ARIZONA EDUCATOR PROFICIENCY ASSESSMENTS™

STUDY GUIDE

08 Chemistry

This AEPA test was replaced by a NES test. Examinees may continue to find this study guide useful as they prepare for the NES, as the previous AEPA test may have covered objectives and content similar to the NES test.

AZ-SG-FLD008-01

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GENERAL INFORMATION ABOUT THE AEPA™ AND TEST PREPARATION

Part 1 of this study guide is contained in a separate PDF file. Click the link below to view or print this section:

General Information About the AEPA and Test Preparation

PART 2:
FIELD-SPECIFIC INFORMATION

Field 08: Chemistry

INTRODUCTION

This section includes a list of the test objectives, practice questions, and an answer key for the selected-response questions.

Test objectives. As noted earlier, the test objectives are broad, conceptual statements that reflect the knowledge, skills, and understanding an entry-level educator needs to practice effectively in Arizona schools. The list of test objectives for each test field is the *only* source of information about what a specific test will cover and therefore should be studied carefully.

Practice questions. The practice selected-response questions and practice performance assignments included in this section are designed to give you an introduction to the nature of the questions included in the AEPA tests. The practice questions represent the various types of questions you may expect to see on an actual test; however, they are *not* designed to provide diagnostic information to help you identify specific areas of individual strengths and weaknesses or to predict your performance on the test as a whole.

When you answer the practice questions, you may wish to use the sample answer sheet and sample Written Response Booklet provided in Part 1 to acquaint yourself with these materials. Use the answer key located after the practice questions to check your answers. Sample responses are provided immediately following each written performance assignment. The sample responses in this guide are for illustrative purposes only. Your written response should be your original work, written in your own words, and not copied or paraphrased from some other work.

To help you identify how the test objectives are measured, the objective statement to which the question corresponds is listed in the answer key. When you are finished with the practice questions, you may wish to go back and review the entire list of test objectives and descriptive statements for your test field.

TEST OBJECTIVES

Field 08: Chemistry

SUBAREAS:

1. Scientific Inquiry
2. Matter and Atomic Structure
3. Energy, Chemical Bonds, and Molecular Structure
4. Chemical Reactions
5. Quantitative Relationships

SCIENTIFIC INQUIRY

0001 Understand the historical and contemporary contexts of the study of chemistry.

For example: the significance of key events, theories, and individuals in the history of chemistry; the historical development of theories and knowledge in chemistry; and the societal implications of developments in chemistry (e.g., pharmaceuticals, new materials, food production).

0002 Understand the nature of science and scientific inquiry.

For example: processes by which new scientific knowledge and hypotheses are generated; processes by which science advances; the reliance of scientific investigation on empirical data, verifiable evidence, and logical reasoning; ethical issues related to scientific processes (e.g., accurately reporting experimental results); and the role of communication among scientists and between scientists and the public in promoting scientific progress.

0003 Understand principles and procedures of scientific investigations.

For example: the identification of questions that can be answered using scientific methods; procedures and considerations in setting up and conducting a scientific investigation; knowledge of sampling techniques; the use of control and experimental groups to test hypotheses; the appropriateness of a specified experimental design to test a given chemistry hypothesis; and the selection and use of materials and techniques for chemistry investigations.

0004 Understand the processes of gathering, organizing, reporting, and analyzing scientific data in the context of chemistry investigations.

For example: the appropriateness of a given method or procedure for collecting data for a specified purpose; the design and use of models; appropriate and effective graphic representations (e.g., graph, table, diagram) for organizing and reporting experimental data; the application of simple descriptive statistics to data; the analysis of data to make predictions and draw conclusions; and procedures and criteria for formally reporting experimental results and data to the scientific community.

0005 Understand the interrelationships among chemistry, society, technology, and the other sciences and the applications of chemistry to everyday life.

For example: unifying concepts and processes (e.g., systems, constancy, form and function) among the sciences; the impact of chemistry and technology on one another and on society; similarities and differences between science and technology (e.g., science as investigating the natural world, technology as solving human adaptation problems); ethical considerations related to science and technology; and the application of chemistry to daily life.

0006 Understand principles and procedures related to safety.

For example: procedures for labeling, storing, and disposing of chemicals; safe methods for preparing and dispensing laboratory chemicals; and proper safety techniques for students in the laboratory.

MATTER AND ATOMIC STRUCTURE

0007 Understand the concept of matter, and analyze chemical and physical properties of and changes in matter.

For example: differentiating among elements, compounds, and mixtures; using the physical and chemical properties of an unknown substance in order to identify it; analyzing the methods by which chemical properties of matter are determined; and distinguishing between physical and chemical changes in matter.

0008 Understand the various models of atomic structure, the principles of quantum theory, and the properties and interactions of subatomic particles.

For example: major features of models of atomic structure (e.g., Bohr, Rutherford, Schrödinger); interactions among electrons, protons, and neutrons and their properties (e.g., mass, charge); relationships among electron energy levels, photons, and atomic spectra; and analysis of the electron configurations of atoms and ions.

0009 Understand the organization of the periodic table.

For example: the organization of the periodic table in terms of atomic number and properties of the elements; trends (e.g., ionization energies, covalent atomic radii) within periods and groups in the periodic table; predicting physical and chemical properties of given elements based on their positions in the periodic table; and using the periodic table to gain information (e.g., relative reactivity) about given elements.

0010 Understand the kinetic theory, the nature of phase changes, and the gas laws.

For example: arrangements and movements of particles in solids, liquids, and gases; basic principles of the kinetic theory (e.g., particles of matter are in continual motion, real versus ideal gas behavior); analyzing heating and cooling curves qualitatively and quantitatively; and setting up and solving problems involving gas law relationships.

0011 Apply the conventions of chemical notation and representations.

For example: the symbolic notation for given elements; applying the IUPAC rules of nomenclature to name given inorganic compounds from their formulas; recognizing and interpreting Lewis structures; and determining molecular geometry from Lewis structures.

0012 Understand the process of nuclear transformation.

For example: characteristics (e.g., mass, penetrating power) of the different types of emanations from the decay of radioactive elements; the processes of natural radioactivity and artificial transmutation; solving problems involving half-life of radioactive particles; understanding the relationship between nuclear mass defect and nuclear binding energy; and applications of nuclear reactions.

ENERGY, CHEMICAL BONDS, AND MOLECULAR STRUCTURE

0013 Understand the principles of thermodynamics and calorimetry.

For example: the three laws of thermodynamics and their applications to chemical systems; predicting the spontaneity of given reactions based on enthalpy changes, entropy changes, and temperatures of the systems; analyzing the results of calorimetry experiments; and distinguishing between heat and temperature.

0014 Understand energy relationships in chemical bonding and chemical reactions.

For example: energy changes due to the formation or breaking of chemical bonds; solving problems involving energy changes during chemical reactions (e.g., heat of combustion, heat of formation); and interpreting potential energy diagrams of chemical reactions.

0015 Understand the types of bonds between atoms (including ionic, covalent, and metallic bonds), the formation of these bonds, and properties of substances containing the different bonds.

For example: the characteristics of various types of bonds between atoms and ions (e.g., bond strength, polarity); electron behavior in the formation of bonds; factors that affect bond strength (e.g., electronegativity, electron affinity); and predicting properties of a substance based bond type.

0016 Understand types and characteristics of molecular interaction and properties of substances containing different types of interactive forces between molecules.

For example: predicting the kind of interaction between molecules of a given structure; the unique properties of water and its molecular structure and intermolecular forces; and relating the physical properties of substances to their intermolecular forces.

0017 Understand the nomenclature and structure of organic compounds.

For example: the chemical composition and basic structure of organic compounds (e.g., hydrocarbons and their derivatives); and distinguishing among structural, geometric, and optical isomers.

CHEMICAL REACTIONS

0018 Understand factors that affect reaction rates and methods of measuring reaction rates.

For example: collision theory and factors that influence reaction rates; relating experimental measurements to reaction rates and rate laws; relating reaction mechanisms to rate laws; determining order of reactions and rate constants; and solving first-order rate problems.

0019 Understand the principles of chemical equilibrium.

For example: the effects of concentration, pressure, temperature, and catalysts on chemical equilibrium; applying Le Chatelier's principle to chemical systems; solving problems involving equilibrium constants; and solving problems involving solubility product constants of slightly soluble salts.

0020 Understand the theories, principles, and applications of acid-base chemistry.

For example: analyzing acids and bases according to operational and conceptual definitions (Arrhenius, Brönsted-Lowry, Lewis); the principles and applications of acid-base titration; determining the hydronium ion concentration and the pH for various acid, base, and salt solutions; and the relative strengths of given acids based on their equilibrium constant, K_a.

0021 Understand redox reactions and electrochemistry.

For example: processes that occur during redox reactions; determining oxidation numbers and balancing redox equations; predicting whether given redox reactions will occur based on standard electrode potentials; and analyzing the components (e.g., anode, cathode) and operating principles of electrochemical and electrolytic cells.

0022 Understand the nature of organic reactions.

For example: analyzing the rates of reactions involving organic compounds based on bond types and strengths; and analyzing common types of reactions (i.e., combustion, addition, substitution, polymerization, oxidation, esterification).

QUANTITATIVE RELATIONSHIPS

0023 Understand the mole concept.

For example: relating the mole to Avogadro's number; relating the gram-atomic mass (i.e., molar mass) of an element to the mass of one mole of the element; and calculating the number of moles in a given mass or volume of a substance.

0024 Understand the relationship between the mole concept and chemical formulas.

For example: solving problems involving molar masses; solving percentage composition problems; and determining empirical and molecular formulas.

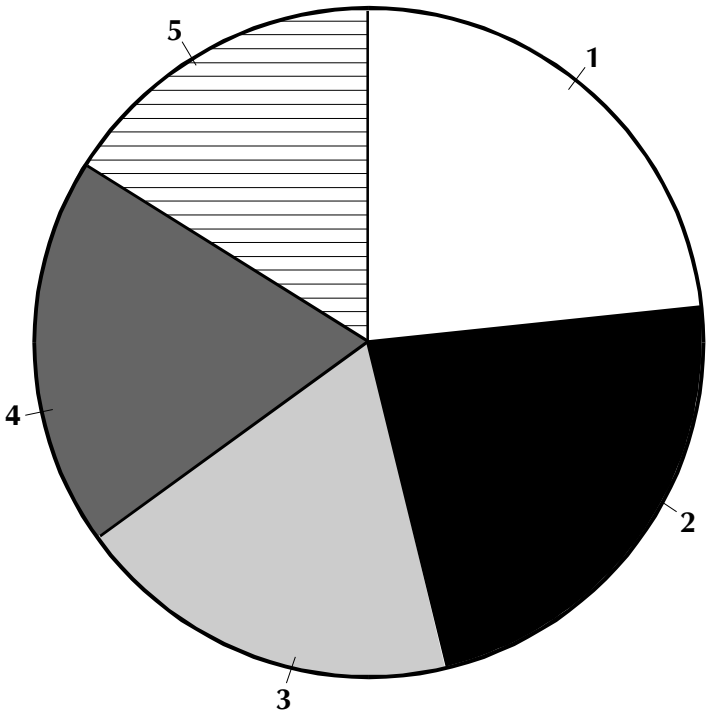
0025 Understand the quantitative relationships expressed in chemical equations.

For example: interpreting chemical notation; balancing equations; recognizing net ionic equations; and solving stoichiometric problems involving moles, mass, and volume (including limiting reactant and percent yield).

0026 Understand the properties of solutions, and analyze factors that affect solubility.

For example: the colligative properties of solutions (i.e., freezing point depression, boiling point elevation, osmotic pressure, vapor pressure lowering); solving problems involving concentrations of solutions (e.g., molarity, molality, percent concentration); and factors (e.g., temperature, pressure, molecular structure) that affect solubility.

DISTRIBUTION OF SELECTED-RESPONSE ITEMS ON THE TEST FORM



Subarea	Approximate Percentage of Selected-Response Items on Test Form
1. Scientific Inquiry	23%
2. Matter and Atomic Structure	23%
3. Energy, Chemical Bonds, and Molecular Structure	20%
4. Chemical Reactions	19%
5. Quantitative Relationships	15%

PERIODIC TABLE OF THE ELEMENTS

1 **IA**																	18 **VIIIA**
1 **H** 1.01	2 **IIA**											13 **IIIA**	14 **IVA**	15 **VA**	16 **VIA**	17 **VIIA**	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 23.0	12 **Mg** 24.3	3 **IIIB**	4 **IVB**	5 **VB**	6 **VIB**	7 **VIIB**	8	9 **VIIIB**	10	11 **IB**	12 **IIB**	13 **Al** 27.0	14 **Si** 28.1	15 **P** 31.0	16 **S** 32.1	17 **Cl** 35.5	18 **Ar** 39.9
19 **K** 39.1	20 **Ca** 40.1	21 **Sc** 45.0	22 **Ti** 47.9	23 **V** 50.9	24 **Cr** 52.0	25 **Mn** 54.9	26 **Fe** 55.8	27 **Co** 58.9	28 **Ni** 58.7	29 **Cu** 63.5	30 **Zn** 65.4	31 **Ga** 69.7	32 **Ge** 72.6	33 **As** 74.9	34 **Se** 79.0	35 **Br** 79.9	36 **Kr** 83.8
37 **Rb** 85.5	38 **Sr** 87.6	39 **Y** 88.9	40 **Zr** 91.2	41 **Nb** 92.9	42 **Mo** 95.9	43 **Tc** 98.9	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57–71	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.0	89–103	104 **Unq** (261)	105 **Unp** (262)	106 **Unh** (263)	107 **Uns** (262)	108 **Uno**	109 **Une**	110 **Uun**	111	112	113	114	115	116	117	118

Lanthanide Series	57 **La** 138.9	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (147)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
Actinide Series	89 **Ac** (227)	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (255)	103 **Lr** (257)

PRACTICE QUESTIONS

Field 08: Chemistry

All examinees taking the Chemistry test (Field 08) will be provided with a Texas Instruments TI 30X Solar Scientific calculator with functions that include the following: addition, subtraction, multiplication, division, square root, percent, sine, cosine, tangent, exponents, and logarithms. **You may NOT bring your own calculator to the test.**

1. In the late eighteenth century, Antoine Lavoisier conducted a series of experiments involving combustion reactions. These experiments were significant primarily because they were the first to document that:

   A. atoms of different elements are present in fixed proportions in a given compound.

   B. combustion involves the splitting of molecules and the recombination of the atoms into different molecules.

   C. the total mass of the products of a reaction equals the total mass of the original substances.

   D. the elemental identities of individual atoms are not changed during a chemical reaction.

2. A farmer is interested in using an insecticide that is biodegradable and causes little harm to birds and mammals. An insecticide that would best meet these criteria is one that:

   A. contains organohalides.

   B. makes use of heavy metal ions.

   C. has a long half-life.

   D. is readily oxidized.

3. Which of the following is the most important practice in managing a school chemistry supply room?

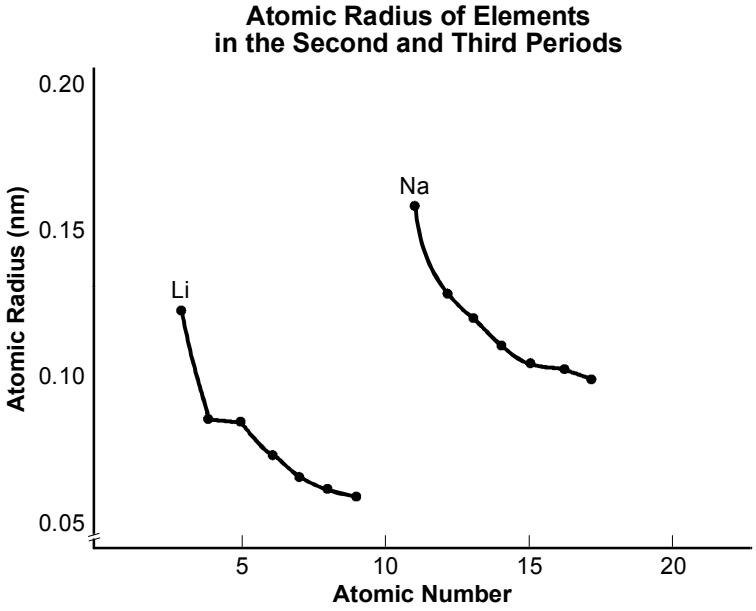
   A. ensuring that all containers are clearly labeled

   B. arranging chemicals in alphabetical order

   C. storing chemicals in unbreakable plastic containers

   D. placing dangerous chemicals on top shelves

4. **Use the graph below to answer the question that follows.**



The graph above shows the relationship between atomic radius and atomic number for elements in the second and third periods of the periodic table. According to the diagram, which of the following statements are true?

I. Within a group, atomic radius tends to decrease as atomic number increases.

II. Within a period, atomic radius tends to decrease as atomic number increases.

III. The largest element in the fourth period is expected to be potassium.

IV. Within a period, main group metals tend to be smaller than nonmetals.

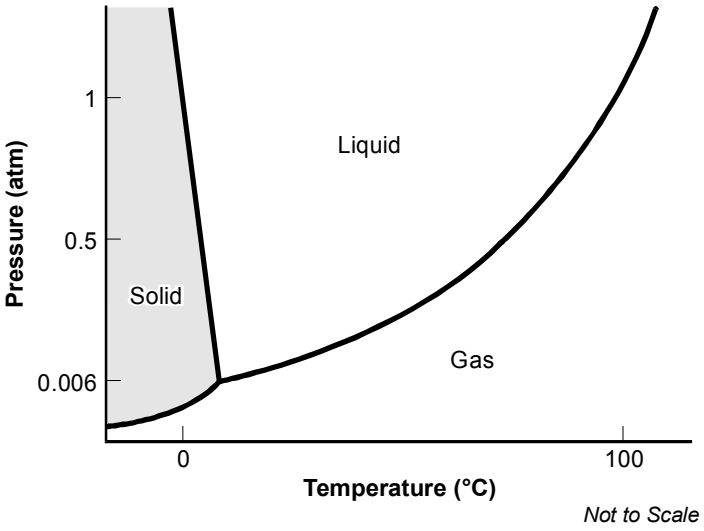
A. I and III only

B. I and IV only

C. II and III only

D. III and IV only

5. **Use the phase diagram below to answer the question that follows.**



Which of the following statements is supported by the phase diagram?

A. The substance sublimes at pressures above 0.006 atm.

B. The substance occurs as a solid or liquid under most natural conditions.

C. The substance's freezing point increases with increasing pressure.

D. The substance's freezing point is between 0°C and ⁻100°C at pressures below 1 atm.

6. ^{32}P and ^{131}I are radioactive isotopes used to treat bone marrow and thyroid cancer. Their usefulness is in part due to their tendency to concentrate in specific organs. Which of the following characteristics is also necessary to make an isotope a good candidate for this form of radiotherapy?

   A. The isotope emits only alpha radiation.

   B. The isotope has a short half-life.

   C. The isotope produces primarily heat energy rather than particle emissions.

   D. The isotope's decay rate is constant.

7. Which of the following properties is most likely to be associated with nonpolar covalent substances?

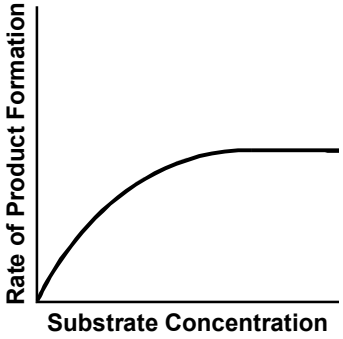
   A. high freezing point

   B. good electrical conduction

   C. high boiling point

   D. poor thermal conduction

8. **Use the diagram below to answer the question that follows.**



The graph above shows the rate of product formation versus substrate concentration in an enzyme-catalyzed reaction. Which of the following best explains why the curve levels off?

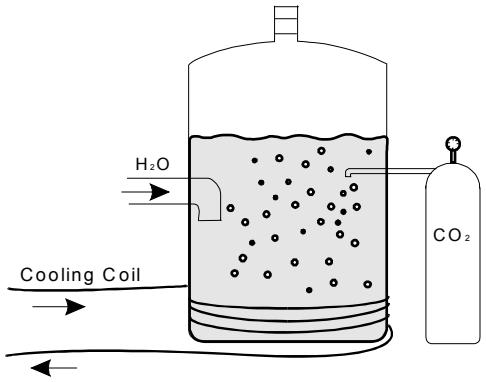
   A. All of the available enzymes are in constant use, leaving no enzyme molecules available to bind with additional amounts of substrate.

   B. As the product concentration increases, the equilibrium shifts so that substrate and product are being formed at equal rates.

   C. As the reaction proceeds, the enzymes are used up and converted into other molecules that do not act as catalysts.

   D. Once the substrate reaches a certain concentration, it inhibits the breakdown of the enzyme-substrate intermediates.

Use the diagram below to answer the two questions that follow.



In the beverage industry, carbon dioxide is introduced into a pressure vessel containing flavored sugar water to give the characteristic fizz associated with soda. After the system has reached equilibrium, the carbonated water is sent through tubing to be bottled.

9. During the manufacturing process, which of the following conditions would shift the equilibrium to favor a reduced carbon dioxide concentration in the beverage?

   A. a leak in the pressure vessel

   B. a decrease in the temperature of the cooling coil

   C. an increase in the length of time the carbon dioxide is left in contact with the sugar water

   D. an increase in the level to which the vessel is filled with sugar water

10. To calculate the amount of energy required for the cooling coil to bring the contents of the vessel to the desired temperature, which of the following information is needed?

    I. desired temperature decrease

    II. specific heat of the sugar water

    III. mass of the sugar water

    IV. molecular weight of the sugar water

    A. I and IV only

    B. II and III only

    C. I, II, and III only

    D. I, III, and IV only

11. **Use the reaction below to answer the question that follows.**

$$\underset{294.2\ g/mol}{K_2Cr_2O_7(aq)} + \underset{127.9\ g/mol}{14HI(aq)} \longrightarrow \underset{432.7\ g/mol}{2CrI_3(aq)} + \underset{166.0\ g/mol}{2KI(aq)} + \underset{253.8\ g/mol}{3I_2(s)} + \underset{18.0\ g/mol}{7H_2O(B)}$$

A solution that contains 98 g of $K_2Cr_2O_7$ is mixed with excess HI. What is the percent yield of the reaction if 130 g of CrI_3 are collected?

A. 48%

B. 45%

C. 42%

D. 40%

12. Eight hundred mL of 0.20 M HNO_3 are obtained by diluting 4.0 M HNO_3 with water. The volume of 4.0 M HNO_3 required for this dilution is:

A. 4 mL.

B. 40 mL.

C. 64 mL.

D. 640 mL.

Below are the directions for the Chemistry performance assignment.

DIRECTIONS FOR THE PERFORMANCE ASSIGNMENT

This section of the test consists of a performance assignment. **The assignment can be found on the next page.** You are asked to prepare a written response of approximately 2–3 pages on the assigned topic. You should use your time to plan, write, review, and edit your response for the assignment.

Read the assignment carefully before you begin to work. Think about how you will organize your response. You may use any blank space in this test booklet to make notes, write an outline, or otherwise prepare your response. **However, your score will be based solely on the version of your response written in Written Response Booklet B.**

As a whole, your response must demonstrate an understanding of the knowledge and skills of the field. In your response to the assignment, you are expected to demonstrate the depth of your understanding of the content area through your ability to apply your knowledge and skills rather than merely to recite factual information.

Your response will be evaluated based on the following criteria.

- **PURPOSE:** the extent to which the response achieves the purpose of the assignment
- **SUBJECT MATTER KNOWLEDGE:** appropriateness and accuracy in the application of subject matter knowledge
- **SUPPORT:** quality and relevance of supporting evidence
- **RATIONALE:** soundness of argument and degree of understanding of the subject area

The performance assignment is intended to assess subject knowledge content and skills, not writing ability. However, your response must be communicated clearly enough to permit scorers to make a valid evaluation of your response according to the criteria listed above. Your response should be written for an audience of educators in this field. The final version of your response should conform to the conventions of edited American English. This should be your original work, written in your own words, and not copied or paraphrased from some other work.

Be sure to write about the assigned topic. Please write legibly. You may not use any reference materials during the test. Remember to review your work and make any changes you think will improve your response.

Below is the scoring scale for the Chemistry performance assignment.

SUBJECT TESTS—PERFORMANCE ASSIGNMENT SCORING SCALE

Score Point	Score Point Description
4	**The "4" response reflects a thorough knowledge and understanding of the subject matter.** • The purpose of the assignment is fully achieved. • There is a substantial, accurate, and appropriate application of subject matter knowledge. • The supporting evidence is sound; there are high-quality, relevant examples. • The response reflects an ably reasoned, comprehensive understanding of the topic.
3	**The "3" response reflects an adequate knowledge and understanding of the subject matter.** • The purpose of the assignment is largely achieved. • There is a generally accurate and appropriate application of subject matter knowledge. • The supporting evidence is adequate; there are some acceptable, relevant examples. • The response reflects an adequately reasoned understanding of the topic.
2	**The "2" response reflects a limited knowledge and understanding of the subject matter.** • The purpose of the assignment is partially achieved. • There is a limited, possibly inaccurate or inappropriate, application of subject matter knowledge. • The supporting evidence is limited; there are few relevant examples. • The response reflects a limited, poorly reasoned understanding of the topic.
1	**The "1" response reflects a weak knowledge and understanding of the subject matter.** • The purpose of the assignment is not achieved. • There is little or no appropriate or accurate application of subject matter knowledge. • The supporting evidence, if present, is weak; there are few or no relevant examples. • The response reflects little or no reasoning about or understanding of the topic.

U	**The response is unrelated to the assigned topic, illegible, primarily in a language other than English, not of sufficient length to score, or merely a repetition of the assignment.**
B	**There is no response to the assignment.**

Practice Performance Assignment

13. **Read the information below; then complete the exercise that follows.**

A secondary-level chemistry class is learning about equilibrium. The teacher is planning a laboratory activity to help students understand the effects of changing concentration on a system in equilibrium. The students will have available to them nearly colorless solutions of $FeCl_3$ and KSCN, which, when combined, produce a red color. In addition, there will be NaSCN, $Fe(NO_3)_3$, and $H_2C_2O_4$ available. Write an essay describing an investigation appropriate for exploring the effects of concentration on equilibrium. In your essay:

- describe an appropriate experimental design, including additional materials and equipment that are necessary and the procedures to be followed;
- describe the kind of data that will need to be gathered and how the data will be collected, recorded, and analyzed; and
- describe the expected results of this investigation, and relate these results to the reactions involved and the concept of chemical equilibrium.

Sample Performance Assignment Response: Score Point 4

When $FeCl_3$ and KSCN are combined, they react to form $FeSCN^{2+}$ ions, which dissociate in water. The equilibrium reaction is shown below.

$FeSCN^{2+}$ e $Fe^{3+} + SCN^-$

The $FeSCN^{2+}$ ions create the red color in solution.

In addition to the chemicals listed, students will need a balance, graduated cylinders, and test tubes to perform this laboratory activity. As students carry out the various steps of the investigation, as outlined below, they will be observing and recording how the color of the solution changes.

To begin, students should note the color of the $FeCl_3$ solution and the color of the KSCN solution. Then, equal volumes of the $FeCl_3$ and KSCN solutions should be combined in a test tube, and any color change should be recorded. As noted above, when these two solutions are combined, the color of the resulting solution should become red.

The next step in this lab activity is to determine the effects of altering the concentration of the reactants or products in the combined solution produced in the previous step. To help make it easier to see if the solution becomes more red, the solution should be diluted with distilled water until the red color is rather pale. Equal amounts (about 25 mL) of this diluted solution should be added to three test tubes. To test tube 1, a weighed amount (0.5 g, for example) of NaSCN should be added and any color change noted. To test tube 2, an equal mass of $Fe(NO_3)_3$ should be added and any color change noted. To test tube 3, an equal mass of $H_2C_2O_4$ should be added and any color change noted. By noting whether the color becomes more red or becomes paler, students can determine in which direction the equilibrium of the reaction is shifted as a result of changing the concentrations of reactants or products.

In a system at equilibrium (as this one is after the initial mixing of the solutions of $FeCl_3$ and KSCN), there is a balance between the forward and reverse reactions. If some condition is changed, it can upset the equilibrium of the system and result in a shift in the equilibrium position of the reaction. Le Chatelier's principle says that a system in equilibrium will adjust itself to offset a stress applied to the system (e.g., a change in temperature, volume, concentration).

This principle can be applied to this investigation to predict the expected results from adding the chemicals to test tubes 1, 2, and 3 as described above. The NaSCN added to test tube 1 will dissociate, increasing the concentration of SCN^- ions. The equilibrium position will tend to shift to the left (in favor of $FeSCN^{2+}$) to offset the "stress" created by the greater concentration of SCN^- ions. The increased concentration of $FeSCN^{2+}$ will cause the solution in

(continued on next page)

Sample Performance Assignment Response: Score Point 4 *(continued)*

test tube 1 to become deeper red. Similarly, the addition of $Fe(NO_3)_3$ to test tube 2 will increase the concentration of Fe^{3+} ions, which will also shift the equilibrium left and result in the solution turning deeper red.

In test tube 3, the $H_2C_2O_4$ will ionize to form $C_2O_4^{2-}$. This ion binds with the Fe^{3+} ions, thus lowering the concentration of free Fe^{3+} ions in the solution. This will shift the equilibrium to the right, causing more dissociation of $FeSCN^{2+}$. The lower concentration of $FeSCN^{2+}$ will cause the red color to become even paler or to disappear altogether in test tube 3.

ANSWER KEY

Field 08: Chemistry

Question Number	Correct Response	Objective
1.	**C**	Understand the historical and contemporary contexts of the study of chemistry.
2.	**D**	Understand the interrelationships among chemistry, society, technology, and the other sciences and the applications of chemistry to everyday life.
3.	**A**	Understand principles and procedures related to safety.
4.	**C**	Understand the organization of the periodic table.
5.	**B**	Understand the kinetic theory, the nature of phase changes, and the gas laws.
6.	**B**	Understand the process of nuclear transformation.
7.	**D**	Understand the types of bonds between atoms (including ionic, covalent, and metallic bonds), the formation of these bonds, and properties of substances containing the different bonds.
8.	**A**	Understand factors that affect reaction rates and methods of measuring reaction rates.
9.	**A**	Understand the principles of chemical equilibrium.
10.	**C**	Understand the principles of thermodynamics and calorimetry.
11.	**B**	Understand the quantitative relationships expressed in chemical equations.
12.	**B**	Understand the properties of solutions, and analyze factors that affect solubility.