



CHEMISTRY TEST



Note: For all questions involving solutions, assume that the solvent is water unless otherwise stated.

Throughout the test the following symbols have the definitions specified unless otherwise noted.

H	= enthalpy
M	= molar
n	= number of moles
P	= pressure
R	= molar gas constant
S	= entropy
T	= temperature
V	= volume

atm	= atmosphere(s)
g	= gram(s)
J	= joule(s)
kJ	= kilojoule(s)
L	= liter(s)
mL	= milliliter(s)
mm	= millimeter(s)
mol	= mole(s)
V	= volt(s)

Part A

Directions: Each set of lettered choices below refers to the numbered statements or questions immediately following it. Select the one lettered choice that best fits each statement or answers each question and then fill in the corresponding circle on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1-4 refer to the elements for which the ground-state electron configurations are shown below.

- (A) $1s^2 2s^1$
- (B) $1s^2 2s^2$
- (C) $1s^2 2s^2 2p^2$
- (D) $1s^2 2s^2 2p^5$
- (E) $1s^2 2s^2 2p^6$

1. The configuration of the element with the largest second ionization energy
2. The configuration of the element whose atoms are most likely to form four covalent bonds
3. The configuration of the element most likely to form diatomic molecules of the form X_2
4. The configuration of the element that exists as single gaseous atoms at 0°C and 1 atm

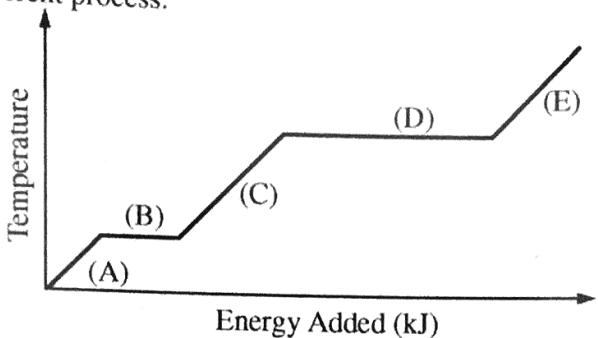
Questions 5-7 refer to the following.

- (A) White precipitate
 - (B) Blue precipitate
 - (C) Orange precipitate
 - (D) Gas bubbles
 - (E) No change
5. Observed when concentrated hydrochloric acid is added to calcium carbonate
 6. Observed when sodium sulfate solution is added to barium chloride solution
 7. Observed when sodium chloride solution is added to potassium nitrate solution



CHEMISTRY TEST—Continued

Questions 8–10 are based on the following heating curve for a pure substance. The substance begins as a solid and ends as a gas; each segment represents a different process.

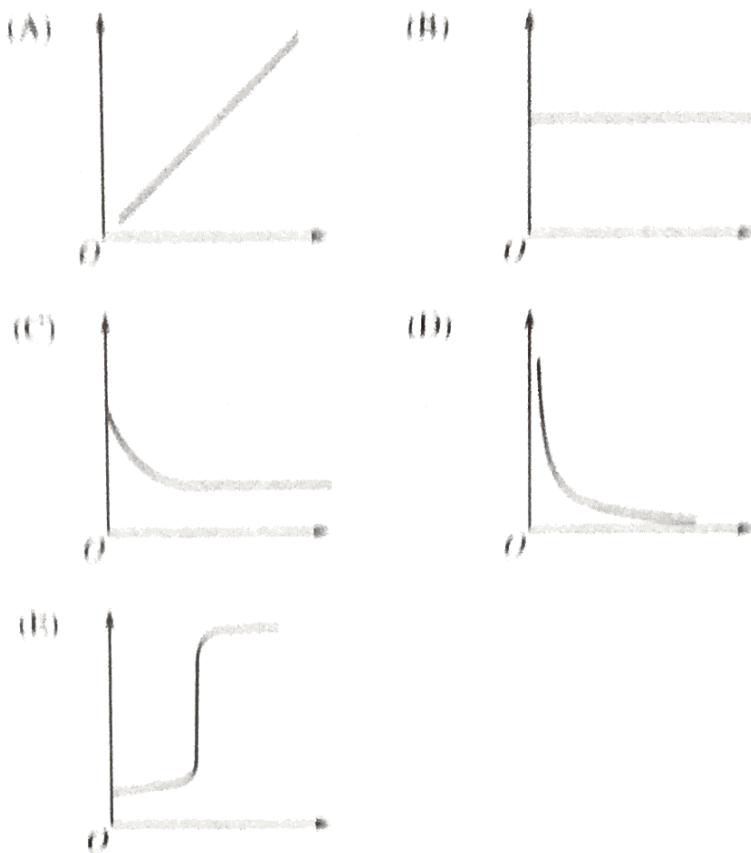


8. Boiling
9. Melting
10. A gas is heated.



CHEMISTRY TEST—Continued

Questions 11–14 refer to the following graphs.



11. Which graph could represent the pH of a 0.1 M solution of nitric acid *versus* the volume of a 0.1 M solution of sodium hydroxide that is added to it?
12. Which graph could represent the concentration of one reactant *versus* time as a reaction approaches and reaches equilibrium?
13. Which graph could represent the pressure of a sample of an ideal gas *versus* its absolute temperature at constant volume?
14. Which graph could represent the product of pressure times volume, PV , for an ideal gas *versus* its pressure at constant temperature?



CHEMISTRY TEST—Continued

Questions 15-17 refer to the following types of substances.

- (A) Hydride
- (B) Halide
- (C) Hydroxide
- (D) Hydrate
- (E) Hydrocarbon

15. A crystalline substance in which water is one of the structural units

16. A compound that contains only a metal and hydrogen

17. An organic compound

Questions 18-19 refer to the following substances at room temperature.

- (A) CO_2
- (B) N_2O
- (C) NO_2
- (D) SiO_2
- (E) CaO

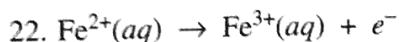
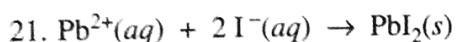
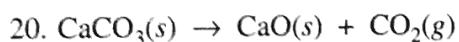
18. Is an ionic solid

19. Is a gas in which each molecule has an unpaired electron

Questions 20-22

- (A) Oxidation
- (B) Decomposition
- (C) Precipitation
- (D) Acid-base
- (E) Reduction

Which of the above best describes the reaction represented by each of the following equations?



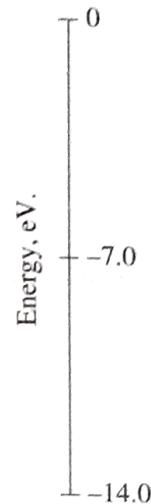
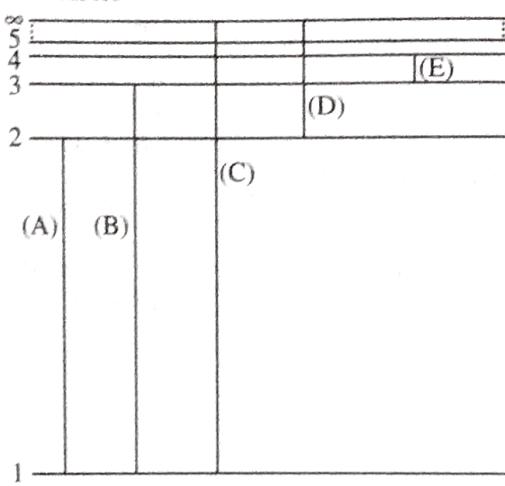


CHEMISTRY TEST—Continued



Questions 23–25 refer to the following energy diagram.

Principal
Quantum Numbers



The diagram above is a plot of the energy levels for the electron of the hydrogen atom (roughly to scale) according to the Bohr theory. The vertical lines represent possible transitions (increases or decreases of energy) that can occur.

23. The transition from the ground state to the first excited state of hydrogen
24. Of the transitions shown, the one that involves the LEAST energy
25. The transition that represents the ionization energy of hydrogen

PLEASE GIVE
OF THE PAPER
QUESTION

Directions:
column. For each question, choose the best answer and fill in the corresponding letter in the space provided. Then write your explanation on the back of this page.

101. The volume of a gas increases when the temperature
102. A 1 M solution of sulfuric acid has a pH of
103. H_2S is a(n) _____
104. In its group, potassium has more electrons than does a potassium atom because it has
105. Liquid nitrogen is used to freeze

106. Metallurgy is the study of
107. Acetic acid is found in



CHEMISTRY TEST—Continued

PLEASE GO TO THE SPECIAL SECTION AT THE LOWER LEFT-HAND CORNER OF THE PAGE OF THE ANSWER SHEET YOU ARE WORKING ON AND ANSWER QUESTIONS 101-115 ACCORDING TO THE FOLLOWING DIRECTIONS.

Part B

Directions: Each question below consists of two statements, I in the left-hand column and II in the right-hand column. For each question, determine whether statement I is true or false and whether statement II is true or false and fill in the corresponding T or F circles on your answer sheet. Fill in circle CE only if statement II is a correct explanation of the true statement I.

EXAMPLES:

I

II

- EX 1.** H_2SO_4 is a strong acid BECAUSE H_2SO_4 contains sulfur.
- EX 2.** An atom of oxygen is electrically neutral BECAUSE an oxygen atom contains an equal number of protons and electrons.

SAMPLE ANSWERS

	I	II	CE*
EX1	● (F)	● (F)	○
EX2	● (F)	● (F)	●

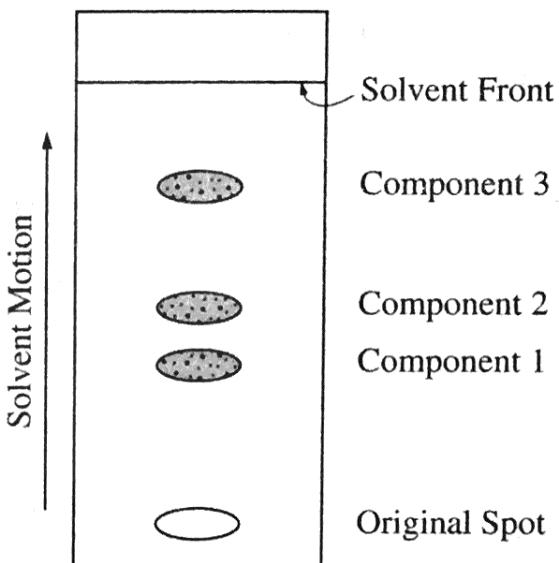
I

II

101. The volume of a gas at constant pressure increases with increasing temperature BECAUSE the average speed of gas molecules decreases with increasing temperature.
102. A 1 M solution of sodium hydroxide has a high pH BECAUSE solutions with a high H^+ concentration have a high pH.
103. H_2S is a polar substance BECAUSE H_2S is a gas at room temperature.
104. In its ground state, a magnesium atom has more electrons in its outer shell than does a potassium atom BECAUSE the total number of electrons in a magnesium atom is greater than the total number of electrons in a potassium atom.
105. Liquid water in an open container evaporates BECAUSE some molecules at the surface of liquid water in an open container have enough kinetic energy to overcome intermolecular attractions.
106. Metallic copper is an electrical conductor BECAUSE in metallic copper, the atoms of copper are covalently bonded.
107. Acetic acid, $\text{HC}_2\text{H}_3\text{O}_2$, is a stronger acid than sulfuric acid BECAUSE acetic acid has more hydrogen atoms in its molecular structure than does sulfuric acid.

108. Under identical conditions, $\text{N}_2(g)$ is more chemically reactive than $\text{O}_2(g)$
109. To prepare a 1 M solution of chloride ions from CaCl_2 (molar mass 110 g/mol), 110 g of CaCl_2 should be dissolved in 1 L of solution
110. The first ionization energy of K is greater than that of Li
111. Catalysts increase the rates of chemical reactions

- BECAUSE the $\text{N}_2(g)$ molecule has a single bond and the $\text{O}_2(g)$ molecule has a double bond.
- BECAUSE each mole of CaCl_2 dissolves to produce 1 mol of chloride ions.
- BECAUSE the Li atom has a smaller radius than the K atom.
- BECAUSE the activation energy of a reaction is lowered by a catalyst for the reaction.



112. In the paper chromatography experiment represented above, component 1 moved up fastest
113. The boiling point of water, H_2O , is much higher than that of methane, CH_4 ,

BECAUSE in the paper chromatography experiment represented above, component 1 moved a shorter distance up the paper than component 2 or 3 did.

BECAUSE the molar mass of water is greater than that of methane.



114. For the reaction represented by the equation above, the entropy increases as the products form
115. At 25°C, the average speed of $\text{H}_2(g)$ molecules is less than the average speed of $\text{O}_2(g)$ molecules

BECAUSE in the reaction represented above, there are more moles of products than of reactants.

BECAUSE at 25°C, the average kinetic energy of $\text{H}_2(g)$ molecules is less than the average kinetic energy of $\text{O}_2(g)$ molecules.

RETURN TO THE SECTION OF YOUR ANSWER SHEET YOU STARTED FOR CHEMISTRY AND ANSWER QUESTIONS 26-70.

Part C

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.

26. The oxidation number of S in SO_3 is

- (A) +2
- (B) +3
- (C) +4
- (D) +5
- (E) +6



27. How many moles of water would be produced if 11.0 g of propane (molar mass 44 g/mol) were burned completely to carbon dioxide and water according to the equation represented above?

- (A) 1.0 mol
- (B) 2.0 mol
- (C) 3.0 mol
- (D) 4.0 mol
- (E) 5.0 mol



28. Which of the following is true of the reaction represented above?

- (A) $\text{Zn}(s)$ is the oxidizing agent.
- (B) $\text{Ag}^+(aq)$ is the oxidizing agent.
- (C) $\text{Zn}(s)$ is reduced.
- (D) $\text{Ag}^+(aq)$ is oxidized.
- (E) A mole of electrons is transferred for each 0.5 mol of $\text{Ag}(s)$ produced.



29. When the equation for the reaction represented above is balanced with all the coefficients reduced to the lowest whole-number terms, the coefficient for $\text{O}_2(g)$ is

- (A) 1
- (B) 2
- (C) 3
- (D) 4
- (E) 6

30. When 0.0025 mol of HCl and 0.0035 mol of NaOH are added to water to make 1 L of solution, the pH of the resulting solution is approximately

- (A) 1
- (B) 3
- (C) 7
- (D) 11
- (E) 14

31. Which of the following molecules is polar?

- (A) Cl_2
- (B) C_2H_6
- (C) NH_3
- (D) CO_2
- (E) CCl_4

32. An atom of which of the following elements has the greatest number of valence electrons?

- (A) Iodine
- (B) Arsenic
- (C) Barium
- (D) Oxygen
- (E) Carbon

33. Which of the following contains the greatest number of atoms?

- (A) 1.0 g of Fe
- (B) 1.0 g of U
- (C) 1.0 g of Li
- (D) 1.0 g of S
- (E) 1.0 g of C

34. What is the maximum mass of Al (molar mass 27 g/mol) that can be obtained from 20.4 g of pure Al_2O_3 (molar mass 102 g/mol)?

- (A) 2.70 g
- (B) 5.40 g
- (C) 8.10 g
- (D) 10.8 g
- (E) 16.3 g



CHEMISTRY TEST—Continued

35. Of the following solutions, which has the highest boiling point?

- (A) 0.1 M sucrose, $C_{12}H_{22}O_{11}$
- (B) 0.1 M acetic acid, $HC_2H_3O_2$
- (C) 0.1 M NaCl
- (D) 0.1 M $CaCl_2$
- (E) 0.1 M $AlCl_3$



36. Which of the following is likely to have the smallest effect on the equilibrium concentrations of reactants and products in the gas-phase reaction represented above?

- (A) Decreasing the temperature of the system by $25^{\circ}C$
- (B) Decreasing the volume of the system by half
- (C) Removing one of the products of the reaction from the system
- (D) Doubling the amount of one of the reactants in the system
- (E) Adding a small amount of a catalyst for the reaction to the system

37. Of the following, the conditions under which the molar volume of gaseous helium is greatest are

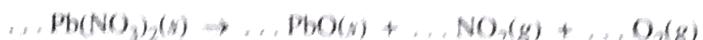
- (A) 237 K and 1 atm
- (B) 300 K and 1 atm
- (C) 400 K and 1 atm
- (D) 500 K and 2 atm
- (E) 600 K and 2 atm

38. How many grams of $RbNO_3$ (molar mass 147 g/mol) are required to produce 0.500 L of a 0.200 M $RbNO_3$ solution?

- (A) 73.5 g
- (B) 29.6 g
- (C) 14.7 g
- (D) 2.96 g
- (E) 1.47 g

39. SiO_2 has a high melting point because its solid state structure is

- (A) ionic
- (B) metallic
- (C) hydrogen bonded
- (D) nonpolar covalent molecular
- (E) covalent network



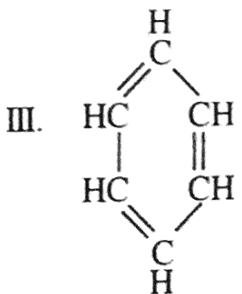
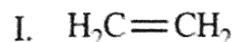
40. When the equation above is balanced and all coefficients are reduced to lowest whole-number terms, the coefficient for $NO_2(g)$ is

- (A) 2
- (B) 4
- (C) 6
- (D) 8
- (E) 10

of water at 7°C is 1.00 g/mL.)

- (A) 0.79 g/mL
- (B) 1.0 g/mL
- (C) 1.3 g/mL
- (D) 2.1 g/mL
- (E) 3.3 g/mL

43. Compounds that have the empirical formula CH include which of the following?



- (A) I only
- (B) III only
- (C) I and II only
- (D) II and III only
- (E) I, II, and III

46. A sample of $\text{H}_2(g)$ is stored in a 0.500 L vessel at 90.0 torr and 300. K. The gas is transferred to a 1.50 L vessel at constant temperature. Which of the following statements about the gas is correct?

- (A) The number of moles of $\text{H}_2(g)$ increases.
- (B) The number of moles of $\text{H}_2(g)$ decreases.
- (C) The pressure of the $\text{H}_2(g)$ increases to 270. torr.
- (D) The pressure of the $\text{H}_2(g)$ decreases to 30.0 torr.
- (E) The pressure of the $\text{H}_2(g)$ remains unchanged.

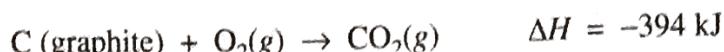
47. How many moles of $\text{O}_2(g)$ are formed when a 6.0 mol sample of $\text{KClO}_3(s)$ decomposes completely to produce $\text{O}_2(g)$ and $\text{KCl}(s)$?

- (A) 1.5 mol
- (B) 3.0 mol
- (C) 6.0 mol
- (D) 9.0 mol
- (E) 12 mol

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CHEMISTRY TEST—Continued



48. On the basis of the information above, what is the change in enthalpy, ΔH , for the following reaction?



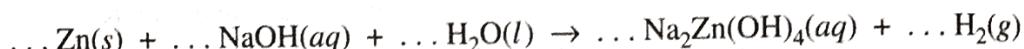
(A) -790 kJ

(B) -4 kJ

(C) -2 kJ

(D) +2 kJ

(E) +790 kJ



49. When the equation above is balanced and all coefficients are reduced to lowest whole-number terms, the coefficient for $\text{H}_2\text{O}(l)$ is

(A) 1

(B) 2

(C) 3

(D) 4

(E) 5



CHEMISTRY TEST—Continued

50. Which of the following best describes the type of bonding between iodine atoms in a molecule of I_2 ?

- (A) Ionic bonding
- (B) Metallic bonding
- (C) Hydrogen bonding
- (D) Covalent bonding
- (E) Dispersion (London) force interactions

51. When Na_2SO_4 dissolves in water, which of the following species is present in the greatest concentration in the solution?

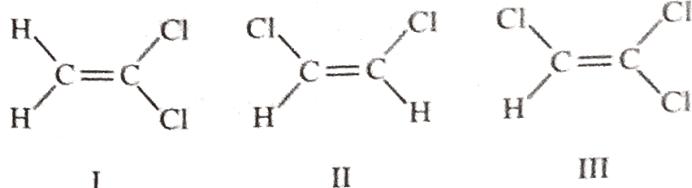
- (A) $Na^+(aq)$
- (B) $Na_2SO_4(aq)$
- (C) $SO_4^{2-}(aq)$
- (D) $S^{2-}(aq)$
- (E) $O^{2-}(aq)$

52. Which of the following statements is true of a solution of $0.10\text{ M } HCl(aq)$?

- (A) The pH is 1.
- (B) The concentration of $Cl^-(aq)$ is greater than the concentration of $H^+(aq)$.
- (C) The concentration of $Cl^-(aq)$ is equal to the concentration of $OH^-(aq)$.
- (D) The concentration of $H^+(aq)$ is equal to the concentration of $OH^-(aq)$.
- (E) The indicator phenolphthalein turns pink when added to the acid solution.

53. The half-life for the radioactive decay of $^{239}_{94}Pu$ is 25,000 years. If 100. g of $^{239}_{94}Pu$ are present initially, how many grams of $^{239}_{94}Pu$ will remain after 50,000 years?

- (A) 100. g
- (B) 50.0 g
- (C) 25.0 g
- (D) 12.5 g
- (E) 0.000 g



54. Which of the formulas above represent isomers of one another?

- (A) None
- (B) I and II only
- (C) I and III only
- (D) II and III only
- (E) I, II, and III

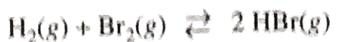
55. Which of the following is always characteristic of an oxidizing agent?

- (A) It contains oxygen.
- (B) It is soluble in water.
- (C) It contains a transition element.
- (D) It can be reduced.
- (E) It forms an ionic lattice.

56. Which of the following statements about a liquid that evaporates readily at room temperature is correct?

- (A) It has strong intermolecular forces.
- (B) It has a high vapor pressure.
- (C) It is considered to be nonvolatile.
- (D) It would make its container feel warm to the touch.
- (E) It should be stored in an open container.

CHEMISTRY TEST—Continued



57. Which of the following is an appropriate expression for the equilibrium constant of the reaction represented above?

(A) $K_c = \frac{[\text{H}][\text{Br}]}{[\text{HBr}]}$

(B) $K_c = \frac{[\text{H}_2][\text{Br}_2]}{[\text{HBr}]}$

(C) $K_c = \frac{[\text{HBr}]}{[\text{H}_2][\text{Br}_2]}$

(D) $K_c = \frac{[\text{HBr}]^2}{[\text{H}_2][\text{Br}_2]}$

(E) $K_c = \frac{[\text{HBr}]^2}{[\text{H}]^2[\text{Br}]^2}$

58. Atoms with high first ionization energies always have

- (A) relatively tightly bound outermost electrons
 (B) multiple oxidation states
 (C) low electronegativities
 (D) large atomic radii
 (E) distinctly metallic properties

59. Substances that can act both as an acid and as a base in aqueous solution include which of the following?

I. Cl^-

II. HSO_4^-

III. CO_3^{2-}

- (A) I only
 (B) II only
 (C) III only
 (D) I and II only
 (E) II and III only



60. When the combustion reaction represented by the equation above is balanced using the lowest whole-number coefficients, what is the coefficient of $\text{O}_2(g)$?

(A) 2

(B) 3

(C) 4

(D) 5

(E) 6

CHEMISTRY TEST—Continued

61. When 28 g of Fe reacts as completely as possible with 8.0 g of S to form FeS, which of the following is true?

- (A) Approximately 4.0 g of S remains unreacted.
- (B) Approximately 14 g of Fe remains unreacted.
- (C) Approximately equal masses of Fe and S react.
- (D) Approximately 27 g of FeS is produced.
- (E) Approximately 36 g of FeS is produced.

62. A 9.0 g sample of liquid water has which of the following?

- I. 1.0 mol of hydrogen atoms
 - II. 8.5 g of oxygen
 - III. A volume of 11.2 L at standard temperature and pressure
- (A) I only
 - (B) II only
 - (C) III only
 - (D) I and II only
 - (E) I, II, and III

63. How much energy is required to heat 100. g of H₂O from 20.0°C to 40.0°C? (The specific heat of H₂O(l) is 4.18 J/(g·°C).)

- (A) 93.6 J
- (B) 482 J
- (C) 2,000 J
- (D) 4,180 J
- (E) 8,360 J

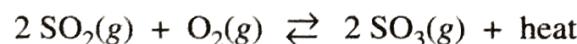
64. If a student were to accurately analyze a mixture of solid NaCl and solid NaOH by titration of the hydroxide ion with a standardized solution of HCl, which of the following would be LEAST useful?

- (A) Bunsen burner
- (B) Analytical balance
- (C) Buret
- (D) Erlenmeyer flask
- (E) Indicator



65. According to the equation for the reaction represented above, what is ΔH for the production of 0.100 mol of HCl(g)?

- (A) -37.0 kJ
- (B) -18.5 kJ
- (C) -9.25 kJ
- (D) +9.25 kJ
- (E) +18.5 kJ



66. For the system represented above, which of the following actions will shift the position of equilibrium to the left?

- (A) Increasing the pressure
- (B) Increasing the temperature
- (C) Putting the mixture in a smaller container
- (D) Adding some O₂(g)
- (E) Removing some SO₃(g)

67. When Na(s) reacts with excess H₂O(l), products of the reaction include which of the following?

- I. Na⁺(aq)
- II. OH⁻(aq)
- III. H₂(g)

- (A) I only
- (B) III only
- (C) I and II only
- (D) I and III only
- (E) I, II, and III

68. When the following air pollutants are present in small amounts, which is LEAST hazardous to humans?

- (A) Ammonia, NH₃
- (B) Carbon dioxide, CO₂
- (C) Sulfur dioxide, SO₂
- (D) Nitrogen dioxide, NO₂
- (E) Hydrogen sulfide, H₂S



CHEMISTRY TEST—Continued

69. A compound containing only carbon and hydrogen is found to have a molar mass of 100 g/mol and to consist of 16 percent hydrogen by mass. The number of carbon atoms in one molecule of the compound is

- (A) 1
- (B) 3
- (C) 4
- (D) 6
- (E) 7

70. A 21 g sample of $\text{NaF}(s)$ (molar mass 42 g/mol) is dissolved in enough water to yield 2.0 L of solution. What is the molar concentration of $\text{Na}^+(aq)$?

- (A) 0.010 M
- (B) 0.050 M
- (C) 0.10 M
- (D) 0.25 M
- (E) 0.50 M

S T O P

**IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS TEST ONLY.
DO NOT TURN TO ANY OTHER TEST IN THIS BOOK.**