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All examinees taking the Chemistry (12) test will be provided with a scientific calculator with functions that include the following: addition, subtraction, multiplication, division, square root, percent, sine, cosine, tangent, exponents, and logarithms. Refer to "Test Selection" in the current MTEL registration bulletin for more information.



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## TABLE OF CONTENTS

Introduction
Purpose of the Practice Test
Taking the Practice Test1
Incorporating the Practice Test in Your Study Plan1
Chemistry Practice Test
Periodic Table, Constants, and Formulas
General Test Directions
Multiple-Choice Answer Sheet7
Multiple-Choice Questions
Directions for the Open-Response Item Assignments
Open-Response Item Assignments and Response Sheets
Practice Test Results
Practice Test Results Overview
Multiple-Choice Question Answer Key Worksheet51
Multiple-Choice Question Practice Test Evaluation Chart
Open-Response Item Evaluation Information58
Open-Response Item Scoring Rubric, Sample Responses, and Analyses
Practice Test Score Calculation

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## INTRODUCTION

This document is a printable version of the Massachusetts Tests for Educator Licensure® (MTEL®) Chemistry (12) Online Practice Test. This practice test is a sample test consisting of 100 multiple-choice questions and 2 open-response item assignments.

To assist you in recording and evaluating your responses on the practice test, a <u>Multiple-Choice Answer Sheet</u>, an <u>Answer Key Worksheet</u>, and an <u>Evaluation Chart</u> by test objective are included for the multiple-choice questions. A blank <u>Response Sheet</u>, <u>Evaluation Information</u>, and <u>Sample Responses and Analyses</u>, as well as a <u>Scoring Rubric</u>, are included for the open-response items. Lastly, there is a <u>Practice Test Score Calculation</u> worksheet.

### PURPOSE OF THE PRACTICE TEST

The practice test is designed to provide an additional resource to help you effectively prepare for the MTEL Chemistry (12) test. The primary purpose of the practice test is to help you become familiar with the structure and content of the test. It is also intended to help you identify areas in which to focus your studies. Education faculty and administrators of teacher preparation programs may also find this practice test useful as they help students prepare for the official test.

### TAKING THE PRACTICE TEST

In order to maximize the benefits of the practice test, it is recommended that you take this test under conditions similar to the conditions under which the official MTEL tests are administered. Try to take the practice test in a quiet atmosphere with few interruptions and limit yourself to the four-hour time period allotted for the official test administration. You will find your results to be more useful if you refer to the answer key only after you have completed the practice test.

### INCORPORATING THE PRACTICE TEST IN YOUR STUDY PLAN

Although the primary means of preparing for the MTEL is your college education, adequate preparation prior to taking or retaking the MTEL test is strongly recommended. How much preparation and study you need depends on how comfortable and knowledgeable you are with the content of the test.

The first step in preparing to take the MTEL is to identify what information the test will address by reviewing the objectives for your field. A complete, up-to-date list of the <u>Test Objectives</u> is included in the <u>Test Information</u> <u>Booklet</u> for each test field. The test objectives are the core of the testing program and a helpful study tool. Before taking or retaking the official test, focus your study time on those objectives for which you wish to strengthen your knowledge.

This practice test may be used as one indicator of potential strengths and weaknesses in your knowledge of the content on the official test. However, because of potential differences in format and difficulty between the practice test and an official MTEL Chemistry (12) test, it is not possible to predict precisely how you might score on an official MTEL Chemistry (12) test. Keep in mind that the subareas for which the test weighting is greatest will receive emphasis on this test. Refer to the <u>Test Information Booklet</u> for additional information about how to prepare for the test.

## CHEMISTRY PRACTICE TEST

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PERIODIC TABLE OF THE ELEMENTS

Candidates taking the Chemistry test (field 12) will be provided with the periodic table, constants, and formulas shown below at the test administration.

103 Lr (262)

102 **No** 259)

101 **Md** 258)

100 **Fm** (257)

99 **Es** 252)

98 **Cf** 251)

97 **BK** 247

96 **Cm** 247)

95 **Am** (243)

94 **Pu** 244)

93 **Np** (237)

92 U 238.0

91 **Pa** 231.0

90 **Th** 232.0

89 **Ac** (227)

> Actinide Series

Description	Value
Ideal gas constant ( <i>R</i> )	0.0821 L•atm/mol•K = 8.31 J/mol•K
Faraday constant ( <i>F</i> )	$9.65 \times 10^4$ C/mol $e^- = 9.65 \times 10^4$ J/V·mol $e^-$
Rydberg constant ( $R_{\rm H}$ )	$1.097 \times 10^7 \text{ m}^{-1}$
Boltzmann constant ( <i>k</i> )	$1.38 \times 10^{-23} \text{ J/K}$
Planck's constant (h)	$6.63 \times 10^{-34} \text{ J} \cdot \text{s}$
Molal freezing point depression constant for water $(K_f)$	1.86°C/ <i>m</i>
Molal boiling point elevation constant for water $(K_b)$	0.51°C/m
Heat of fusion of water $(\Delta H_{fus})$	334  J/g = 80  cal/g = 6.01  kJ/mol
Heat of vaporization of water $(\Delta H_{vap})$	2260 J/g = 540 cal/g = 40.7 kJ/mol
Specific heat (s) of water (liquid)	$4.18 \text{ J/g} \cdot \text{K} = 4.18 \text{ J/g} \cdot ^{\circ}\text{C} = 1.0 \text{ cal/g} \cdot ^{\circ}\text{C}$
Dissociation constant of water $(K_w)$	$1.0 \times 10^{-14}$ at 25°C
Standard atmospheric pressure	1 atm = 760 mm Hg = 760 torr = 101.325 kPa
Speed of light in a vacuum ( <i>c</i> )	$3.00 \times 10^8 \text{ m/s}$
1 calorie (cal)	4.184 J
1 watt (W)	1 J/s

## CONSTANTS

Description	Formula
Gibbs free energy equation	$\Delta G = \Delta H - T \Delta S$
Nernst equation	$E = E^{\circ} - \left(\frac{0.0592 \text{ V}}{n}\right) \log Q$ at 298 K
Relationship between emf and free energy change for reactants and products in their standard states	$\Delta G^{\circ} = -nFE^{\circ}$
Energy change as an electron transitions between energy states	$\Delta E = R_{\rm H} h c \left( \frac{1}{n_{\rm i}^2} - \frac{1}{n_{\rm f}^2} \right)$
Henderson-Hasselbalch equation	$pH = pK_a + \log\left(\frac{[\text{conjugate base}]}{[\text{acid}]}\right)$
Coulombs (C)	$C = amperes \times seconds$
Photon energy	E = h v
Speed of light	$c = \lambda v$
Amount of heat (q)	$q = ms\Delta T$
Root-mean-square speed	$u_{\rm rms} = \sqrt{\frac{3RT}{M}}$
Graham's law of diffusion	$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

## FORMULAS

### NOTES FOR CHEMISTRY TEST

Not all constants and formulas necessary are listed, nor are all constants and formulas listed used on this test.

While attention has been paid to significant figures, no answer should be considered incorrect solely because of the number of significant figures.

### **GENERAL TEST DIRECTIONS**

This practice test consists of two sections: (1) a multiple-choice question section and (2) an open-response item assignment section. Each multiple-choice question on the practice test has four answer choices. Read each question carefully and choose the ONE best answer. Record each answer on the answer sheet provided.

- Sample Question: 1. What is the capital of Massachusetts?
  - A. Worcester
  - B. New Bedford
  - C. Boston
  - D. Springfield

The correct answer to this question is C. You would indicate that on the answer sheet.

The open-response section of this practice test requires written responses. Directions for the open-response item assignments appear immediately before those assignments.

You may work on the multiple-choice questions and open-response item assignments in any order that you choose. You may wish to monitor how long it takes you to complete the practice test. When taking the actual MTEL Chemistry (12) test, you will have one four-hour test session in which to complete the test.

## MULTIPLE-CHOICE ANSWER SHEET

Question	Your
Number	Response
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Question	Your
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Question	Your
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### **MULTIPLE-CHOICE QUESTIONS**

- 1. A chemist hypothesizes that a newly developed photodegradable plastic will degrade twice as fast as currently available photodegradable plastics. Which of the following investigations would best test this hypothesis?
  - A. modeling the chemical reactions involved in the degradation of the new plastic and using this model to project degradation rates under different environmental conditions
  - B. subjecting the new plastic and the existing plastics to the same environmental conditions and measuring their degradation rates
  - C. comparing the degradation rate of the new plastic with the degradation rates provided by the manufacturers of the existing photodegradable plastics
  - D. exposing the new photodegradable plastic to conditions of constant UV radiation and no UV radiation and comparing the resulting degradation rates

- 2. Several unknown solutions have been tested for the presence of Group 1 or Group 2 metals using a flame-test protocol. Which of the following methods would be the best way to represent the collected data?
  - A. a table
  - B. a histogram
  - C. a scatter plot
  - D. a line graph
- 3. A chemist is attempting to identify an unknown solid substance by determining its density. The substance is found to have a volume of 70.3 cm<sup>3</sup>, and repeated weighing of the solid produced an average mass of 51.12 g. Given these data, which of the following correctly reports the density of the solid substance with the correct number of significant figures?
  - A.  $7 \times 10^{-1} \text{ g/cm}^3$
  - B.  $7.2 \times 10^{-1} \text{ g/cm}^3$
  - C.  $7.27 \times 10^{-1} \text{ g/cm}^3$
  - D.  $7.272 \times 10^{-1} \text{ g/cm}^3$



4. Use the information below to answer the question that follows.

A chemist is using paper chromatography to identify the components of a sample known to contain at least one of the cations shown in the reference table. Given the chromatogram shown above, the unknown consists of:

- A.  $Cu^{2+}$  cations.
- B.  $Ni^{2+}$  and  $Fe^{3+}$  cations.
- C.  $Fe^{3+}$  and  $Cu^{2+}$  cations.
- D.  $Ni^{2+}$ ,  $Cu^{2+}$ , and  $Fe^{3+}$  cations.

5. Use the graph below to answer the question that follows.



The graph above depicts the results of a titration experiment. Which of the following conclusions about the titration experiment is best supported by these data?

- A. The acid being titrated is a polyprotic acid.
- B. A strong base is being titrated with a weak acid.
- C. The titrant used in this experiment is a strong acid.
- D. A weak acid is being titrated with a strong base.

- 6. A chemistry class is planning to use a fume exhaust hood to study the reaction between the elements copper and sulfur. Before beginning the experiment, the teacher will review with the class the proper use of the exhaust hood. Which of the following instructions should be included in this discussion?
  - A. Avoid using Bunsen burners within the fume exhaust hood.
  - B. Turn off the fan while performing the experiment.
  - C. Keep the sash in its lowered position during the experiment.
  - D. Step away from the fume exhaust hood once the reaction has begun.

7. Use the diagram below to answer the question that follows.



The apparatus shown above is most likely to be used in which of the following scientific experiments?

- A. separating a mixture of two unknown liquids
- B. determining the boiling point of an unknown liquid
- C. constructing a titration curve of an unknown liquid
- D. detecting the presence of cations in an unknown liquid

- 8. When a chemical is transferred from a stock bottle into another container for use in the laboratory, the label on the new container must include the name and formula of the chemical, its concentration, and the:
  - A. room number of the laboratory.
  - B. date the stock reagent bottle was received.
  - C. hazard warnings for the chemical.
  - D. phone number of the chemical hygiene officer.
- 9. Which of the following is an example of a chemistry protocol being carried out in a safe manner?
  - A. heating a compound in a test tube over a flame with the test tube opening oriented away from people
  - B. evaporating acetone from a beaker using direct heat from a Bunsen burner
  - C. using a glass stirring rod to assist in pouring a solution of NaClO into a beaker containing HCl
  - D. transferring a beaker containing boiling water directly from a hot plate into an ice bath

- 10. A student splashes a chemical into an eye during a lab experiment. Which of the following is the first thing the teacher should do when responding to this situation?
  - A. drive the student to an emergency room at the closest area hospital
  - B. flush the student's eye with water at the eyewash after checking for the presence of a contact lens
  - C. alert the school administrators that an accident has occurred
  - D. call the local poison control center for guidance on how to treat the student
- 11. Which of the following is a serious ethical concern associated with the complete sequencing of the human genome?
  - A. The results are maintained by multiple government agencies and universities and are difficult to access.
  - B. The DNA used in the study was taken from one individual and is not representative of all human genomes.
  - C. The sequencing technology used was inadequate for sequencing such a large genome, and the results have proven to be inaccurate.
  - D. An individual could be denied health insurance due to a genetic predisposition for a life-threatening disease.

- 12. Which of the following correctly identifies both an advantage and a disadvantage of using nuclear fission as a method of generating electricity?
  - A. advantage: produces only nonhazardous waste products disadvantage: leads to thermal pollution of rivers
  - B. advantage: uses an unlimited inexpensive fuel source disadvantage: accelerates the rate of ozone depletion
  - C. advantage: produces minimal greenhouse gases disadvantage: requires long-term storage of radioactive waste
  - advantage: inhibits the formation of acid rain disadvantage: presents problems in safely containing plasma
- 13. Research into the production of ethanol from corn has been promoted by society's need to:
  - A. decrease the price of corn-based food products.
  - B. stimulate job growth in automobile manufacturing.
  - C. decrease dependence on fossil fuels.
  - D. increase the number of small family-owned farms.

- 14. Which of the following technologies uses X-rays to visualize an object?
  - A. positron emission tomography (PET scan)
  - B. magnetic resonance imaging (MRI)
  - C. computerized axial tomography (CT scan)
  - D. scanning tunneling microscopy (STM)
- 15. Which of the following responses correctly matches a technological development with its corresponding area of chemistry research?
  - A. computer chips: chemical analysis of DNA
  - B. pest-resistant corn species: chemical equilibrium
  - C. photovoltaic cells: electrochemistry
  - D. synthetic fertilizers: molecular modeling

- 16. Potassium hydrogen carbonate is best classified as which of the following types of matter?
  - A. heterogeneous mixture
  - B. element
  - C. homogeneous mixture
  - D. compound

- 17. Fog, which is composed of finely divided water droplets dispersed in air, is an example of which of the following types of mixtures?
  - A. solution
  - B. aerosol
  - C. foam
  - D. emulsion
- 18. The products of a chemical reaction are solid zinc carbonate and aqueous sodium chloride. Which of the following procedures will achieve the best separation of the mixture into its three components?
  - A. filtering the mixture and then distilling the filtrate
  - B. crystallizing the mixture and then decanting the aqueous portion
  - C. centrifuging the mixture and then crystallizing the supernatant
  - D. distilling the mixture and then centrifuging the distillate

- 19. Which of the following statements correctly identifies a difference between a physical change and a chemical change?
  - A. New atoms are formed in a chemical change but not in a physical change.
  - B. Energy is conserved in a physical change but not in a chemical change.
  - C. New substances are formed in a chemical change but not in a physical change.
  - D. Mass is conserved in a physical change but not in a chemical change.

Properties of Selected Alcohols					
Alcohol	Melting Point (°C)	Boiling Point (°C)	Density (g/cm³)		
2-propanol	-90	82	0.786		
Cyclopentanol	-19	141	0.948		
Cyclohexanol	25	161	0.962		
2-methyl-2-propanol	26	82	0.789		

#### 20. Use the table below to answer the question that follows.

An unknown alcohol is a liquid at room temperature (20°C), and a 50.0 mL sample has a mass of 39.4 g. Based on these properties, the unknown alcohol can be identified as:

- A. 2-propanol.
- B. cyclopentanol.
- C. cyclohexanol.
- D. 2-methyl-2-propanol.
- 21. The constituent particles in a substance in its solid state tend to:
  - A. remain motionless.
  - B. vibrate about fixed positions.
  - C. slide freely past one another.
  - D. move constantly in straight lines.

- 22. According to the kinetic molecular theory, which of the following happens to the molecules of a gas when the gas is compressed?
  - A. The average distance between the molecules decreases.
  - B. The electrostatic repulsion between molecules decreases.
  - C. The atomic radii of the atoms in the molecules decrease.
  - D. The lengths of the bonds within the molecules decrease.
- 23. Use the cooling curve below to answer the question that follows.



Which of the following statements is supported by the data presented in the cooling curve for substance X shown above?

- A. The heat of vaporization for substance X is greater than its heat of fusion.
- B. The specific heat of substance X is greater than its heat of formation.
- C. The boiling point of substance X is greater than its condensing point.
- D. The melting point of substance X is greater than its freezing point.

24. Use the phase diagram below to answer the question that follows.



Based on the phase diagram above, which of the following pressures in combination with temperature T would result in the substance being present only as a gas?

- A.  $P_1$
- B. *P*<sub>2</sub>
- C. *P*<sub>3</sub>
- D. *P*<sub>4</sub>
- 25. A 20.0 L cylinder of oxygen gas is at a temperature of 27.0°C and a pressure of 5.00 atm. What is the density of the oxygen gas in the cylinder?
  - A. 72.0 g/L
  - B. 6.50 g/L
  - C. 3.25 g/L
  - D. 0.203 g/L

- 26. An atom with 6 protons, 6 neutrons, and 6 electrons gains an additional electron. What is the resulting charge of the atom?
  - A. –7
  - B. -1
  - C. +1
  - D. +7
- 27. Which of the following quantum numbers describes the shape of an orbital?
  - A. the magnetic quantum number,  $m_l$
  - B. the angular momentum quantum number, *l*
  - C. the electron spin quantum number,  $m_s$
  - D. the principle quantum number, *n*
- 28. How much energy is emitted when an electron in a hydrogen atom transitions from the  $n_i = 6$  state to the  $n_f = 2$  state?
  - A.  $7.27 \times 10^{-19} \text{ J}$
  - B.  $6.06 \times 10^{-19} \text{ J}$
  - C.  $4.84 \times 10^{-19} \text{ J}$
  - D.  $1.36 \times 10^{-19} \text{ J}$

- 29. Which of the following is the correct electron configuration for a neutral iron atom?
  - A.  $1s^22s^22p^63s^23p^64s^24d^6$
  - B.  $1s^22s^22p^63s^23p^64s^23d^6$
  - C.  $1s^22s^22p^63s^23p^64s^24p^6$
  - D.  $1s^22s^22p^63s^23p^64s^23f^6$
- 30. Use the graph below to answer the question that follows.

Number of Neutrons vs. Number of Protons for Stable Isotopes



The isotope located in position *X* in the graph of nuclear stability shown above is most likely to undergo radioactive decay by emitting:

- A. alpha particles.
- B. gamma rays.
- C. positrons.
- D. beta particles.

 $^{239}_{94}$ Pu +  $^{4}_{2}$ He  $\longrightarrow ^{242}_{96}$ Cm +  $^{1}_{0}$ n

In order to overcome the electrostatic repulsion between alpha particles and the target nucleus, the reaction shown above is carried out using:

- A. high speeds.
- B. low temperatures.
- C. high pressure.
- D. low volumes.
- 32. Given that the half-life of strontium-90 is 28.8 years, what mass of a 50.0 g sample of strontium-90 will remain after 144 years?
  - A. 25.0 g
  - B. 6.25 g
  - C. 1.56 g
  - D. 0.391 g
- 33. As atomic number increases in a group of the periodic table, which of the following atomic properties decreases?
  - A. electronegativity
  - B. metallic character
  - C. atomic mass
  - D. atomic radius

- 34. Which of the following elements has an atomic radius closest to but smaller than that of sulfur?
  - A. selenium
  - B. phosphorus
  - C. oxygen
  - D. chlorine
- 35. Which of the following series of halogens is arranged in order of increasing boiling point?
  - A. I<sub>2</sub>, Br<sub>2</sub>, Cl<sub>2</sub>, F<sub>2</sub>
  - B. Cl<sub>2</sub>, I<sub>2</sub>, F<sub>2</sub>, Br<sub>2</sub>
  - C.  $F_2$ ,  $Cl_2$ ,  $Br_2$ ,  $I_2$
  - D. Br<sub>2</sub>, F<sub>2</sub>, I<sub>2</sub>, Cl<sub>2</sub>
- 36. The oxidation state of Mn in the permanganate ion  $(MnO_4^-)$  is:
  - A. -8.
  - B. -1.
  - C. +2.
    - D. +7.

- 37. Which of the following symbols represents the element silver?
  - A. Si
  - B. Hg
  - C. Sn
  - D. Ag
- 38. What is the IUPAC name for the molecule CH<sub>3</sub>CH<sub>2</sub>CHClCH<sub>3</sub>?
  - A. 2-chlorobutane
  - B. 3-chloropropane
  - C. 2-chloroethane
  - D. 3-chloropentane
- **39.** Use the diagram below to answer the question that follows.



Which of the following organic functional groups does the molecule shown above contain?

- A. hydroxyl
- B. ether
- C. carbonyl
- D. ester

- 40. The complex ion  $[Pt(NH_3)_4]^{2+}$  has a square planar structure. Which of the following substances, in which chloride ions replace ammonia as ligands, can exist as geometric isomers?
  - A.  $[PtCl(NH_3)_3]^{1+}$
  - B.  $PtCl_2(NH_3)_2$
  - C.  $[PtCl_3NH_3]^{1-}$
  - D.  $[PtCl_4]^{2-}$
- 41. What is the molar mass of the compound  $Zr(NO_3)_4$ ?
  - A. 259.2 g/mol
  - B. 297.2 g/mol
  - C. 339.2 g/mol
  - D. 612.8 g/mol
- 42. What is the percentage by mass of oxygen in  $C_3H_5N_3O_9$ ?
  - A. 7.045%
  - B. 37.18%
  - C. 63.41%
  - D. 84.20%

- 43. A compound is found to be composed of 30.9% sodium, 47.7% chlorine, and 21.5% oxygen. What is the empirical formula of this compound?
  - A. NaClO
  - B. NaClO<sub>2</sub>
  - C. NaClO<sub>3</sub>
  - D. NaClO<sub>4</sub>
- 44. A substance with an empirical formula of  $CH_2$  has a molecular weight of 28.05 amu. What is the molecular formula for this substance?
  - A. CH
  - B. CH<sub>2</sub>
  - $C. C_2H_4$
  - D.  $C_3H_6$
- 45. In which of the following substances is the bonding between atoms ionic?
  - A.  $P_2S_5$
  - B. HBr
  - C. Al<sub>2</sub>O<sub>3</sub>
  - D. P<sub>4</sub>

- 46. Which of the following molecules has the strongest O H bond?
  - A. HClO<sub>4</sub>
  - B. HClO<sub>3</sub>
  - C. HClO<sub>2</sub>
  - D. HClO
- 47. Use the diagram below to answer the question that follows.

Lewis Structure for Element "X"

Which of the following elements could the Lewis structure shown above represent?

- A. helium
- B. beryllium
- C. titanium
- D. germanium
- 48. Which of the following molecules has trigonal planar molecular geometry?
  - A. BF<sub>3</sub>
  - B. PBr<sub>3</sub>
  - C. ClF<sub>4</sub>
  - D. AsH<sub>3</sub>

- 49. Which of the following molecules can form a hydrogen bond with water?
  - A. HCl
  - B. H<sub>2</sub>S
  - C. CH<sub>3</sub>F
  - D. NH<sub>3</sub>
- 50. In which of the following substances are dipole-dipole forces the primary intermolecular force?
  - A. PCl<sub>5</sub>
  - B. CCl<sub>4</sub>
  - C. BeCl<sub>2</sub>
  - D. NCl<sub>3</sub>

- 51. Methanol is considerably more soluble in water than 1-hexanol. Which of the following best explains this difference in solubility?
  - A. Methanol contains fewer hydroxyl groups than 1-hexanol.
  - B. The alkyl group is longer in 1-hexanol than in methanol.
  - C. 1-hexanol is a significantly more polar molecule than methanol.
  - D. The greater number of hydrogen atoms in 1-hexanol increases the amount of hydrogen bonding.

 $C_{3}H_{6}(g) + H_{2}(g) \longrightarrow C_{3}H_{8}(g)$ 

The reaction shown above is an example of which of the following types of chemical reaction?

- A. addition
- B. neutralization
- C. double displacement
- D. combustion

- 53. Which of the following chemical equations is an example of a neutralization reaction?
  - A.  $2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(l)$
  - B.  $2\text{KClO}_3(s) \longrightarrow 2\text{KCl}(s) + 3\text{O}_2(g)$
  - C.  $HCl(aq) + NaOH(aq) \longrightarrow NaCl(s) + H_2O(l)$
  - D.  $2Ca(s) + O_2(g) \longrightarrow 2CaO(s)$

 $2O_3(g) \longrightarrow 3O_2(g)$ 

Which of the following compounds is a catalyst for the chemical reaction shown above?

- A. CH<sub>4</sub>
- B. H<sub>2</sub>SO<sub>4</sub>
- C. CO<sub>2</sub>
- D.  $CF_2Cl_2$

- 55. Which of the following is a primary cause of eutrophication in aquatic ecosystems?
  - A. an increase in the amount of acid precipitation
  - B. an increase in the concentration of heavy metals
  - C. an overabundance of nitrogencontaining compounds
  - D. an overabundance of dissolved oxygen
- 56. In a reaction between KBr and  $Pb(NO_3)_2$ , which of the following substances will precipitate out of solution?
  - A. PbBr<sub>2</sub>
  - B. K<sub>2</sub>Pb
  - C. KNO<sub>3</sub>
  - D. NO<sub>3</sub>Br
- 57. Which of the following products is formed when benzene  $(C_6H_6)$  undergoes a substitution reaction with nitric acid (HNO<sub>3</sub>)?
  - A.  $C_6H_5NO_2$
  - B. CNO<sub>3</sub>
  - C. C<sub>6</sub>H<sub>7</sub>NO<sub>3</sub>
  - D. HCO<sub>3</sub>

- 58. What is the pH of a buffer made from 0.25 *M* NH<sub>3</sub> and 0.50 *M* NH<sub>4</sub>Cl at 25°C? ( $K_b$  for NH<sub>3</sub> = 1.8 × 10<sup>-5</sup>)
  - A. 4.7
  - B. 7.5
  - C. 9.0
  - D. 13
- 59. A chemist uses 22.0 mL of  $0.10 M H_2 SO_4$  to neutralize 10.0 mL of NaOH. What is the concentration of the NaOH solution?
  - A. 0.055 *M*
  - B. 0.11 *M*
  - C. 0.22 M
  - D. 0.44 *M*

#### 60. Use the incomplete unbalanced chemical equation below to answer the question that follows.

 $NO_{2}(aq) + Al(s) \longrightarrow NH_{3}(aq) + Al(OH)_{4}(aq)$ 

Nitrite ions  $(NO_2^-)$  and aluminum (Al) react in a basic environment as shown in the incomplete unbalanced equation above. When this oxidation-reduction reaction is balanced with the lowest set of whole-number coefficients, what is the coefficient for the hydroxide ion (OH<sup>-</sup>) and on which side of the equation will it appear?

- A. 2, on the product side
- B. 1, on the product side
- C. 2, on the reactant side
- D. 1, on the reactant side

- 61. Which of the following chemical equations is balanced correctly?
  - A.  $\operatorname{Zn}(s) + 2\operatorname{AgNO}_3(aq) \longrightarrow 2\operatorname{Ag}(s) + \operatorname{Zn}(\operatorname{NO}_3)_2(aq)$
  - B.  $CH_3OH(l) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$
  - C.  $Al(s) + 3O_2(g) \longrightarrow Al_2O_3(s)$
  - D.  $H_2SO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4(s) + H_2O(l)$

$$2\mathrm{H}_{2}\mathrm{O}_{2}(l) \longrightarrow 2\mathrm{H}_{2}\mathrm{O}(l) + \mathrm{O}_{2}(g)$$

Hydrogen peroxide decomposes according to the equation shown above. What volume of oxygen gas, measured at standard temperature and pressure, will be produced from the decomposition of 50.0 g of hydrogen peroxide?

- A. 16.5 L
- B. 23.5 L
- C. 33.0 L
- D. 65.9 L

 $Pb(NO_3)_2(s) + 2NaOH(aq) \longrightarrow Pb(OH)_2(s) + 2NaNO_3(aq)$ 

According to the reaction shown above, approximately how many grams of Pb(OH)<sub>2</sub> will be formed when 100 g of Pb(NO<sub>3</sub>)<sub>2</sub> is reacted with 250 mL of 2.00 *M* NaOH?

A. 60.3 g
B. 72.8 g
C. 121 g

D. 241 g

#### 64. Use the chemical equation below to answer the question that follows.

 $2\mathrm{NH}_3(g) + \mathrm{CO}_2(g) \longrightarrow (\mathrm{NH}_2)_2\mathrm{CO}(aq) + \mathrm{H}_2\mathrm{O}(l)$ 

A chemist reacts 258 g of  $NH_3$  with 425 g of  $CO_2$  and produces 298 g  $(NH_2)_2CO$  according to the reaction shown above. What is the percent yield for this reaction?

- A. 16.4%
- B. 32.8%
- C. 51.4%
- D. 65.5%

- 65. How many grams of NaCl are contained in 50.0 mL of a 1.75 *M* NaCl solution?
  - A. 35.0 g
  - B. 28.6 g
  - C. 5.12 g
  - D. 0.875 g
- 66. Which of the following pairs of gas samples would have closest to the same number of particles?
  - A.  $4.0 \text{ g of } O_2 \text{ and } 4.0 \text{ g of } N_2$
  - B.  $73.1 \text{ g of } SF_6 \text{ and } 1.0 \text{ g of } H_2$
  - C. 8.8 g of  $CO_2$  and 10.4 g of  $C_3H_8$
  - D. 10.8 g of Ne and 36.0 g of Kr
- 67. What is the pH of a 0.22 *M* hypochlorous acid (HOCl) solution? ( $K_a = 3.5 \times 10^{-7}$ )
  - A. 0.66
  - B. 3.56
  - C. 5.80
  - D. 6.46

 $Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$ 

Which of the following changes will increase the rate of the reaction shown above?

- A. decreasing the temperature of the reaction
- B. using an open beaker as the reaction vessel
- C. decreasing the initial concentration of HCl
- D. using zinc powder as a reactant

## 69. Use the chemical equation below to answer the question that follows.

 $2\text{KClO}_3(s) \longrightarrow 2\text{KCl}(s) + 3\text{O}_2(g)$ 

Why does the reaction rate for the combustion of glucose increase with the addition of KClO<sub>3</sub>?

- A. The presence of  $KClO_3$  lowers the activation energy of the reaction.
- B. The decomposition of  $KClO_3$ increases the concentration of a combustion reactant.
- C. The decomposition of  $KClO_3$  yields a large quantity of heat.
- D. The KCl formed from the decomposition of KClO<sub>3</sub> is very reactive.

Experiment	Initial [A <sub>2</sub> ] ( <i>M</i> )	Initial [B] ( <i>M</i> )	Initial Rate ( <i>M</i> /s)
1	0.25	0.10	2.8 × 10 <sup>−2</sup>
2	0.25	0.30	8.3 × 10 <sup>−2</sup>
3	0.25	0.40	1.1 × 10 <sup>−1</sup>
4	0.50	0.10	5.5 × 10 <sup>−2</sup>
5	0.75	0.30	2.5 × 10 <sup>−1</sup>

#### 70. Use the table below to answer the question that follows.

The table above shows initial concentrations and reaction rates for the hypothetical reaction  $A_2 + 2B \longrightarrow 2AB$ . Using these data, which of the following is the rate law for this reaction?

- A. rate =  $k[A_2]$
- B. rate =  $k[A_2][B]^2$
- C. rate =  $k[A_2][B]$
- D. rate =  $k[A_2]^3[B]$

Experiment	Initial [H <sub>2</sub> O <sub>2</sub> ] ( <i>M</i> )	Initial Rate ( <i>M</i> /min)
1	1.50 × 10 <sup>−2</sup>	1.59 × 10 <sup>–₅</sup>
2	3.00 × 10 <sup>−2</sup>	3.18 × 10 <sup>−5</sup>
3	4.50 × 10 <sup>−2</sup>	4.77 × 10 <sup>−5</sup>
4	7.50 × 10 <sup>−2</sup>	7.95 × 10 <sup>–5</sup>

71. Use the table below to answer the question that follows.

Using the data for the decomposition of  $H_2O_2$  shown above, what is the reaction rate when  $[H_2O_2] = 6.50 \times 10^{-1}$ ?

- A.  $6.36 \times 10^{-5} M/min$
- B.  $6.89 \times 10^{-4} M/min$
- C.  $4.60 \times 10^{-2} M/min$
- D.  $6.50 \times 10^{-1} M/min$

#### 72. Use the information below to answer the question that follows.

The proposed mechanism for the reaction between  $NO_2$  and CO at temperatures less than 600 K is shown below.

step 1: $2NO_2(g) \rightleftharpoons NO_3(g) + NO(g)$ (slow)step 2: $NO_3(g) + CO(g) \longrightarrow NO_2(g) + CO_2(g)$ (fast)

overall:  $NO_2(g) + CO(g) \longrightarrow NO(g) + CO_2(g)$ 

Given this information, which of the following rate laws best represents this reaction mechanism?

- A. rate = k[CO]
- B. rate =  $k[NO_2]^2$
- C. rate =  $k[NO_3][CO]$
- D. rate =  $k[NO_2]^2[CO]$

#### 73. Use the information below to answer the question that follows.

The proposed mechanism for the reaction between  $I^-$  and  $OC1^-$  is shown below.

step 1: $OCl^-(aq) + H_2O(l) \longrightarrow HOCl(aq) + OH^-(aq)$ step 2: $I^-(aq) + HOCl(aq) \longrightarrow HOI(aq) + Cl^-(aq)$ step 3: $HOI(aq) + OH^-(aq) \longrightarrow H_2O(l) + IO^-(aq)$ overall: $I^-(aq) + OCl^-(aq) \longrightarrow IO^-(aq) + Cl^-(aq)$ 

Given the reaction mechanism shown above, how many intermediates are involved in the reaction between  $I^-$  and OC1<sup>-</sup>?

- A. 1
- B. 2
- C. 3
- D. 4

## 74. Use the chemical equation below to answer the question that follows.

 $2AB + C_2 \longrightarrow 2AC + 2B$ 

Experimental data have shown that the reaction above has the following experimental rate law.

rate =  $k[AB]^2[C_2]$ 

What is the overall order for this reaction?

- A. first order
- B. second order
- C. third order
- D. fourth order

Experiment	Initial [NH₄] ( <i>M</i> )	Initial [NO₂] ( <i>M</i> )	Initial Rate ( <i>M</i> /s)
1	0.08	0.065	1.40 × 10 <sup>-6</sup>
2	0.16	0.065	2.80 × 10 <sup>-6</sup>
3	0.16	0.26	1.12 × 10⁻⁵

75. Use the table below to answer the question that follows.

The table above shows rate data for the following reaction.

 $\mathrm{NH}_{4}^{+}(aq) + \mathrm{NO}_{2}^{-}(aq) \longrightarrow \mathrm{N}_{2}(g) + 2\mathrm{H}_{2}\mathrm{O}(l)$ 

Using these data, what is the value of the rate constant for this reaction?

- A.  $1.04 \times 10^{-3} M^{-1} s^{-1}$
- B.  $2.70 \times 10^{-4} M^{-1} s^{-1}$
- C.  $1.21 \times 10^{-7} M^{-1} s^{-1}$
- D.  $7.28 \times 10^{-9} M^{-1} s^{-1}$

## 76. Use the equation below to answer the question that follows.

 $S = k \times \log W$ 

Which of the following best describes what happens to the variables in the equation above as a compound undergoes a phase transition from solid to liquid to gas?

- A. The value of *S* decreases.
- B. The value of *k* increases.
- C. The values of *S*, *k*, and *W* decrease.
- D. The value of *W* increases.

- 77. A system undergoes an exothermic process releasing 2.5 kJ of heat. During this process, the system does 0.5 kJ of work. According to the first law of thermodynamics, what is the change in the system's internal energy?
  - A. –3.0 kJ
  - B. –2.0 kJ
  - C. 2.0 kJ
  - D. 3.0 kJ
- 78. Given that the specific heat of copper is 0.385 J/g•K, how much heat is required to raise the temperature of 50.0 g of copper from 25.0°C to 100°C?
  - A. 1.44 kJ
  - B. 1.93 kJ
  - C. 6.70 kJ
  - D. 7.18 kJ

- 79. When  $1.0 \times 10^2$  g of an unknown metal at 80.0°C is placed in a calorimeter containing  $1.0 \times 10^2$  g of water, the temperature of the water rises from 20.0°C to 25.0°C. Given that the specific heat of water is 4.184 J/g•K, what is the specific heat of the metal?
  - A. 0.26 J/g•K
  - B. 0.38 J/g•K
  - C. 1.52 J/g•K
  - D. 1.90 J/g•K
- 80. A constant pressure calorimeter with negligible heat capacity contains 200.0 g of  $H_2O$  at 25.00°C. When 12.3 g of KClO<sub>3</sub> is dissolved in the  $H_2O$ , the temperature of the solution in the calorimeter drops to 20.05°C. Assuming the specific heat of the solution is 4.184 J/g•K, what is the heat of solution of KClO<sub>3</sub>?
  - A. 0.255 kJ/mol
  - B. 0.337 kJ/mol
  - C. 44.0 kJ/mol
  - D. 168 kJ/mol

Bond	Bond Enthalpy (kJ/mol)
N — N	159
N = N	418
$N \equiv N$	941
F — F	153
N — F	272

$$\frac{1}{2}N_2(g) + \frac{3}{2}F_2(g) \longrightarrow NF_3(g)$$

Based on the bond enthalpies and chemical equation shown above, what is the best estimate for the enthalpy of formation for 1 mol of  $NF_3$ ?

- A. -816 kJ/mol
- B. -507 kJ/mol
- C. -387 kJ/mol
- D. -116 kJ/mol

82. Use the table and chemical equation below to answer the question that follows.

Bond	Bond Enthalpy (kJ/mol)
0-0	138
O = O	498
CI — CI	243

$$\frac{1}{2}O_2(g) + Cl_2(g) \longrightarrow OCl_2(g)$$

The standard enthalpy of formation of  $OCl_2$  is 105 kJ/mol. Based on the bond enthalpies and chemical equation shown above, what is the best estimate for the bond enthalpy for an O — Cl bond?

- A. 104 kJ/mol
- B. 194 kJ/mol
- C. 318 kJ/mol
- D. 387 kJ/mol
- 83. The bond energy for oxygen gas (O<sub>2</sub>) is
  499 kJ/mol. Based on this information, what is the standard enthalpy of formation of gaseous oxygen atoms (O)?
  - A. 0.00 kJ/mol
  - B. 250 kJ/mol
  - C. 499 kJ/mol
  - D. 998 kJ/mol
| Reaction | Chemical Equation                                | ∆ <i>H</i> °(kJ) | ∆S° (J/K) |
|----------|--|------------------|-----------|
| 1        | $2SO_3(g) \longrightarrow 2SO_2(g) + O_2(g)$     | 198              | 188       |
| 2        | $2AsF_3(I) \longrightarrow 2As(s) + 3F_2(g)$     | -1643            | 316       |
| 3        | $N_2O(g) + 2H_2O(l) \longrightarrow NH_4NO_3(s)$ | 36               | -446      |
| 4        | $4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(s)$   | -1650            | -549      |

84. Use the table below to answer the question that follows.

Which of the reactions shown in the table above is spontaneous only at sufficiently high temperatures?

- A. reaction 1
- B. reaction 2
- C. reaction 3
- D. reaction 4

85. Use the diagram below to answer the question that follows.



Which of the following expressions best represents the change in enthalpy for the reaction in the potential energy diagram shown above?

- A. b-c
- B. c-b
- C. a-d
- D. d-a

86. Use the chemical equation below to answer the question that follows.

$$2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g)$$

Which of the following changes would affect the value of the equilibrium constant for the reaction shown above?

- A. increasing the pressure
- B. removing  $O_2$  as it is formed
- C. adding a catalyst to the reaction
- D. decreasing the temperature

#### 87. Use the chemical equation below to answer the question that follows.

 $2N_2(g) + 6H_2O(l) \rightleftharpoons 4NH_3(g) + 3O_2(g) \quad \Delta H = 1530 \text{ kJ}$ 

Which of the following changes would cause the equilibrium reaction shown above to shift to the right?

- A. removing  $NH_3(g)$
- B. increasing the pressure
- C. decreasing the temperature
- D. adding  $H_2O(l)$
- 88. What mass of silver ion is present in a 500 mL solution of saturated silver acetate  $(AgC_2H_3O_2)? (K_{sp} = 1.9 \times 10^{-3})$ 
  - A. 0.10 g
  - B. 0.21 g
  - C. 2.4 g
  - D. 4.7 g

89. Use the information below to answer the question that follows.

 $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$  $K_p = 2.79 \times 10^{-5} \text{ at } 472^{\circ}C$ 

Compound	Initial Partial Pressure (atm)
N <sub>2</sub>	3.69
H <sub>2</sub>	11.1
NH <sub>3</sub>	0.415

The compounds shown in the table above are placed in a sealed flask at 472°C. Using the given initial partial pressures, what is the value for the reaction quotient  $(Q_p)$  and how will the reaction proceed from these initial conditions to reach equilibrium?

- A.  $Q_p = 1.01 \times 10^{-2}$  and the reaction will shift left.
- B.  $Q_p = 1.01 \times 10^{-2}$  and the reaction will shift right.
- C.  $Q_p = 3.41 \times 10^{-5}$  and the reaction will shift left.
- D.  $Q_p = 3.41 \times 10^{-5}$  and the reaction will shift right.

90. Use the information below to answer the question that follows.

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

Temperature (°C)	K <sub>eq</sub>
200	4 × 10 <sup>−1</sup>
300	4 × 10 <sup>−3</sup>
400	2 × 10 <sup>-4</sup>
500	2 × 10⁻⁵

The equilibrium constant  $(K_{eq})$  for the formation of NH<sub>3</sub> from N<sub>2</sub> and H<sub>2</sub> at various temperatures is shown in the table above. Given this information, at which temperature is the formation of NH<sub>3</sub> most favored?

- A. 200°C
- B. 300°C
- C. 400°C
- D. 500°C
- 91. Assuming complete dissociation of the solute, what is the freezing point of a solution containing 24.0 g of  $SrCl_2$  and 100.0 g of water?
  - A. –2.32°C
  - В. –2.81°С
  - C. –5.62°C
  - D. -8.44°C

- 92. Assuming complete dissociation of electroytes, which of the following solutions would have the lowest boiling point?
  - A. 120.0 g of  $C_6H_{12}O_6$  in 1.0 L of  $H_2O$
  - B.  $100.0 \text{ g of } C_3H_8O_3 \text{ in } 1.0 \text{ L of } H_2O$
  - C.  $80.0 \text{ g of } \text{ZnSO}_4 \text{ in } 1.0 \text{ L of } \text{H}_2\text{O}$
  - D.  $60.0 \text{ g of } \text{NH}_4\text{Cl in } 1.0 \text{ L of } \text{H}_2\text{O}$
- 93. Use the graph below to answer the question that follows.



Which of the lines indicated in the solubility curve above best represents the relationship between temperature and gas solubility at a constant pressure?

- A. line 1
- B. line 2
- C. line 3
- D. line 4

- 94. An elevation in temperature will increase the solubility in water of which of the following compounds?
  - A.  $CO_2(g)$
  - B. NaCl(s)
  - C.  $O_2(g)$
  - D.  $\operatorname{CCl}_4(l)$
- 95. Use the graph below to answer the question that follows.



Based on the gas solubility curve shown above, which of the following changes will cause gas to be evolved?

- A. cooling a 0.50 m*M* solution from 25°C to 10°C at constant pressure
- B. warming a 2.0 mM solution from 5°C to 20°C at constant pressure
- C. cooling a 1.5 mM solution from 10°C to 5°C at constant pressure
- D. warming a 1.0 mM solution from 5°C to 15°C at constant pressure

Standard Reduction Potentials (1.0 <i>M</i> at 25°C)					
Half-reaction	<i>E</i> ° (V)				
$Ba^{2+}(aq) + 2e^{-} \longrightarrow Ba(s)$	-2.91				
$Na^+(aq) + e^- \longrightarrow Na(s)$	-2.71				
$Mn^{2+}(aq) + 2e^{-} \longrightarrow Mn(s)$	-1.18				
$TI^+(aq) + e^- \longrightarrow TI(s)$	-0.34				
$Ag^+(aq) + e^- \longrightarrow Ag(s)$	+0.80				
$Au^{3+}(aq) + 3e^- \longrightarrow Au(s)$	+1.50				

96. Use the table below to answer the question that follows.

Using the standard reduction potentials shown above, which of the following cells is spontaneous at standard conditions?

- A. Mn | Mn<sup>2+</sup> || Tl<sup>+</sup> | Tl
- B. Ag  $|Ag^+| | Mn^{2+} | Mn$
- C. Ag  $|Ag^+||$  Na<sup>+</sup> Na
- D. Na | Na<sup>+</sup> || Ba<sup>2+</sup> | Ba

97. Use the table below to answer the question that follows.

Standard Reduction Potentials (1.0 <i>M</i> at 25°C)				
Half-reaction	<i>E</i> ° (V)			
$\operatorname{Sn}^{2+}(aq) + 2e^{-} \longrightarrow \operatorname{Sn}(s)$	-0.138			
$Pb^{2+}(aq) + 2e^{-} \longrightarrow Pb(s)$	-0.126			

A voltaic cell using the half-reactions shown in the table above begins operation at standard conditions. At what ratio of the concentration of  $\text{Sn}^{2+}$  to  $\text{Pb}^{2+}$  will the cell potential become zero?

- A. 0.331
- B. 0.930
- C. 1.11
- D. 2.53
- 98. Ni-Cd storage batteries are rechargeable, whereas standard Zn-MnO<sub>2</sub> dry-cell batteries are not rechargeable. Which of the following statements best accounts for this difference between these two types of batteries?
  - A. The salt bridge in a Ni-Cd battery is unidirectional.
  - B. An applied current can be used to reverse the reaction of a Ni-Cd battery.
  - C. In a Zn-MnO $_2$  battery, either electrode can serve as the anode.
  - D. In a  $Zn-MnO_2$  battery, the oxidation and reduction reactions are not linked.

Standard Reduction Potentials (1.0 <i>M</i> at 25°C)				
Half-reaction	<i>E</i> ° (V)			
$O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O(I)$	+1.23			
$Br_2(l) + 2e^- \longrightarrow 2Br^-(aq)$	+1.08			

99. Use the information below to answer the question that follows.

The following reaction takes place at 25°C.

 $4Br^{-}(aq) + O_2(g) + 4H^{+}(aq) \longrightarrow 2H_2O(l) + 2Br_2(l)$ 

Using the equations and half-reactions shown above, what is the value of the equilibrium constant (*K*) for this chemical reaction?

- A.  $1.1 \times 10^{39}$
- $B. \qquad 1.9\times 10^{20}$
- $C. \qquad 1.4\times 10^{10}$
- $D. \qquad 3.5\times 10^2$
- 100. An oxidation-reduction reaction has a negative electrochemical potential at standard conditions. Which of the following is true about the standard free energy change ( $\Delta G^{\circ}$ ) and equilibrium constant (*K*) for this reaction at 25°C?

A. 
$$\Delta G^{\circ} > 0, K < 1$$

- B.  $\Delta G^{\circ} > 0, K > 1$
- C.  $\Delta G^{\circ} < 0, K < 1$
- D.  $\Delta G^{\circ} < 0, K > 1$

## DIRECTIONS FOR THE OPEN-RESPONSE ITEM ASSIGNMENTS

This section of the test consists of two open-response item assignments that appear on the following pages. You will be asked to prepare a written response of approximately 150-300 words (1-2 pages) for each assignment. You should use your time to plan, write, review, and edit your response for each assignment.

For each assignment, read the topic and directions 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.

As a whole, your response to each assignment must demonstrate an understanding of the knowledge of the field. In your response to each assignment, you are expected to demonstrate the depth of your understanding of the subject area by applying your knowledge rather than by merely reciting factual information.

Your response to each assignment will be evaluated based on the following criteria.

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

The open-response item assignments are intended to assess subject knowledge. Your responses must be communicated clearly enough to permit valid judgment of the evaluation criteria by scorers. Your responses should be written for an audience of educators in this field. The final version of each response should conform to the conventions of edited American English. Your responses 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 topics. 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 responses.

Write or print your response in the space provided following the assignment.

#### **OPEN-RESPONSE ITEM ASSIGNMENT #1**

#### Read the information below; then complete the exercise that follows.

A chemist wants to design a laboratory investigation demonstrating the law of conservation of mass. The chemist is planning to heat  $KClO_3$  and study its decomposition into KCl and  $O_2$ .

Using your knowledge of scientific inquiry, describe a suitable experiment addressing this topic. In your response:

- describe the data to be collected;
- list the equipment needed to collect the data; and
- describe the methods used in collecting and analyzing the data generated in the experiment, including a description of the formulas and associated calculations that would be needed.

## **OPEN-RESPONSE SHEET—ASSIGNMENT #1**



## **OPEN-RESPONSE SHEET—ASSIGNMENT #1**

#### **OPEN-RESPONSE ITEM ASSIGNMENT #2**

#### Read the information below; then complete the exercise that follows.

A chemist wants to increase the rate of the following chemical reaction.

$$\mathrm{H}_{3}\mathrm{C}_{6}\mathrm{H}_{5}\mathrm{O}_{7}(aq) + \mathrm{HCO}_{3}(aq) \longrightarrow \mathrm{H}_{2}\mathrm{C}_{6}\mathrm{H}_{5}\mathrm{O}_{7}(aq) + \mathrm{H}_{2}\mathrm{O}(l) + \mathrm{CO}_{2}(g).$$

Prepare an organized, developed response on this topic in which you:

- describe two changes that will lead to an increase in reaction rate; and
- explain how at the molecular level these changes lead to an increase in the reaction rate.

## **OPEN-RESPONSE SHEET—ASSIGNMENT #2**



## **OPEN-RESPONSE SHEET—ASSIGNMENT #2**



# PRACTICE TEST RESULTS

#### PRACTICE TEST RESULTS OVERVIEW

The practice test provides valuable information regarding your preparedness for the MTEL Chemistry (12) test. In this section, you will find information and tools to help you determine your preparedness on the various sections of the test.

#### **Multiple-Choice Questions**

A <u>Multiple-Choice Question Answer Key Worksheet</u> is provided to assist you in evaluating your multiple-choice responses. The worksheet contains five columns. The first column indicates the multiple-choice question number, the second column indicates the objective to which the test question was written, and the third column indicates the correct response. The remaining columns are for your use in calculating the number of multiple-choice questions you answered correctly.

An <u>Evaluation Chart</u> for the multiple-choice questions is also provided to help you assess which content covered by the test objectives may require additional study.

#### **Open-Response Items**

<u>Evaluation Information</u>, <u>Sample Responses and Analyses</u>, as well as a <u>Scoring Rubric</u> are provided for these items. You may wish to refer to this information when evaluating your practice test responses.

#### **Total Test**

<u>Practice Test Score Calculation</u> information is provided to help you estimate your score on the practice test. Although you cannot use this practice test to precisely predict how you might score on an official MTEL Chemistry (12) test, you may be able to determine your degree of readiness to take an MTEL test at an operational administration. No passing score has been determined for the practice test.

Question	Objective	Correct	Your Response		
Number	Number	Response	Correct?	Incorrect?	
1	0001	В			
2	0001	A			
3	0001	C			
4	0001	В			
5	0001	D			
6	0002	C			
7	0002	В			
8	0002	C			
9	0002	A			
10	0002	В			
11	0003	D			
12	0003	C			
13	0003	C			
14	0003	C			
15	0003	C			
16	0004	D			
17	0004	В			
18	0004	A			
19	0004	C			
20	0004	A			
21	0005	В			
22	0005	A			
23	0005	A			
24	0005	A			
25	0005	В			
26	0006	В			
27	0006	В			
28	0006	C			
29	0006	В			
30	0007	D			
31	0007	A			
32	0007	C			
33	0008	A			
34	0008	D			

## MULTIPLE-CHOICE QUESTION ANSWER KEY WORKSHEET

Question	Objective	Correct	Your Response		
Number	Number	Response	<b>Correct?</b>	Incorrect?	
35	0008	C			
36	0008	D			
37	0009	D			
38	0009	Α			
39	0009	D			
40	0009	В			
41	0010	С			
42	0010	C			
43	0010	A			
44	0010	C			
45	0011	C			
46	0011	D			
47	0011	D			
48	0011	A			
49	0012	D			
50	0012	D			
51	0012	В			
52	0013	A			
53	0013	C			
54	0013	D			
55	0013	С			
56	0013	A			
57	0013	A			
58	0013	C			
59	0013	D			
60	0014	D			
61	0014	A			
62	0014	A			
63	0014	A			
64	0014	D			
65	0014	C			
66	0014	В			
67	0014	В			
68	0015	D			

## MULTIPLE-CHOICE QUESTION ANSWER KEY WORKSHEET (continued)

Question	Objective	Correct	Your R	Response
Number	Number	Response	Correct?	Incorrect?
69	0015	В		
70	0015	С		
71	0015	В		
72	0015	В		
73	0015	C		
74	0015	C		
75	0015	В		
76	0016	D		
77	0016	A		
78	0016	A		
79	0016	В		
80	0016	C		
81	0017	D		
82	0017	В		
83	0017	В		
84	0017	A		
85	0017	D		
86	0018	D		
87	0018	А		
88	0018	С		
89	0018	С		
90	0018	А		
91	0019	D		
92	0019	A		
93	0019	D		
94	0019	В		
95	0019	В		
96	0020	A		
97	0020	D		
98	0020	В		
99	0020	C		
100	0020	A		

## MULTIPLE-CHOICE QUESTION ANSWER KEY WORKSHEET (continued)

Count the number of multiple-choice questions you answered correctly:

\_\_\_\_ of 100 multiple-choice questions

## MULTIPLE-CHOICE QUESTION PRACTICE TEST EVALUATION CHART

In the evaluation chart that follows, the multiple-choice questions are arranged in numerical order and by test objective. Check your responses against the correct responses provided to determine how many questions within each objective you answered correctly.

	Objective 0001: Understand the processes of gathering, organizing, analyzing, and reporting scientific data.						
1B	2A	3C	_ 4B	5D	/5		
0	bjective 00	002: Under	rstand scie	tific tools, instruments, materials	s, and safety practices.		
6C	7B	8C	_ 9A	10B	/5		
	Objective (	0004: Und	erstand ch	emical and physical properties an	d changes in matter.		
16D	Objective ( 17B	0004: Und	erstand ch	emical and physical properties an	d changes in matter. /5		
(	Objective 0	005: Unde	erstand the	kinetic molecular theory, the nat and the gas laws.	ure of phase changes,		
21B_	22A	23A_	24A_	25B	/5		

## MULTIPLE-CHOICE QUESTION PRACTICE TEST EVALUATION CHART (continued)

Obje	ctive 0006:	Understa part	nd atomic structure, the properties and interactions of suba icles, and the principles of quantum theory.	tomic
26B	27B	_ 28C	29B	/4
	Obje	ective 0007	7: Understand the process of nuclear transformation.	
30D	31A	32C		/3
	Obj	ective 000	8: Understand the organization of the periodic table.	
33A	34D	_ 35C	36D	/4
	Objecti	ve 0009: 1	Understand the nomenclature and structure of inorganic and organic compounds.	
37D	38A	39D	40B	/4
	Objectiv	e 0010: U	nderstand the mass relationships in chemical compounds.	
41C	42C	43A	44C	/4
	Objective (	0011: Und	erstand chemical bonding and the effect of bond type on the properties of substances.	<u>,</u>
45C	46D	_ 47D	48A	/4
	Objectiv	e 0012: Ur	nderstand the connection between intramolecular bonding and intermolecular forces.	
49D	50D	51B		/3

## MULTIPLE-CHOICE QUESTION PRACTICE TEST EVALUATION CHART (continued)

	Objective	e 0013: Un	derstand th	ne types and	l characteri	stics of che	mical reacti	ons.
52A	53C	54D	55C	56A	57A	58C	59D	/8
Obje	ective 0014	: Understa	and the qua	ntitative re	lationships	expressed i	n chemical	equations.
60D	61A	62A	63A	64D	65C	66B	67B	/8
	Objectiv	ve 0015: U	nderstand t of me	he factors t easuring re	hat affect r action rates	eaction rat	es and meth	ods
68D	69B	70C	71B	72B	73C	74C	75B	/8

## MULTIPLE-CHOICE QUESTION PRACTICE TEST EVALUATION CHART (continued)

	Objective	e 0016: Un	derstand th	e principles of	thermodynamics and	calorimetry.
76D	77A	78A	79B	80C		/5
Objectiv	ve 0017: U	Inderstand	the energy	relationships i	n chemical bonding a	nd chemical reactions
81D	82B	83B	_ 84A	85D		/5
	Ob	jective 001	8: Underst	and the princi	oles of chemical equili	brium.
86D	87A	88C	89C	90A	<u> </u>	/5
0	)bjective ()	019: Unde	rstand the	properties of so	olutions as they relate	to equilibrium.
91D	92A	93D	94B	95B		/5
		Ob	jective 0020	): Understand	electrochemistry.	
96A	97D	98B	99C	100A	-	/5
				<b>a</b> 1		

## **OPEN-RESPONSE ITEM EVALUATION INFORMATION**

#### How Open-Response Items Are Scored

Open-response items are scored through a process called focused holistic scoring. Scorers judge the overall effectiveness of the response rather than individual aspects considered in isolation. Scorer judgments are based on the quality of the response, not on length or neatness. Responses must be long enough to cover the topic adequately and scorers must be able to read what is written.

#### How to Evaluate Your Practice Responses

On the following pages, you will find two "strong" and two "weak" sample responses. PLEASE DO NOT REVIEW THE SAMPLE RESPONSES UNTIL AFTER YOU HAVE WRITTEN YOUR OWN RESPONSE. When you do review the two "strong" and "weak" sample responses and analyses included here, please note the following points:

- $\checkmark$  For the purposes of the practice test, responses are identified as "strong" or "weak" rather than given a score point of 1–4.
- ✓ The responses identified as "strong" may contain flaws; however, these responses do demonstrate the performance characteristics of a "strong response."
- ✓ The two "strong" responses demonstrate the examinees' appropriate understanding and application of the subject matter knowledge. However, these responses do not necessarily reflect the full range of "correct answers" that would demonstrate an understanding of the subject matter.
- ✓ The "Analysis" accompanying each "strong" and "weak" response discusses the main attributes of the responses, but does not identify all flaws or strengths that may be present.

Compare your practice responses to the <u>Sample Responses</u> to determine whether your responses are more similar to the strong or weak responses. Also review the <u>Analyses</u> on those pages and the <u>Scoring Rubric</u> to help you better understand the characteristics of strong and weak responses. This evaluation will help you identify specific problems or weaknesses in your practice responses. Further information on scoring can be found in the <u>Test Information Booklet</u> and Faculty Guide at <u>www.mtel.nesinc.com</u> and at <u>www.doe.mass.edu/mtel</u>; select "FAQ," then "After the Test."

# OPEN-RESPONSE ITEM SCORING RUBRIC, SAMPLE RESPONSES, AND ANALYSES

# Massachusetts Tests for Educator Licensure® SCORING RUBRIC FOR SUBJECT TESTS

#### **Performance Characteristics:**

Purpose	The extent to which the response achieves the purpose of the assignment.		
Subject Matter Knowledge	Accuracy and appropriateness in the application of subject matter knowledge.		
Support	Quality and relevance of supporting details.		
Rationale	Soundness of argument and degree of understanding of the subject matter.		

#### **Scoring Scale:**

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

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.

## FIRST SAMPLE WEAK RESPONSE FOR OPEN-RESPONSE ITEM ASSIGNMENT #1

In order to confirm that mass is conserved, a scientist must measure the total mass before and after a reaction. The scientist must account for the mass of any gas as well as any reactants or products that are not part of the core mass. A suitable data table might look like this:

	mass KClO₃	mass KCI	mass O2
Trial 1			
Trial 2			

The scientist will need a flask, a heat source, a thermometer, and a device for conserving the  $2KCIO_3$  gas. I do not know the formula.

## ANALYSIS FOR FIRST WEAK RESPONSE TO OPEN-RESPONSE ITEM ASSIGNMENT #1

#### This is an example of a weak response because it is characterized by the following:

**Purpose:** The purpose of the assignment is partially achieved. The response indicates an understanding that the total mass before the reaction should equal the total mass after the reaction. In addition, some of the needed equipment is identified. Methods of collecting and analyzing data are not addressed.

**Subject Matter Knowledge:** There is little subject matter knowledge demonstrated. There are no balanced equations for the reaction. The candidate does not explain the method for obtaining the mass of oxygen nor provide a complete list of the equipment needed to collect the data.  $2\text{KCIO}_3$  is incorrectly identified as a gas. The inclusion of two trials in the chart indicates some understanding of the scientific method.

**Support:** The response to the second bullet is weak; there is no information on how to collect oxygen. For the third bullet, the candidate does not describe a method for calculating the mass of gas.

**Rationale:** The candidate states "I do not know the formula," demonstrating little or no reasoning or understanding of topic.

## SECOND SAMPLE WEAK RESPONSE FOR OPEN-RESPONSE ITEM ASSIGNMENT #1

The law of conservation of mass states that matter is neither created or destroyed. Therefore, in any reaction, the masses of each element must remain constant as they transition from reactants to products.

For this experiment,  $KCIO_3$  should be placed in a boiler flask, which is connected to a ring stand, and contains boiler chips. A Bunsen burner is used to heat the compound. Attached to the boiler flask should be a condenser, which will aid in the separation of products based on their individual boiling points. Finally, at the other end of the condenser, a collection flask should be placed.

Data to be recorded includes the mass of  $KCIO_3$  used, the boiling point of  $KCIO_3$ , the time at the start of the experiment, the time when KCI begins to condense, and the time when condensation of KCI is completed. The temperature of the  $KCIO_3$  should be taken at each of these time points, so an experimental-grade metric thermometer should also be included in the equipment lists.

## ANALYSIS FOR SECOND WEAK RESPONSE TO OPEN-RESPONSE ITEM ASSIGNMENT #1

#### This is an example of a weak response because it is characterized by the following:

**Purpose:** The purpose of the assignment is partially achieved. While the massing of  $KClO_3$  is identified correctly, boiling point, time, and temperature are not relevant parameters. Appropriate methods used in collecting and analyzing the data are omitted along with an appropriate method for collecting oxygen.

**Subject Matter Knowledge:** The candidate demonstrates limited subject matter knowledge. Inappropriate parameters are included within the response (i.e., boiling point, time, and temperature). The candidate shows understanding of the law of conservation of matter. Minimal knowledge of equipment necessary to collect data is presented; boiling chips and condenser are erroneous. The mathematical processes that are required are not addressed.

**Support:** The response lacks relevant supporting details. There is no mention of the method of collecting and calculating the mass of oxygen. There is no balanced equation.

**Rationale:** There is a weak understanding shown of the topic. Experimentally, the candidate cannot verify the conservation of matter. Timing, "temperature taking," and incorrect process move the response in the wrong direction.

## FIRST SAMPLE STRONG RESPONSE FOR OPEN-RESPONSE ITEM ASSIGNMENT #1

Conservation of mass states that mass can neither be created nor destroyed. Accordingly, the mass of  $KCIO_3$  prior to decomposition should be equal to the mass of the products of its decomposition, KCI and  $O_3$ .

The following equipment will be needed: a balance, a clean test tube, glass and plastic tubing, a ring stand, test tube clamp, a Bunsen burner, a water bath, and a bottle filled with water.

In order to verify that mass has been conserved, measurements of mass will be critical.  $KCIO_3$  and KCI are both solids at room temperature and stable, so any standard balance will suffice. The oxygen released by the reaction will be in gaseous form, however, so a more complicated calculation will be required. This reaction will have to be performed in a hermetically sealed environment by displacement of water. The apparatus will also have to be heat resistant, as this decomposition reaction is strongly exothermic.

The decomposition reaction will proceed according to the formula

 $2\text{KClO}_3(s) \rightarrow 2\text{KCl}(s) + 3O_2(g)$ 

Ideally, the apparatus in which the reaction is to be conducted will allow for the entire apparatus to be weighed prior to and after the reaction, much like Antoine Lavoisier's apparatus for capturing the mass of the products of combustion.

Comparing the masses prior to and after the reaction is conducted will verify that mass is conserved during this decomposition. The oxygen gas should be collected by displacement of water and its volume measured. Dalton's law of partial pressures must be used to determine the correct pressure of the pure oxygen: total gas pressure minus the pressure of water vapor at the experimental temperature and conditions equals the pressure of oxygen. The next part of the process would involve determining the mass of oxygen collected in grams. PV = nRT can be used to determine the moles of oxygen produced, and then the number of moles can be converted to grams by multiplying by 32 grams/mole.

This shows conservation of matter or, that no matter was lost:

Mass of  $2KCIO_3 = Mass$  of 2KCI + mass of  $3O_2$ 

#### ANALYSIS FOR FIRST STRONG RESPONSE TO OPEN-RESPONSE ITEM ASSIGNMENT #1

#### This is an example of a strong response because it is characterized by the following:

**Purpose:** The purpose of the assignment is fully achieved. Each part of the assignment is thoroughly addressed. The method of collecting and analyzing the data is clear.

**Subject Matter Knowledge:** The response demonstrates a complete understanding of the scientific method. The methods of investigation are well presented, including the "hermetically sealed environment" so that oxygen will not escape, which recognizes the effect of such on measuring the mass.

**Support:** The level of detail is strong—the response includes the relevant application of Dalton's law and Lavoisier's work. In addition, the response cites the formula PV = nRT, the ideal gas law, as a proper method for converting volume of gas collected to the number of moles. Further, converting the number of moles to the mass in grams by multiplying the molecular weight provides precise, high-quality detail.

**Rationale:** There is a logical, well-reasoned, and clear flow to show that mass of reactants equals mass of products.

## SECOND SAMPLE STRONG RESPONSE FOR OPEN-RESPONSE ITEM ASSIGNMENT #1

A known mass of  $KCIO_3$  will be measured and recorded. The sample will be placed in a clean stoppered test tube. A small amount of pure  $MnO_2$  should be used as a catalyst and mixed with the  $KCIO_3$  to facilitate the reaction by lowering the activation energy required. A rubber hose will be connected to a glass tube and the glass tube will be inserted into the rubber stopper. A gas bottle filled with  $H_2O$  will be inverted and placed in a water trough. The other end of the hose will be inserted into the collection bottle(s).

Carefully heat the test tube until no more bubbles appear in the collector bottle(s). After allowing the gas to cool, use Dalton's law of partial pressures to determine the pressure of oxygen gas in the bottle(s). Then use the ideal gas law, PV = nRT, to determine the n (moles of gas). Then, multiply this by the atomic weight (32) to obtain the number of grams of  $O_2$ . The mass of the KClO<sub>3</sub> should be equal to the mass of the products--KCl and  $O_2$ .

The equation representing what actually happened is:  $2KCIO_3 \rightarrow 2KCI + 3O_2$  gas.

Due to the nature of the experiment, care must be taken to have clean equipment, gentle heating, and use of pure chemicals.

## ANALYSIS FOR SECOND STRONG RESPONSE TO OPEN-RESPONSE ITEM ASSIGNMENT #1

#### This is an example of a strong response because it is characterized by the following:

**Purpose:** The response shows thorough knowledge and understanding of the topic. All parts of the assignment are clearly addressed.

**Subject Matter Knowledge:** The correct steps of the scientific method are clearly stated in an ordered manner. The use of proper equipment and procedure is demonstrated. The chemical equation is accurate. Calculations to obtain the mass of gas are straightforward and correct. A safety concern is evidenced.

**Support:** The candidate provides supporting evidence by suggesting the addition of a catalyst and including the application of the gas law.

**Rationale:** The response demonstrates sound procedures and reflects a precise understanding of the calculations needed. The degree of understanding of the topic is thorough.

## FIRST SAMPLE WEAK RESPONSE FOR OPEN-RESPONSE ITEM ASSIGNMENT #2

 $H_{3}C_{k}H_{5}O_{7}(aq) + HCO_{3}(aq) \rightarrow H_{2}C_{k}H_{5}O_{7}(aq) + H_{2}O(1) + CO_{2}(g)$ 

To propel this reaction forward, allowing the  $CO_2(g)$  to escape would help favor the products. If  $CO_2(g)$  was escaping, more products would be made to keep equilibrium. In this chemical reaction the equation is balanced, showing conservation of matter. More reactants could also be added to keep equilibrium.

#### ANALYSIS FOR FIRST WEAK RESPONSE TO OPEN-RESPONSE ITEM ASSIGNMENT #2

#### This is an example of a weak response because it is characterized by the following:

**Purpose:** The candidate's response to the first part of the assignment is that  $CO_2(g)$  should be allowed to escape and more reactants should be added. The given reaction is not a system at equilibrium, and as a result, neither of the factors cited is relevant. The second part of the assignment is not addressed since there is no explanation of reactants at a molecular level.

**Subject Matter Knowledge:** The response demonstrates some knowledge of a balanced equation and conservation of matter. However, by concentrating on equilibrium instead of the factors that affect reaction rate (temperature, reactant concentration, catalysts), the focus of the assignment is lost. Knowledge of what occurs on a molecular level is not demonstrated.

**Support:** No relevant examples of factors that increase reaction rate are cited.

**Rationale:** The response reflects no understanding of the factors that affect reaction rates and how at the molecular level these changes occur.

#### SECOND SAMPLE WEAK RESPONSE FOR OPEN-RESPONSE ITEM ASSIGNMENT #2

By heating the solution we could cause the rate of reacting to increase.

At the molecular level atoms are more attracted to each other as temperature is increased. The greater the attraction, the more products are produced. This increases the reaction rate.

The reaction rate could also be increased by adding more concentration of  $H_2O$ . Because water is a polar molecule, the atoms are more attracted.

#### ANALYSIS FOR SECOND WEAK RESPONSE TO OPEN-RESPONSE ITEM ASSIGNMENT #2

#### This is an example of a weak response because it is characterized by the following:

**Purpose:** Two changes are cited, but only an increased temperature is correct; the addition of water would actually have the reverse effect. The behavior on a molecular level is incorrect as reactions are due to random collisions, not molecular attraction.

**Subject Matter Knowledge:** While temperature will increase the reaction rate, the explanation for the way in which this affects a rate change is incorrect. The connection between increased temperature and increased kinetic energy and the frequency, strength, and orientation of collisions is not made.

**Support:** The response correctly cites temperature as a way to increase the rate of reaction. However, the response lacks additional supportive details that would demonstrate a clear understanding of the topic.

**Rationale:** The degree of understanding of the topic is limited, as evidenced by inaccuracies. The response discusses an attraction between molecules (as opposed to collisions) and the addition of water, which are both incorrect.

## FIRST SAMPLE STRONG RESPONSE FOR OPEN-RESPONSE ITEM ASSIGNMENT #2

Two changes that would increase the rate of this reaction are (1) increasing the molarity of the reactants and (2) increasing the temperature of the reactants. Both changes would allow more molecules of  $H_3C_6H_5O_7$  (aq) (citric acid) to combine with bicarbonate ions.

Increasing the molarity of the reactants allows more collision opportunities per unit of time, thus increasing the rate of the reaction. For example, by doubling molarity, the molecules of the reactants are twice as likely to encounter one another and create products. Increasing the concentration of reactants increases the reaction rate because the higher concentration increases the frequency of collisions between molecules.

Increasing the temperature of the reactants increases the molecules' Kinetic energy. As the molecules move around faster, they have a greater chance of colliding. These higher-energy collisions have more energy for bond breakage and formation. The reaction rate can therefore be increased by increasing the frequency of the collisions.

## ANALYSIS FOR FIRST STRONG RESPONSE TO OPEN-RESPONSE ITEM ASSIGNMENT #2

#### This is an example of a strong response because it is characterized by the following:

**Purpose:** Purpose is fully achieved by citing two examples that would increase reaction rate—increase in molarity and temperature. In response to the second bullet, purpose is also achieved by explaining that an increase in collision will occur by increasing temperature and/or increasing molarity.

**Subject Matter Knowledge:** There is a substantial, accurate, and appropriate application of subject matter knowledge as shown by the discussion of increasing molarity and temperature—both of which would increase the reaction rate. In addition, the response correctly identifies the formulae of citric acid and bicarbonate ions.

**Support:** The response includes relevant supporting evidence by citing two examples of changes. An increase of kinetic energy is also cited as a way of increasing the number of collisions.

**Rationale:** By showing ways to increase the number of collisions, the response demonstrates a comprehensive understanding of the topic.

## SECOND SAMPLE STRONG RESPONSE FOR OPEN-RESPONSE ITEM ASSIGNMENT #2

In this reaction, two ways to increase the reaction rate are by increasing the temperature of the reaction mixture or by adding a catalyst to the reaction mixture.

By increasing the temperature of the reaction mixture, the kinetic energy of the reactants will

increase. This will lead to more frequent and energetic collisions between  $H_3C_bH_5O_7$  and  $HCO_3^-$ . As the number and energy of collisions between the reactants increase, the likelihood that they will undergo a chemical reaction increases.

While the given reaction between  $H_{3}C_{6}H_{5}O_{7}$  and  $HCO_{3}$  may or may not involve a catalyst, in general, reaction rates can be increased by the addition of a catalyst. A catalyst does not change chemically during a reaction, but it can change the speed of a reaction between other reactants. A catalyst does this by lowering the activation energy of the reaction. A catalyst lowers the activation energy by helping the bonds in a molecule break more easily, which then allows the molecule to react with other reactants. Overall, this can help the reaction speed up.

#### ANALYSIS FOR SECOND STRONG RESPONSE TO OPEN-RESPONSE ITEM ASSIGNMENT #2

#### This is an example of a strong response because it is characterized by the following:

**Purpose:** The purpose of the assignment is fully achieved. The response accurately cites two ways in which reaction rates can be increased—by increasing temperature or by adding a catalyst. The response correctly describes how, at the molecular level, a change in temperature or a catalyst leads to an increase in the reaction rate.

**Subject Matter Knowledge:** There is accurate and appropriate application of subject matter knowledge as demonstrated by discussion of the effects of increasing temperature on the kinetic energy of the reactants and their movements. The description of the nature and role of catalysts in chemical reactions is accurate.

**Support:** The response includes relevant supporting evidence by citing two accurate examples of ways to increase reaction rate. Details about how temperature affects the kinetic energy of molecules and how catalysts function are provided.

**Rationale:** The response is concise and accurate and addresses all parts of the assignment in a well-reasoned and logical manner.

## PRACTICE TEST SCORE CALCULATION

The practice test score calculation is provided so that you may better gauge your performance and degree of readiness to take an MTEL test at an operational administration. Although the results of this practice test may be used as one indicator of potential strengths and weaknesses in your knowledge of the content on the official test, it is not possible to predict precisely how you might score on an official MTEL test.

The Sample Responses and Analyses for the open-response items may help you determine whether your responses are more similar to the strong or weak samples. The Scoring Rubric can also assist in estimating a score for your open responses. You may also wish to ask a mentor or teacher to help evaluate your responses to the open-response questions prior to calculating your total estimated score.

#### How to Calculate Your Practice Test Score

Review the directions in the sample below and then use the blank practice test score calculation worksheet on the following page to calculate your estimated score.

SAMPLE		
Multiple-Choice Section		
Enter the total number of multiple-choice questions you answered correctly:	<u>77</u>	
Use Table 1 below to convert that number to the score and write your score in <b>Bo</b>	<b>x A</b> :	<b>A:</b> 194

Open-Response Section				
Enter the number of points (1 to 4) for your first open-response question:	<u>3</u>			
Enter the number of points (1 to 4) for your second open-response question:	<u>3</u>			
Add those two numbers (Number of open-response question points):	6			
Use Table 2 below to convert that number to the score and write your score in I	В:	48		
Total Practice Test Score (Estimated MTEL Score)				

Add the numbers in **Boxes A and B** for an estimate of your MTEL score: A + B =242
A:

B:

A + B =

======

Table 1:		Table 2:					
Number of	Estimated		Number of	Estimated		Number of	Estimated
Multiple-Choice	MTEL		Multiple-Choice	MTEL		Open-Response	MTEL
Questions Correct	<u>Score</u>		Questions Correct	<u>Score</u>		Question Points	Score
0 to 25	80		61 to 65	163		2	24
26 to 30	90		66 to 70	173		3	30
31 to 35	100		71 to 75	184		4	36
36 to 40	111		76 to 80	194		5	42
41 to 45	121		81 to 85	205		6	48
46 to 50	131		86 to 90	215		7	54
51 to 55	142		91 to 95	225		8	60
56 to 60	152		96 to 100	236			

## Practice Test Score Calculation Worksheet: Chemistry

Print the form below to calculate your estimated practice test score.

## Multiple-Choice Section

Enter the total number of multiple-choice questions you answered correctly:

Use Table 1 above to convert that number to the score and write your score in **Box A**:

## **Open-Response Section**

Enter the number of points (1 to 4) for your first open-response question:

Enter the number of points (1 to 4) for your second open-response question:

Add those two numbers (Number of open-response question points):

Use Table 2 above to convert that number to the score and write your score in **Box B**:

## Total Practice Test Score (Estimated MTEL Score)

Add the numbers in **Boxes A and B** for an estimate of your MTEL score: