunity to improve the functioning of cooperative learning groups. Base your response on principles of effective instructional strategies.
- *“Minimum-wage jobs are a ticket to nowhere. They are boring and repetitive and teach employees little or nothing of value. Minimum-wage employers take advantage of people because they need a job.”*
 - Discuss the extent to which you agree or disagree with this opinion. Support your views with specific reasons and examples from your own experience, observations, or reading.

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

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

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

General Assistance For The Test

Praxis® Interactive Practice Test

This full-length *Praxis*® practice test lets you practice answering one set of authentic test questions in an environment that simulates the computer-delivered test.

- Timed just like the real test
- Correct answers with detailed explanations
- Practice test results for each content category

ETS provides a free interactive practice test with each test registration. You can learn more [here](#).

Doing Your Best

Strategy and Success Tips

Effective *Praxis* test preparation doesn't just happen. You'll want to set clear goals and deadlines for yourself along the way. Learn from the experts. Get practical tips to help you navigate your *Praxis* test and make the best use of your time. Learn more at [Strategy and Tips for Taking a *Praxis* Test](#).

Develop Your Study Plan

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

Helpful Links

[Ready to Register](#) – How to register and the information you need to know to do so.

[Disability Accommodations](#) – Testing accommodations are available for test takers who meet ETS requirements.

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

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

[Getting Your Scores](#) – Find out where and when you will receive your test scores.

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[Other Praxis Tests](#) – Learn about other *Praxis* tests and how to prepare for them.

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