

ANSWERS TO DIAGNOSTIC TEST

MULTIPLE-CHOICE ANSWERS

Using the table below, score your test.

Determine how many questions you answered correctly and how many you answered incorrectly. You will find explanations of the answers on the following pages.

1. A	2. D	3. B	4. A	5. B
6. C	7. E	8. B	9. C	10. A
11. E	12. A	13. C	14. B	15. A
16. A	17. A	18. A	19. A	20. A
21. E	22. D	23. C	24. A	25. B
26. A	27. A	28. A	29. E	30. D
31. D	32. A	33. C	34. C	35. C
36. A	37. E	38. B	39. C	40. E
41. A	42. C	43. A	44. A	45. B
46. B	47. B	48. C	49. E	50. A
51. B	52. D	53. A	54. B	55. B
56. B	57. E	58. C	59. C	60. E
61. A	62. C	63. E	64. A	65. C
66. C	67. E	68. E	69. D	70. B
71. A	72. D	73. A	74. A	75. E

CALCULATE YOUR SCORE:

Number answered correctly: _____

Adjust $\frac{1}{4}$ point for guessing penalty: _____

Count the number of questions you

answered incorrectly, multiply by .25, and subtract: - _____

Determine your adjusted score: _____

WHAT YOUR SCORE MEANS:

Each year, since the test is different, the scoring is a little different. But generally, if you scored 25 or more on the multiple-choice questions, you'll most likely get a 3 or better on the test. If you scored 35 or more, you'll probably score a 4 or better. And if you scored a 50 or more, you'll most likely get a 5. Keep in mind that the multiple-choice section is worth 45% of your final grade, and the free-response section is worth 55% of your final grade. To learn more about the scoring for the free-response questions, turn to the last page of this section.

ANSWERS AND EXPLANATIONS

MULTIPLE-CHOICE ANSWERS

1. ANSWER: A

2. ANSWER: D

3. ANSWER: B

In questions like 1, 2 and 3, it is helpful to consider what you do know about each of the listed responses. In this case you know that chromium is a transition element which suggests that the ion is capable of being multicharged. Transition metals are frequently colored in compounds. You might recall the polyatomic ion list which includes CrO_4^{2-} (chromate ion) and $\text{Cr}_2\text{O}_7^{2-}$ (dichromate ion). Sodium, like all of the alkali metals, reacts with water to form hydrogen. You have most likely seen this reaction demonstrated in your classroom. Recall also that the oxides of metals form water solutions of hydroxide ions (bases), whereas the oxides of nonmetals form acidic solutions. Note also that an answer can be used more than once in this type of question (*Chemistry* 6th ed. pages 324–335, 619, 986–998 / 7th ed. pages 309–318, 588, 943–955).

4. ANSWER: A

5. ANSWER: B

6. ANSWER: C

7. ANSWER: E

The term *descriptive chemistry* hides much information that you “just must know.” Of course there is so much of it that it is essential to get some direction on what things are paramount. This includes knowing the six strong acids, the common solubility rules, the colors of several ions (usually encountered in your laboratory work), which ions tend to complex, and a few very specific properties. Knowing that hydrofluoric acid, although a weak acid, will dissolve (etch) glass and that carbon dioxide will not support combustion, are examples of properties that a well-educated chemist—that’s you!—is expected to know (*Chemistry* 6th ed. pages 657–662, 148–156, 998–1003 / 7th ed. pages 626–631, 140–148, 955–959).

8. ANSWER: B Increasing the $[\text{Ag}^+]$ will cause a shift toward products, causing an increase in the potential difference of this cell. This would, over time, cause an increase in the concentration of copper (II) ions, making the blue of the copper (II) ions darker. You could also consider this from the Nernst equation. In that case, as $[\text{Ag}^+]$ is increased, $[\text{Cu}^{2+}]/[\text{Ag}^+]^2 < 1$ such that $\log Q$ is a negative number. Subtracting a negative number from the standard potential then

gives a larger cell potential (*Chemistry* 6th ed. pages 841–846 / 7th ed. pages 803–808).

9. ANSWER: C By definition the anode is the site of oxidation. Oxidation is the loss of electrons. Copper must lose two electrons to become copper (II) ions. Half-reactions involving a decrease in positive charge, like responses (B) and (E), require a gain of electrons (*Chemistry* 6th ed. pages 828–837 / 7th ed. pages 791–800).
10. ANSWER: A It is necessary for the reactants to gain enough energy to form the activated complex; the difference in the energy of the reactants and the activated complex is called the activation energy [Section 12.7, especially Figure 12.11]. Of course, both hydrogen and oxygen have already vaporized; they exist as gases at room conditions. Enthalpy change represents the difference in energy between the reactants and the products (at constant pressure) [Section 6.2], Entropy change represents the change in the disorder from reactants to products (*Chemistry* 6th ed. pages 582–588 esp. Figure 12.11, 248–256, 790 / 7th ed. pages 552–557 esp. Figure 12.11, 235–242, 755).
11. ANSWER: E This is a very straightforward use of the chemical formula and your understanding of moles. Since there are two moles of silver atoms per formula unit of silver sulfide, there are twice as many moles of silver atoms as moles of formula units of the silver sulfide. You can also quickly see that the grams formed would be about 0.4 g if you recall that silver has an atomic mass of about 108 g/mol (*Chemistry* 6th ed. pages 86–90 / 7th ed. pages 82–85).
12. ANSWER: A Some flame colors which you should know include lithium: bright red; sodium: pale-yellow; potassium: violet; rubidium: purple; cesium: blue; calcium: orange-red; strontium: crimson-red; and barium: yellowish-green (*Chemistry* 6th ed. pages 297–299 / 7th ed. pages 284–285).
13. ANSWER: C “*R*” is the general gas constant and applies as long as the gas behaves ideally. This means that the value of “*R*” and the expression $PV = nRT$ must be adjusted in the nonideal conditions of high temperature and/or low pressure [Section 5.8]. That is what the van der Waals equation is all about. The gas laws are based on Kelvin temperature change (not Celsius), since Kelvin is an index of the motion of the gas particles. The value of PV/nRT for ideal gases is 1 (*Chemistry* 6th ed. pages 222–224 / 7th ed. pages 208–210).
14. ANSWER: B Freezing temperature depression is directly related to the number of particles (in this case, ions) in solutions. Since AlCl_3 provides four ions per formula unit, the higher concentration of ions for that salt would cause a greater freezing-temperature lowering (*Chemistry* 6th ed. pages 531–535 / 7th ed. pages 504–507).

15. ANSWER: A Both CaO and MgO are ionically bonded. Both involve oxygen; therefore the difference in melting temperatures must be due to the difference in attraction developed by Mg compared to that of Ca. Both are 2+ ions, but magnesium ions are smaller, meaning that the charge is more concentrated in the Mg^{2+} ion. The combination of charge and size factors, called the charge density, affects the force of attraction that the ion has; ionic charge / ionic radius = charge density (*Chemistry* 6th ed. pages 324–335 / 7th ed. pages 309–318).
16. ANSWER: A The 'general formulas' for these common organic molecules are R–OH—alcohol; R–C=O–H—aldehydes; R–C=O–OH—carboxylic acids; R–C=O–R'—ketones; R–C=O–OH—esters (*Chemistry* 6th ed. pages 1052–1064 esp. Table 22.4 / 7th ed. pages 1005–1016 esp. Table 22.4).
17. ANSWER: A The reaction forms $\text{BaSO}_4(\text{s})$ which means that ions are removed from solution, thereby making the solution less conductive. However, continued addition of the acid causes the conductivity to increase again with the excess of ions (*Chemistry* 6th ed. pages 148–154 / 7th ed. pages 140–145).
18. ANSWER: A The Law of Multiple Proportions is illustrated by two elements which form at least two compounds. It then compares the ratios of the masses of one element with a constant mass of the other element in the two (or more) compounds. These ratios always reduce to simple whole numbers (*Chemistry* 6th ed. pages 43–46 / 7th ed. pages 41–43).
19. ANSWER: A In addition to remembering Rutherford for his work with the nucleus, recall Thomson for his work with the electron, Dalton for an early model of the atom, Boyle for the gas law dealing with volume and pressure, and Lavoisier for the conservation of mass in chemical reactions (*Chemistry* 6th ed. pages 42–53 / 7th ed. pages 39–49).
20. ANSWER: A Isotopes are found for every element and differ from each other in mass for the same element due only to a different number of neutrons in the nucleus (*Chemistry* 6th ed. pages 53–56, 81–85 / 7th ed. pages 49–52, 77–81).
21. ANSWER: E Begin by determining the formula for iron (II) phosphate: $\text{Fe}_3(\text{PO}_4)_2$. From this you can see that there are two phosphate ions with four oxygens in each, for a total of 8 moles of oxygen for each unit of $\text{Fe}_3(\text{PO}_4)_2$ (*Chemistry* 6th ed. pages 62–72 / 7th ed. pages 57–67).
22. ANSWER: D When solving K_{sp} problems, first write the equation with the solid on the left and the ions on the right: $\text{MgF}_2(\text{s}) \rightleftharpoons \text{Mg}^{2+}(\text{aq}) + 2\text{F}^{-}(\text{aq})$. If s represents the mol/L of the solid that goes into solution, $[\text{Mg}^{2+}]$ also equals s , and $2s$ represents the $[\text{F}^{-}]$. Next write the K_{sp} expression in terms of s : $K_{\text{sp}} = (s)(2s)^2 = 4s^3 =$

6.4×10^{-9} . Solve for s (*Chemistry* 6th ed. pages 751–754 / 7th ed. pages 717–719).

23. ANSWER: C A good clue as to the type of titration curve is the position of the equivalence point, which is the center of the vertical section of the graph showing the very rapid change of pH. In this case, that is in the basic region (above 9). At this point, the amount of added OH^- equals the original amount of acid. The pH exceeds 7 (neutral) due to the hydrolysis of the anion from the acid (*Chemistry* 6th ed. pages 729–730, 733–741 / 7th ed. pages 696–697, 700–707).
24. ANSWER: A The leveling-off shown between F and G is caused by buffering. Optimal buffering occurs when $[\text{HA}] = [\text{A}^-]$, which would be at a volume of 25 mL of base in this case (*Chemistry* 6th ed. pages 726–727, 733–741 / 7th ed. pages 693–694, 700–707).
25. ANSWER: B The systematic naming system, the Stock Nomenclature, uses Roman numerals only for transition elements whose ions display more than one charge (e.g., Cu^{2+} is called copper (II) ion, and Cu^+ is known as copper (I) ion). Calcium is not a transition element; it is found only as a 2+ ion. OCl^- is the hypochlorite ion (*Chemistry* 6th ed. pages 62–72 esp. Table 2.5 / 7th ed. pages 57–67 esp. Table 2.5).
26. ANSWER: A Lone pairs of electrons (unbonded pairs) are less associated with the attractive forces of positive nuclei, therefore will occupy more space than bonded pairs (*Chemistry* 6th ed. pages 392–393 / 7th ed. pages 369–371).
27. ANSWER: A Acids which contain oxygen often give students some difficulty. These names are formed from the root name of the anion with a suffix of -ic or -ous. The -ous form always contains one less oxygen than the -ic form. For example, H_2SO_4 is sulfuric acid and H_2SO_3 is sulfurous acid (*Chemistry* 6th ed. Tables 2.7, 2.8, and Figure 2.25 on page 72 / 7th ed. Tables 2.7, 2.8, and Figure 2.25 on page 67).
28. ANSWER: A Before reaction, no combination of NH_3 and Ag^+ has formed; the silver nitrate is found as ions, the ammonia is molecular, and water is also present (*Chemistry* 6th ed. pages 766–769 / 7th ed. pages 731–734).
29. ANSWER: E The low value for K_a , indicates that H_3PO_4 is a weak acid. The three values suggest three steps in dissociation. The large differences in these K_a values indicate that only step 1 will provide a significant $[\text{H}^+]$ (*Chemistry* 6th ed. pages 682–687, 715 / 7th ed. pages 650–655, 682–683).
30. ANSWER: D Significant figures is a method of indicating to others how accurately you have measured a value; all measured values have some uncertainty in the measurement, (another method is to show the measured value followed by a \pm value which indicates

how precisely you have measured or how much the measurement is limited by the equipment you have used to obtain it). All of the numerals are significant here. It is the zero which can be difficult. If this value were known only to the nearest 1 mL then it would be correctly written as 22. mL; since 22.00 mL were recorded there must have been a reason to record the values in the tenths and hundredths places. The reason is that the measurement was taken to the hundredths of a mL (*Chemistry* 6th ed. pages 524–531 / 7th ed. pages 497–504).

31. ANSWER: D The average is found by totaling the five readings. When adding (or subtracting), examine the position of the decimal point. In this case, all five values are known to the nearest thousandth, so the total can be known to the nearest thousandths. When this total is divided by five (an exact number in this case), a different rule applies. When multiplying or dividing you must count the number of significant figures; the least precise piece of data used to obtain a result determines the number of significant figures in that result. In this case, that would be four (*Chemistry* 6th ed. pages 11–18 / 7th ed. pages 10–16).
32. ANSWER: A This answer is limited to the nearest tenths by the measured value 3.2 g. Note that this is an application of the rule for addition and subtraction (*Chemistry* 6th ed. pages 11–18, esp. “Rules for Significant Figures in Mathematical Operations” on page 16 / 7th ed. pages 10–16, esp. “Rules for Significant Figures in Mathematical Operations” on page 14).
33. ANSWER: C Recall that $d = m/v$, $36.123\text{g}/(27.1 - 13.0) \text{ mL} = 2.56 \text{ g/mL}$. Here the number of significant figures in the answer is limited by the divisor which has three significant figures (*Chemistry* 6th ed. pages 14–18, 25–26 / 7th ed. pages 13–16, 24).
34. ANSWER: C This time $d = m/v$ is used in the form $v = m/d$. The answer is limited to three significant figures by the measured value of the density, 0.714 g/cm^3 , which is known to only three significant figures. Note that in this as well as several of the other questions, it is not the mathematical processes that are being tested but your understanding of how to apply significant figures (look at all of the answers!). Significant figures are important on the AP Chemistry Examination too, especially in the second section (free-response problems) where one point is lost for each such error (*Chemistry* 6th ed. pages 25–26 / 7th ed. pages 24).
35. ANSWER: C The anion of the acid is reacting with water (this is hydrolysis, of course): $A^- + \text{HOH} \rightarrow \text{AH} + \text{OH}^-$ and occurs when HA is a weak acid (*Chemistry* 6th ed. pages 733–741 / 7th ed. pages 700–707).
36. ANSWER: A The atomic number indicates the number of protons for the atom (as well as for the ion!) and therefore identifies the element. Even though most oxygen has a mass of 16, this is still oxygen. It differs in the number of neutrons ($17 - 8 = 9$), so it is an

isotope of oxygen (*Chemistry* 6th ed. pages 53-56, 81-85 / 7th ed. pages 49-52, 77-81).

- 37. ANSWER: E All three of these factors are essential, according to collision theory (*Chemistry* 6th ed. pages 582-586 / 7th ed. pages 552-555).
- 38. ANSWER: B Since HBr is a strong acid (completely dissociated), the $[H^+]$ would be 0.00100 M which gives a $pH = -\log 0.00100 = 3.0$ (*Chemistry* 6th ed. pages 657-666 / 7th ed. pages 626-635).
- 39. ANSWER: C The substances you might expect to form solids due to low solubility might be lead (II) chromate and potassium nitrate. There are two rules which suggest the latter is not going to precipitate: "most 1A compounds are soluble," and "most nitrate salts are soluble" (*Chemistry* 6th ed. pages 148-154 / 7th ed. pages 140-145).
- 40. ANSWER: E If gas is allowed to escape, then there are fewer molecules left within the cylinder; these fewer molecules exert less pressure (gas pressure is due to the collision of gas particles with the sides of the container). These remaining gas molecules occupy the entire container, so there must be more room between the individual molecules (*Chemistry* 6th ed. pages 190-192, 212-219 / 7th ed. pages 179-181, 199-206).
- 41. ANSWER: A Gas solubility in water depends on both temperature and pressure. Gases dissolve more completely at low temperatures and higher pressures (consider your experiences with carbonated drinks) (*Chemistry* 6th ed. pages 519-531 / 7th ed. pages 492-504).
- 42. ANSWER: C While this may appear to be an equilibrium question, it is actually just asking you to show an understanding of the stoichiometry between ammonia and hydrogen gases as this reaction proceeds. If enough ammonia reacts to cause a decrease of 0.40 atm in pressure, then enough hydrogen is formed to cause an increase in pressure of 0.60 atm., $(0.40 \text{ atm} \times 3 \text{ mol } H_2 / 2 \text{ mol } NH_3)$ (*Chemistry* 6th ed. pages 108-112 / 7th ed. pages 102-106).
- 43. ANSWER: A Go back to first principles: What is pressure? The basic Kinetic Molecular Theory of Gases indicates that gas pressure is due to molecular collisions and more collisions mean greater pressure (*Chemistry* 6th ed. pages 212-219 / 7th ed. pages 199-206).
- 44. ANSWER: A Real gases differ from ideal gases because of two factors: attractions between real gas molecules and the molecular volume of real gases. These factors become important only under conditions of high pressure (molecules closer together) and low temperature (lower average kinetic energy) (*Chemistry* 6th ed. pages 212-219, 222-224 / 7th ed. pages 199-206, 208-210).

45. ANSWER: B Gas particles move faster at higher temperature. Real gas molecules do have attractions between each other. While they certainly do move in a random manner, it is the collisions that cause pressure (*Chemistry* 6th ed. pages 190–192, 212–219, 222–224 / 7th ed. pages 179–181, 199–206, 208–210).
46. ANSWER: B This stoichiometry problem may cause you to reach for your calculator, but that tool is not needed; note the widely differing answers for the volume of the gas. 0.40 mol of KClO_3 will form 0.60 mol of oxygen gas. The molar volume of gases at STP is 22.4 L / mol, so the volume is around 14 L ($0.60 \text{ mol} \times 22 \text{ L / mol}$) (*Chemistry* 6th ed. pages 108–112, 203–206 / 7th ed. pages 102–106, 190–194).
47. ANSWER: B The part of the pressure (partial pressure) due to a gas in a mixture of gases is the same as the mole ratio of that gas to the total, which is the same as the ratio of the number of molecules of that gas is to the total number of molecules. In this case there are 3 moles of gas total of which Ne is 1 part, hence 1/3 of the total pressure is due to the Ne (*Chemistry* 6th ed. pages 206–211 / 7th ed. pages 194–199).
48. ANSWER: C The atomic volume decreases due to an increase in nuclear charge; note that the ‘added’ electrons are going into the same gross energy level as you go from left to right across the same period (*Chemistry* 6th ed. pages 324–330 esp. fig. 7.35, 914–918 esp. fig. 19.2 / 7th ed. pages 309–314 esp. fig. 7.34, 875–880 esp. fig. 19.2).
49. ANSWER: E Since this occurs as a one step reaction, we can write that the rate = $k[A]^2[B]$. Initially the rate will be proportional to $(3)^2(2) = 18$. Later, $[A]$ becomes $3 - 2 = 1$, and $[B]$ becomes $2 - 1 = 1$, so the rate is then proportional to $(1)^2(1) = 1$. That means a change in the rate by a factor of 18 to 1, or that the rate is now 1/18 as large as it was originally (*Chemistry* 6th ed. pages 563–582 / 7th ed. pages 534–552).
50. ANSWER: A This time you need to use the form $k = \text{rate}/[X][Y]$ to determine the value of the rate constant, k .

$$\begin{aligned}
 k &= 4.0 \times 10^{-6} \text{ mol/L} \cdot \text{min} / (4.0 \times 10^{-1} \text{ mol/L})(4.0 \times 10^{-1} \text{ mol/L}) \\
 &= 1/4 \times 10^{-4} \text{ L / mol} \cdot \text{min} = .25 \times 10^{-4} \text{ L / mol} \cdot \text{min} \\
 &= 2.5 \times 10^{-5} \text{ L} \cdot \text{mol}^{-1} \text{min}^{-1}.
 \end{aligned}$$

(Note that if set up in this way, the mathematics become rather easy to handle.) Do watch units for rate constants, which, unlike equilibrium constants, traditionally have units assigned (*Chemistry* 6th ed. pages 563–579 / 7th ed. pages 534–549).

51. ANSWER: B There is almost always a question on kinetics like this on a test. Note that it is not just the greater number of molecular

collisions that cause the reaction to occur faster but an increase in the fraction of high energy molecules which can then obtain the activation energy requirement and reaction that cause this rate increase (*Chemistry* 6th ed. pages 582–595 esp. fig. 12.12 / 7th ed. pages 552–563 esp. fig. 12.12).

52. ANSWER: D Catalysts lower the activation energy barrier by forming a different activated complex (*Chemistry* 6th ed. pages 588–595, esp. fig. 12.15 and 12.16 / 7th ed. pages 557–563, esp. fig. 12.15 and 12.16).
53. ANSWER: A For a zero-order rate law, $\text{rate} = k[A]^0$ (i.e. $n = \text{zero}$). Since any number taken to the zero power is equal to 1, $\text{rate} = k$ (the rate constant). This has the physical meaning that the rate does not speed up or slow down over time (like most reactions do); it either takes place at a constant rate or does not take place at all (*Chemistry* 6th ed. pages 568–578, Table 12.6 on page 578, 595–597 / 7th ed. pages 538–547, Table 12.6 on page 548, 564–565).
54. ANSWER: B Using the general half-life expression, $t_{1/2} = 0.693 / k$, $k = 0.693 / 1.4 \text{ min} = 0.50 \text{ min}^{-1}$. Note that this expression is valid only for first-order reactions, which would include nuclear decay processes (*Chemistry* 6th ed. pages 568–578 / 7th ed. pages 538–547).
55. ANSWER: B If you wish to determine how order is affected by a given concentration, then a series of reactions should be run with changes in only the concentration of that substance, with all other concentrations held constant (as well as all other conditions like temperature held constant) (*Chemistry* 6th ed. pages 568–578 esp. Sample Exercise 12.5 / 7th ed. pages 538–547 esp. Sample Exercise 12.5).
56. ANSWER: B This is another application of the half-life expression for first-order rate laws, $t_{1/2} = 0.693/k$. Note that half-life (time) and the rate constant are inversely related; hence the element with the lower rate constant will have the longer half-life (*Chemistry* 6th ed. pages 568–578 / 7th ed. pages 538–547).
57. ANSWER: E Since the activation energy for the reverse reaction is the sum of the activation energy for the forward reaction plus the reverse of the enthalpy change for the forward reaction, and we do not know this last value, the value cannot be calculated (*Chemistry* 6th ed. pages 579–582, fig. 12.11 on page 584 / 7th ed. pages 549–552, fig. 12.11 on page 553).
58. ANSWER: C If the volume is reduced to 1/3 the original value, then the concentration of these gases will all be three times greater. Using the given rate law and increasing both concentrations by a factor of 3, gives a rate increase of $(3)^2(3) = 27$ times (*Chemistry* 6th ed. pages 563–579 / 7th ed. pages 534–549).

59. ANSWER: C Since only the concentration of B is altered, you need to see how tripling $[B]$ affects the rate: from $r = k[X][B]^2$ you can see that the rate increases by a factor of $(3)^2$, or 9 times (*Chemistry* 6th ed. pages 563–579 / 7th ed. pages 534–549).

60. ANSWER: E Use the equation $\Delta G = \Delta H + T\Delta S$, and remember that a negative value for the Gibb's Free Energy is required for a spontaneous reaction. Then determine the signs for ΔH and for ΔS which give a negative ΔG (T is always positive, of course) (*Chemistry* 6th ed. pages 784–795 / 7th ed. pages 749–759).

61. ANSWER: A For systems at the boiling temperature, the change in state does not offer any free energy. So G is zero. This allows you to use $\Delta S = \Delta H / T$ to find the entropy change:

$$\Delta S = +60,000 \text{ J / mol} / 300.\text{K} = +200. \text{ J / mol} \cdot \text{deg. K.}$$

Note the change from kJ to J in this calculation (*Chemistry* 6th ed. pages 795–798 / 7th ed. pages 759–762).

62. ANSWER: C From $K_a \times K_b = K_w$; $K_b = 1.0 \times 10^{-14} / 5.0 \times 10^{-10} = 2.0 \times 10^{-5}$ (*Chemistry* 6th ed. pages 687–693 / 7th ed. pages 655–660).

63. ANSWER: E Using the general equation $B^- + HOH \rightarrow HB + OH^-$, $[HB][OH^-]/[B^-] = 1.0 \times 10^{-5}$, $[OH^-] = 1.0 \times 10^{-3} \text{ M}$, $pOH = 3.0$. $pH = 14.0 - 3.0 = 11.0$. OH^- $pOH = -\log 1.0 \times 10^{-3}$ (*Chemistry* 6th ed. pages 681–682 / 7th ed. pages 649–650).

64. ANSWER: A Compounds with these properties are ionically bonded. This suggests elements from the far left side of the Periodic Table (1A or 2A) with elements from the far right side (6A or 7A) (*Chemistry* 6th ed. pages 366–367, 479–483 / 7th ed. pages 346–347, 456–459).

65. ANSWER: C Ions with negative charges have gained an electron and are therefore larger than their parent atoms. Between the chloride ions and the bromide ion you have outermost electrons in the third gross energy level versus the fourth gross energy level, hence we would expect Br^- to be larger (*Chemistry* 6th ed. pages 357–362 esp. fig. 8.7 / 7th ed. pages 338–342 esp. fig. 8.8).

66. ANSWER: C While using actual electronegativities would be helpful for this question, a good generalization is that the further apart the elements are on the periodic table the greater the difference in control they have over the shared electron pair, and the more polar the bond. Of course, if an element from the 1A or 2A Group bonds with something from the 6A or 7A Group, the difference in control over the electron is so great that we call the bond ionic, but that possibility is not one of the answers in this question. Note also that this is a question dealing with the polarity of an individual bond and not with the polarity of an entire molecule (*Chemistry* 6th ed. pages 352–354 / 7th ed. pages 333–335).

67. ANSWER: E The need for resonance structures seems to be greatest for molecules in which the same two elements are bonded with different type bonds (e.g. one single, one double bond) in the same molecule. The usual Lewis structure for sulfur dioxide shows that the sulfur and oxygen are bonded with one single bond and, in the other sulfur-oxygen bond, doubly bonded. (Be sure you can draw this Lewis structure.) (*Chemistry* 6th ed. pages 383-388 / 7th ed. pages 363-367)
68. ANSWER: E The VSEPR Model is very helpful in describing almost all molecular shapes. Note that in PH_3 the shape may, at first, seem to be tetrahedral, but it does not have a hydrogen in one of the four apex positions, so it is a trigonal pyramid. Molecular shape is determined by the position of the nuclei and not by the position of just electrons, either pairs or single electrons (*Chemistry* 6th ed. pages 389-400 esp. fig. 8.15 / 7th ed. pages 367-379 esp. fig. 8.16).
69. ANSWER: D Hybridization is a way of describing the atomic orbitals used to share electrons and thereby form bonds. The careful student will become familiar with the five types of hybrid orbitals indicated by the five responses to this question (*Chemistry* 6th ed. pages 413-426 / 7th ed. pages 391-403).
70. ANSWER: B The temperature at which substances boil is a function of the forces between the molecules of that substance (intermolecular forces). Small, nonpolar molecules boil at the lowest temperatures since they have the weakest IMF to overcome. As polarity increases, so does the boiling temperature, from semi-polar to the extremely polar hydrogen 'bond.' Ionic substances have even higher boiling temperatures (*Chemistry* 6th ed. pages 450-453 / 7th ed. pages 426-429).
71. ANSWER: A The more easily a substance can obtain the vapor state, the more molecules will be available to exert vapor pressure. The lower the polarity of the molecule, the easier it will vaporize. The $\text{CH}_3\text{CH}_2\text{OH}$ is the most polar of this group, due to the hydrogen 'bonding' at the $-\text{OH}$ site; it will have the lowest vapor pressure. Propane is the most symmetrical of these molecules, the least polar, and will have the highest vapor pressure (*Chemistry* 6th ed. pages 450-453, 483-492 / 7th ed. pages 426-429, 459-466).
72. ANSWER: D If you think about equilibrium shifting to attempt to achieve pressure equilibrium, then only when the same number of moles of gas are found on both sides of the reaction will the system not be affected. This is the case in this problem when you have two moles of gas on each side. This effect of a change in pressure on an equilibrium system is described by Le Châtelier's principle (*Chemistry* 6th ed. pages 636-642 esp. Sample Exercise 13.14 / 7th ed. pages 604-610 esp. Sample Exercise 13.14).
73. ANSWER: A Since the stoichiometry of this reaction indicates that twice as much X will react as will Y and that you have added equal numbers of moles of these materials initially, then there must be

less X remaining after any reaction takes place (*Chemistry* 6th ed. pages 610–613 / 7th ed. pages 579–582).

74. ANSWER: A Note that the second equation is the reverse of the first, and has been doubled. Therefore the K_c for the second equation will be the reciprocal of the first squared: $(1/4)^2 = 16$ (*Chemistry* 6th ed. pages 613–617 especially Sample Exercise 13.2 and “We Can Summarize These Conclusions About the Equilibrium Expression” / 7th ed. pages 582–586 especially Sample Exercise 13.2 and “We Can Summarize These Conclusions About the Equilibrium Expression”).
75. ANSWER: E From the equation $\text{Zn(OH)}_2 \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$ you can see that if 2.0×10^{-6} mol/L of the zinc hydroxide dissolves, that will result in the same concentration of zinc ions (2.0×10^{-6} mol/L) and twice that much of hydroxide ions (2.0×10^{-6} mol/L $\times 2 = 4.0 \times 10^{-6}$ mol/L). Then: $K_{sp} = [\text{Zn}^{2+}][\text{OH}^-]^2 = (2.0 \times 10^{-6} \text{ mol/L})(4.0 \times 10^{-6} \text{ mol/L})^2 = 32 \times 10^{-18}$ (usually units are not shown with this kind of value) (*Chemistry* 6th ed. pages 751–760 / 7th ed. pages 717–724).

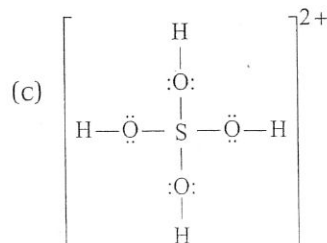
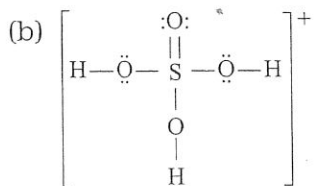
SECTION II FREE-RESPONSE ANSWERS

Question 1: Answers

- (a) $K_c = [\text{O}_2][\text{SO}_2]^2 / [\text{SO}_3]^2$
- (b) $[\text{SO}_2] = 1.23 \times 10^{-2} \text{ mol} / 2.25 \text{ L} = 0.00547 \text{ M}$
 $[\text{O}_2] = (\text{one half as much as above}) = 0.00273 \text{ M}$
 $[\text{SO}_3] = 0.0401 \text{ mol} - 0.0123 \text{ mol} / 2.25 \text{ L} = 0.0124 \text{ M}$
 note: $3.21 \text{ g} / 80.1 \text{ g/mol} = 0.401 \text{ mol}$ of SO_3 initially
- (c) $K_c = (0.00273)(0.00547)^2 / (0.0124)^2 = 5.31 \times 10^{-4}$
- (d) $K_p = K_c(RT)^{\Delta n} = 5.31 \times 10^{-4} (0.0821)(500.)^1 = 2.18 \times 10^{-2}$
 (*Chemistry* 6th ed. pages 618–619, 625–630 / 7th ed. pages 587–588, 593–598)

Question 2: Answers

- (a) The pairs are HBrO_4 (acid) / BrO_4^- (conjugate base) and H_3SO_4^+ (acid) / H_2SO_4 (base). Note that acid form always has one more H^+ than its conjugate base; this reaction takes place in pure acids; no water is involved.



- (d) Arrhenius acids produce H^+ ions in water solutions. Brønsted-Lowry acids donate H^+ (protons) in any solvent; these acids need not be in an aqueous solution. Lewis acids are electron pair acceptors (in any solvent).
(*Chemistry* 6th ed. pages 655–656, 660, 696–699 / 7th ed. pages 624–626, 629, 663–665)

Question 3: Answers

Note that physical states need not be included, and that the expressions need not be balanced. Do not include spectator ions.

- $NH_3 + BCl_3 \rightarrow H_3N:BCl_3$ (this could be shown as NH_3BCl_3)
- $Fe^{3+} + I^- \rightarrow Fe^{2+} + I_2$
- $K_2O + HOH \rightarrow K^+ + OH^-$
- $H_2O_2 + Fe^{2+} \rightarrow Fe^{3+} + H_2O$
- $NH_3 + Fe^{3+} + H_2O \rightarrow Fe(OH)_3 + NH_4^+$
- $KClO_3 \rightarrow KCl + O_2$
- $NH_3 + Cu^{2+} \rightarrow Cu(NH_3)_4^{2+}$
- $MgO + CO_2 \rightarrow MgCO_3$

(*Chemistry* 6th ed. pages 148–155 / 7th ed. pages 140–146)

Question 4: Answers

- a(i) The $KMnO_4$ is actually less concentrated than you believe it to be since it has been diluted with the water left in the buret. That means that more of the standardized solution will be needed to react with the iron (II) solution leading you to report that the iron concentration is higher than it actually is.
- a(ii) If the air bubble stays in the buret during the entire titration, then there is no effect. However, if it is replaced by the $KMnO_4$ solution during the titration, then less solution leaves the buret than you are reporting, leading to a higher than correct percentage of the iron (II).
- a(iii) If more water is added to the flask that contains the iron salt, it will not affect the number of moles of iron (II) and therefore not affect the reported result.
- a(iv) If the same point on the meniscus is used as a reference, there will not be any effect on the percentage of iron reported.

(b) % Error

$$= (\text{your lab. results} - \text{accepted value}) / \text{accepted value} \times 100\% \\ (6.896 - 7.77) / 7.77 \times 100\% = -11\%$$

Note that the answer is negative, and known only to two sig. fig.

- (c) $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$.

Fe^{2+} is undergoing oxidation (the loss of electrons) and so it is the reducing agent.

(*Chemistry* 6th ed. pages 161–162, 168–177 / 7th ed. pages 151–152, 158–167)

Question 5: Answers

- (a) The thermal energy added is used to overcome the forces of attraction (IMF) in the solid (not to make the particles move faster, which is an increase in kinetic energy, thereby temperature.)
 - (b) The distance between K^+ and Cl^- is greater than the distance between Na^+ and F^- , and so the lattice energy is smaller.
 - (c) Br_2 (i) is nonpolar and has lower IMF than polar ICl .
 - (d) The bonding electrons are shared much more unevenly in HF , giving rise to a very polar molecule. This leads to stronger dipole-dipole forces in HF (called hydrogen 'bonding,' of course).
 - (e) An endothermic process causes this. The alcohol evaporates. This requires energy which is lost by your skin, so the temperature of your skin decreases.
- (*Chemistry* 6th ed. pages 488–490, 360–365, 459–460, 354–356, 243–249 / 7th ed. pages 463–465, 340–345, 435–436, 335–337, 231–236)

Question 6: Answers

- (a) By running a series of reactions while changing the concentration of only substance X, or of only substance Y, and noting how this affects the reaction rate.
 - (b) It is first order with respect to X, it is first order with respect to Y, and second order overall.
 - (c) The rate constant may be changed by changing the temperature (but not by changing the concentration of X or of Y). Recall the Arrhenius equation.
 - (d) For zero-order reactions, the rate is constant {Rate = $k[A]^0 = k(1) = k$ }. This means that the rate constant does not change with concentration as it does with a first-order reaction {Rate = $k[A]^1$ }.
 - (e) All reactants in the rate determining step must be part of the rate law expression because each of those reactants controls the reaction rate.
- (*Chemistry* 6th ed. pages 563–565, 568–570, 576, 579–582, Table 12.6 on page 578 / 7th ed. pages 534–536, 538–540, 546, 549–552, Table 12.6 on page 548)

SCORING THE DIAGNOSTIC TEST FREE-RESPONSE QUESTIONS

It is difficult to come up with an exact score for this section of test. However, if you compare your answers to the answers in this book, remembering that each part of the test you answer correctly is worth points even if the other parts of the answer are incorrect (see the section titled "Scoring for the Free-Response Questions" on page 12 of this book), you can get a general idea of the percentage of the questions for which you would get credit. If you believe that you got at least one-third of the possible credit, you would probably receive a 3 on this part of the test. If you believe that you would receive close to half or more of the available credit, your score would more likely be a 4 or a 5.