APPENDIX VII

Answers to Putting It Together Review Exercises

Chapters 1–4

Multiple Choice: **1.** d **2.** a **3.** d **4.** b **5.** d **6.** c **7.** a **8.** d **9.** a **10.** b **11.** a **12.** d **13.** b **14.** c **15.** a **16.** d **17.** c **18.** b **19.** d **20.** c **21.** c **22.** a **23.** b **24.** c **25.** c **26.** a **27.** d **28.** d **29.** c **30.** a **31.** b **32.** a **33.** c **34.** c **35.** c **36.** d **37.** a **38.** a **39.** d **40.** d **41.** c **42.** c **43.** b **44.** b **45.** c **46.** b **47.** b

Free Response:

1. $(1.5\text{ m})\left(\frac{100\text{ cm}}{1\text{ m}}\right)\left(\frac{1\text{ in.}}{2.54\text{ cm}}\right)\left(\frac{1\text{ ft}}{12\text{ in.}}\right) = 4.9\text{ ft}$

$(4\text{ m})\left(\frac{100\text{ cm}}{1\text{ m}}\right)\left(\frac{1\text{ in.}}{2.54\text{ cm}}\right)\left(\frac{1\text{ ft}}{12\text{ in.}}\right) = 13\text{ ft}$

$(27°\text{C} \times 1.8) + 32 = 81°\text{F}$

2. Jane needs to time how long it took from starting to heat to when the butter is just melted. From this information, she can determine how much heat the pot and butter absorbed. Jane can look up the specific heat of copper. Jane should weigh the pot and measure the temperature of the pot and the temperature at which the butter just melted. This should allow Jane to calculate how much heat the pot absorbed. Then she simply has to subtract the heat the pot absorbed from the heat the stove put out to find out how much heat the butter absorbed.

3. $CaCO_3 \longrightarrow CaO + CO_2$

75 g → 42 g + X

$X = 75\text{ g} - 42\text{ g} = 33\text{ g}$

44 g CO_2 occupies 24 dm^3

Therefore, 33 g CO_2 occupies $(33\text{ g})\left(\frac{24\text{ dm}^3}{44\text{ g}}\right)\left(\frac{1\text{ L}}{1\text{ dm}^3}\right) = 18\text{ L}$

4. (a), (b), and (c) Picture (2) best represents a homogeneous mixture. Pictures (1) and (3) show heterogeneous mixtures, and picture (4) does not show a mixture, as only one species is present.

Picture (1) likely shows a compound, as one of the components of the mixture is made up of more than one type of "ball." Picture (2) shows a component with more than one part, but the parts seem identical, and therefore it could be representing a diatomic molecule.

5. (a) Picture (3) because fluorine gas exists as a diatomic molecule.

(b) Other elements that exist as diatomic molecules are oxygen, nitrogen, chlorine, hydrogen, bromine, and iodine.

(c) Picture (2) could represent SO_3 gas.

6. (a) Tim's bowl should require less energy. Both bowls hold the same volume, but since snow is less dense than a solid block of ice, the mass of water in Tim's bowl is less than the mass of water in Sue's bowl. (Both bowls contain ice at 12°F.)

(b) $\dfrac{12°F - 32}{1.8} = -11°C$

Temperature change: $-11°C$ to $25°C = 36°C$

(c) temperature change: $-11°C$ to $0°C = 11°C$

specific heat of ice $= 2.059$ J/g°C

$$\text{vol. of } H_2O = 1 \text{ qt} = (0.946 \text{ L})\left(\frac{1000 \text{ mL}}{\text{L}}\right) = 946 \text{ mL}$$

$$\text{mass of ice} = \text{mass of water} = (946 \cancel{\text{mL}})\left(\frac{1 \text{ g}}{1 \cancel{\text{mL}}}\right) = 946 \text{ g}$$

$$\text{heat required} = (\text{m})(\text{sp. ht.})(\Delta t)$$

$$= (946 \text{ g})\left(\frac{2.059 \text{ J}}{\text{g°C}}\right)(11°C)\left(\frac{1 \text{ kJ}}{1000 \text{ J}}\right) = 21 \text{ kJ}$$

(d) Physical changes

7. (a) Let x = RDA of iron

60% of x = 11 mg Fe

$$x = \frac{11 \text{ mg Fe} \times 100\ \%}{60\ \%} = 18 \text{ mg Fe}$$

(b) density of iron = 7.86 g/mL

$$\text{V} = \frac{\text{m}}{\text{d}} = (11 \text{ mg Fe})\left(\frac{1 \text{ g}}{1000 \text{ mg}}\right)\left(\frac{1 \text{ mL}}{7.86 \text{ g}}\right) = 1.4 \times 10^{-3} \text{ mL Fe}$$

8. (a) $Ca_3(PO_4)_2$: molar mass = 3(40.08) + 2(30.97) + 8(16.00) = 310.3

$$\%\text{Ca in } Ca_3(PO_4)_2 = \frac{3(40.08)}{310.3}(100) = 38.7\%$$

Let x = mg $Ca_3(PO_4)_2$

38.7% of x = 162 mg Ca

$$x = \frac{(162 \text{ mg})(100)}{38.7} = 419 \text{ mg } Ca_3(PO_4)_2$$

(b) $Ca_3(PO_4)_2$ is a compound.

(c) Convert 120 mL to cups

$$(120 \text{ mL})\left(\frac{1 \text{ L}}{1000 \text{ mL}}\right)\left(\frac{1.059 \text{ qt}}{1 \text{ L}}\right)\left(\frac{4 \text{ cups}}{1 \text{ qt}}\right) = 0.51 \text{ cup}$$

13% of x = 0.51 cup

$$x = \frac{(0.51 \text{ cup})(100)}{13} = 3.9 \text{ cups}$$

9. If Alfred inspects the bottles carefully, he should be able to see whether the contents are solid (silver) or liquid (mercury). Alternatively, since mercury is more dense than silver, the bottle of mercury should weigh more than the bottle of silver (the question indicated that both bottles were of similar size and both were full). Density is mass/volume.

10. (a) Container holds a mixture of sulfur and oxygen.

(b) No. If the container were sealed, the total mass would remain the same whether a reaction took place or not. The mass of the reactants must equal the mass of the products.

(c) No. Density is mass/volume. The volume is the container volume, which does not change. Since the total mass remains constant even if a reaction has taken place, the density of the container, including its contents, remains constant. The density of each individual component within the container may have changed, but the total density of the container is constant.

Chapters 5–6

Multiple Choice: **1.** b **2.** d **3.** b **4.** d **5.** b **6.** b **7.** a **8.** b **9.** d **10.** c **11.** b **12.** d **13.** a **14.** c **15.** d

Names and Formulas: The following are correct: 1, 2, 4, 5, 6, 7, 9, 11, 12, 15, 16, 17, 18, 19, 21, 22, 25, 28, 30, 32, 33, 34, 36, 37, 38, 40.

Free Response:

1. (a) An ion is a charged atom or group of atoms. The charge can be either positive or negative.

(b) Electrons have negligible mass compared with the mass of protons and neutrons. The only difference between Ca and Ca^{2+} is two electrons. The mass of those two electrons is insignificant compared with the mass of the protons and neutrons present (and whose numbers do not change).

2. (a) Let x = abundance of heavier isotope.

$$303.9303(x) + 300.9326(1 - x) = 303.001$$
$$303.9303x - 300.9326x = 303.001 - 300.9326$$
$$2.9977x = 2.068$$
$$x = 0.6899$$
$$1 - x = 0.3101$$

% abundance of heavier isotope = 68.99%

% abundance of lighter isotope = 31.01%

(b) ${}^{304}_{120}Wz$, ${}^{301}_{120}Wz$

(c) mass number − atomic number = 303 − 120 = 183 neutrons

3. Cl_2O_7 Cl: $17p \times 2 = 34$ protons

O: $8p \times 7 = \underline{56}$ protons

90 protons in Cl_2O_7

Since the molecule is electrically neutral, the number of electrons is equal to the number of protons, so Cl_2O_7 has 90 electrons. The number of neutrons cannot be precisely determined unless it is known which isotopes of Cl and O are in this particular molecule.

4. Phosphate has a −3 charge; therefore, the formula for the ionic compound is $M_3(PO_4)_2$.

P has 15 protons; therefore, $M_3(PO_4)_2$ has 30 phosphorus protons.

$$3\text{ (number of protons in M)} = \frac{30 \times 6}{5} = 36 \text{ protons in 3 M}$$

$$\text{number of protons in M} = \frac{36}{3} = 12 \text{ protons}$$

from the periodic table, M is Mg.

5. (a) Iron can form cations with different charges (e.g., Fe^{2+} or Fe^{3+}). The Roman numeral indicating which cation of iron is involved is missing. This name cannot be fixed unless the particular cation of iron is specified.

(b) $K_2Cr_2O_7$. Potassium is generally involved in ionic compounds. The naming system used was for covalent compounds. The name should be potassium dichromate. (Dichromate is the name of the $Cr_2O_7^{2-}$ anion.)

(c) Sulfur and oxygen are both nonmetals and form a covalent compound. The number of each atom involved needs to be specified for covalent compounds. There are two oxides of sulfur—SO_2 and SO_3. Both elements are nonmetales, so the names should be sulfur dioxide and sulfur trioxide, respectively.

6. No. Each compound, SO_2 and SO_3, has a definite composition of sulfur and oxygen by mass. The law of multiple proportions says that two elements may combine in different ratios to form more than one compound.

7. (a) Electrons are not in the nucleus.
(b) When an atom becomes an anion, its size increases.
(c) An ion of Ca (Ca^{2+}) and an atom of Ar have the same number of electrons.

8. (a) $12\ \text{amu} \times 7.18 = 86.16\ \text{amu}$
(b) The atom is most likely Rb or Sr. Other remote possibilities are Kr or Y.
(c) Because of the possible presence of isotopes, the atom cannot be positively identified. The periodic table gives average masses.
(d) M forms a +1 cation and is most likely in group 1A. The unknown atom is most likely $^{86}_{37}Rb$.

9. The presence of isotopes contradicts Dalton's theory that all atoms of the same element are identical. Also, the discovery of protons, neutrons, and electrons suggests that there are particles smaller than the atom and that the atom is not indivisible.
Thomson proposed a model of an atom with no clearly defined nucleus.
Rutherford passed alpha particles through gold foil and inspected the angles at which the alpha particles were deflected. From his results, he proposed the idea of an atom having a small dense nucleus.

Chapters 7–9

Multiple Choice: **1.** a **2.** a **3.** d **4.** d **5.** a **6.** b **7.** a **8.** b **9.** b
10. d **11.** a **12.** d **13.** b **14.** c **15.** c **16.** d **17.** d **18.** b **19.** b
20. a **21.** b **22.** c **23.** d **24.** b **25.** b **26.** a **27.** d **28.** c **29.** c
30. b **31.** c **32.** c **33.** b **34.** d **35.** b **36.** d **37.** c **38.** b **39.** c
40. d **41.** a **42.** c **43.** c **44.** b **45.** b **46.** a **47.** d **48.** b **49.** b
50. a

Free Response:

1. (a) $104\ \text{g}\ O_2 = (104\ \text{g}\ O_2)\left(\dfrac{1\ \text{mol}}{32.00\ \text{g}}\right) = 3.25\ \text{mol}\ O_2$

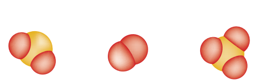
$$\underset{}{X} + \underset{3.25\ \text{mol}}{O_2} \longrightarrow \underset{2\ \text{mol}}{CO_2} + \underset{2.5\ \text{mol}}{H_2O} \quad \text{(multiply moles by 4)}$$

$$4X + 13\,O_2 \longrightarrow 8\,CO_2 + 10\,H_2O$$

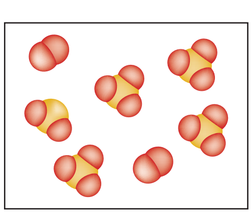
Oxygen is balanced. By inspection, X must have 8/4 C atoms and 20/4 H atoms (2 C and 5 H).
Empirical formula is C_2H_5.

(b) Additional information needed is the molar mass of X.

2. (a)



SO_2 O_2 SO_3



(b) $25\text{ g } SO_2\left(\dfrac{1\text{ mol}}{64.07\text{ g}}\right) = 0.39\text{ mol } SO_2$

$5\text{ g } O_2\left(\dfrac{1\text{ mol}}{32.00\text{ g}}\right) = 0.16\text{ mol } O_2$

$\text{mol ratio} = \dfrac{0.39}{0.16} = \dfrac{2.4\text{ mol } SO_2}{1\text{ mol } O_2}$

O_2 is the limiting reagent

(c) False. The percentages given are not mass percentages. The percent composition of S in SO_2 is $(32/64) \times 100 = 50.\%$ S. The percent composition of S in SO_3 is $(32/80) \times 100 = 40.\%$ S.

3. (a) $\%O = 100 - (63.16 + 8.77) = 28.07\%$ O

Start with 100 g compound Z

C: $(63.16\text{ g})\left(\dfrac{1\text{ mol}}{12.01\text{ g}}\right) = 5.259\text{ mol}$ $\qquad \dfrac{5.259\text{ mol}}{1.75\text{ mol}} = 2.998$

H: $(8.77\text{ g})\left(\dfrac{1\text{ mol}}{1.008\text{ g}}\right) = 8.70\text{ mol}$ $\qquad \dfrac{8.70\text{ mol}}{1.754\text{ mol}} = 4.96$

O: $(28.07\text{ g})\left(\dfrac{1\text{ mol}}{16.00\text{ g}}\right) = 1.754\text{ mol}$ $\qquad \dfrac{1.754\text{ mol}}{1.754\text{ mol}} = 1.000$

The ratio of C:H:O is 3:5:1.

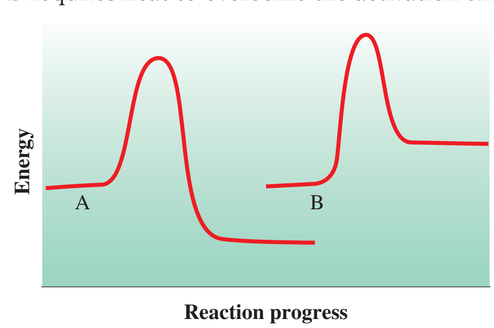
The empirical formula is C_3H_5O.

molar mass = 114; mass of empirical formula is 57

Therefore, the molecular formula is $C_6H_{10}O_2$.

(b) $2\,C_6H_{10}O_2 + 15\,O_2 \longrightarrow 12\,CO_2 + 10\,H_2O$

4. (a) Compound A must have a lower activation energy than compound B because B requires heat to overcome the activation energy for the reaction.



(b) (i) $2\,NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Decomposition of 0.500 mol $NaHCO_3$ requires 85.5 kJ of heat.
If 24.0 g CO_2 is produced, then

$(24.0\text{ g } CO_2)\left(\dfrac{1\text{ mol } CO_2}{44.01\text{ g}}\right)\left(\dfrac{1\text{ mol } H_2O}{1\text{ mol } CO_2}\right)\left(\dfrac{18.02\text{ g}}{1\text{ mol } H_2O}\right) = 9.83\text{ g } H_2O$

produced

0.500 mol $NaHCO_3$ produces

$(0.500\text{ mol } NaHCO_3)\left(\dfrac{1\text{ mol } CO_2}{2\text{ mol } NaHCO_3}\right)\left(\dfrac{44.01\text{ g } CO_2}{1\text{ mol } CO_2}\right) = 11.0\text{ g } CO_2$

producing 11.0 g CO_2 required 85.5 kJ

producing 24.0 g CO_2 requires $\left(\dfrac{24.0\text{ g}}{11.0\text{ g}}\right)(85.5\text{ kJ}) = 187\text{ kJ}$

(ii) $NaHCO_3$ could be compound B. Since heat was absorbed for the decomposition of $NaHCO_3$, the reaction was endothermic. Decomposition of A was exothermic.

5. (a) Double-displacement reaction

(b) $2\,NH_4OH(aq) + CoSO_4(aq) \longrightarrow (NH_4)_2SO_4(aq) + Co(OH)_2(s)$

(c) 8.09 g is 25% yield

Therefore, 100% yield $= (8.09\text{ g }(NH_4)_2SO_4)\left(\frac{100\%}{25\%}\right) = 32.4\text{ g }(NH_4)_2SO_4$ (theoretical yield)

(d) molar mass of $(NH_4)_2SO_4 = 132.2$ g/mol

theoretical moles $(NH_4)_2SO_4 = (32.4\text{ g})\left(\frac{1}{132.2\text{ g/mol}}\right) = 0.245\text{ mol }(NH_4)_2SO_4$

Calculate the moles of $(NH_4)_2SO_4$ produced from 38.0 g of each reactant.

$$(38.0\text{ g }NH_4OH)\left(\frac{1\text{ mol}}{35.05\text{ g}}\right)\left(\frac{1\text{ mol }(NH_4)_2SO_4}{2\text{ mol }NH_4OH}\right) = 0.542\text{ mol }(NH_4)_2SO_4$$

$$(38.0\text{ g }CoSO_4)\left(\frac{1\text{ mol}}{155.0\text{ g}}\right)\left(\frac{1\text{ mol }(NH_4)_2SO_4}{1\text{ mol }CoSO_4}\right) = 0.254\text{ mol }(NH_4)_2SO_4$$

Limiting reactant is $CoSO_4$; NH_4OH is in excess

6. (a) $C_6H_{12}O_6 \longrightarrow 2\,C_2H_5OH + 2\,CO_2(g)$

Calculate the grams of $C_6H_{12}O_6$ that produced 11.2 g C_2H_5OH.

$$(11.2\text{ g }C_2H_5OH)\left(\frac{1\text{ mol}}{46.07\text{ g}}\right)\left(\frac{1\text{ mol }C_6H_{12}O_6}{2\text{ mol }C_2H_5OH}\right)\left(\frac{180.1\text{ g}}{1\text{ mol}}\right) = 21.9\text{ g }C_6H_{12}O_6$$

$25.0\text{ g} - 21.9\text{ g} = 3.1\text{ g }C_6H_{12}O_6$ left unreacted

Volume of CO_2 produced:

$$(11.2\text{ g }C_2H_5OH)\left(\frac{1\text{ mol}}{46.07\text{ g}}\right)\left(\frac{2\text{ mol }CO_2}{2\text{ mol }C_2H_5OH}\right)\left(\frac{24.0\text{ L}}{\text{mol}}\right) = 5.83\text{ L}$$

The assumptions made are that the conditions before and after the reaction are the same and that all reactants went to the products.

(b) theoretical yield

$$= (25.0\text{ g }C_6H_{12}O_6)\left(\frac{1\text{ mol}}{180.1\text{ g}}\right)\left(\frac{2\text{ mol }C_2H_5OH}{1\text{ mol }C_6H_{12}O_6}\right)\left(\frac{46.07\text{ g}}{\text{mol}}\right)$$

$$= 12.8\text{ g }C_2H_5OH$$

$$\%\text{ yield} = \left(\frac{11.2\text{ g}}{12.8\text{ g}}\right)(100) = 87.5\%$$

(c) decomposition reaction

7. (a) double decomposition (precipitation)

(b) lead(II) iodide (PbI_2)

(c) $Pb(NO_3)_2(aq) + 2\,KI(aq) \longrightarrow 2\,KNO_3(aq) + PbI_2(s)$

If $Pb(NO_3)_2$ is limiting, the theoretical yield is

$$(25\text{ g }Pb(NO_3)_2)\left(\frac{1\text{ mol}}{331.2\text{ g}}\right)\left(\frac{1\text{ mol }PbI_2}{1\text{ mol }Pb(NO_3)_2}\right)\left(\frac{461.0\text{ g}}{\text{mol}}\right) = 35\text{ g }PbI_2$$

If KI is limiting, the theoretical yield is

$$(25\text{ g KI})\left(\frac{1\text{ mol}}{166.0\text{ g}}\right)\left(\frac{1\text{ mol }PbI_2}{2\text{ mol KI}}\right)\left(\frac{461.0\text{ g}}{\text{mol}}\right) = 35\text{ g }PbI_2$$

$$\text{percent yield} = \left(\frac{7.66\text{ g}}{35\text{ g}}\right)(100) = 22\%$$

8. (a) Balance the equation

$$2\,XNO_3 + CaCl_2 \longrightarrow 2\,XCl + Ca(NO_3)_2$$

$$(30.8\text{ g }CaCl_2)\left(\frac{1\text{ mol}}{111.0\text{ g}}\right)\left(\frac{2\text{ mol XCl}}{1\text{ mol }CaCl_2}\right) = 0.555\text{ mol XCl}$$

$$\text{Therefore, molar mass of XCl} = \frac{79.6\text{ g}}{0.555\text{ mol}} = 143\text{ g/mol}$$

mass of (X + Cl) = mass of XCl

mass of X = 143 − 35.45 = 107.6

X = Ag (from periodic table)

(b) No. Ag is below H in the activity series.

9. (a) $2\,H_2O_2 \longrightarrow 2\,H_2O + O_2$

There must have been eight H_2O_2 molecules and four O_2 molecules in the flask at the start of the reaction.

(b) The reaction is exothermic.

(c) Decomposition reaction

(d) The empirical formula is OH.

Chapters 10–11

Multiple Choice: **1.** c **2.** a **3.** b **4.** a **5.** a **6.** b **7.** b **8.** b **9.** c **10.** a **11.** d **12.** d **13.** a **14.** b **15.** c **16.** c **17.** b **18.** c **19.** d **20.** d **21.** d **22.** a **23.** c **24.** c **25.** a **26.** b **27.** d **28.** a **29.** b **30.** b **31.** a **32.** b **33.** c **34.** c **35.** d **36.** a **37.** a **38.** c **39.** d **40.** b **41.** c **42.** c **43.** c **44.** a

Free Response:

1. The compound will be ionic because there is a very large difference in electronegativity between elements in Group 2A and those in Group 7A of the Periodic Table. The Lewis structure is

$[M]^{2+}$ $[:\ddot{\underset{..}{X}}:]^-$ $[:\ddot{\underset{..}{X}}:]^-$

2. Having an even atomic number has no bearing on electrons being paired. An even atomic number means only that there is an even number of electrons. For example, carbon is atomic number six, and it has two unpaired *p* electrons: $1s^22s^22p_x^12p_y^1$.

3. False. The noble gases do not have any unpaired electrons. Their valence shell electron structure is ns^2np^6 (except He).

4. The outermost electron in potassium is farther away from the nucleus than the outermost electrons in calcium, so the first ionization energy of potassium is lower than that of calcium. However, once potassium loses one electron, it achieves a noble gas electron configuration, and therefore taking a second electron away requires considerably more energy. For calcium, the second electron is still in the outermost shell and does not require as much energy to remove it.

5. The ionization energy is the energy required to *remove* an electron. A chlorine atom forms a chloride ion by *gaining* an electron to achieve a noble gas configuration.

6. The anion is Cl^-; therefore, the cation is K^+ and the noble gas is Ar. K^+ has the smallest radius, while Cl^- will have the largest. K loses an electron, and therefore, in K^+, the remaining electrons are pulled in even closer. Cl was originally larger than Ar, and gaining an electron means that, since the nuclear charge is exceeded by the number of electrons, the radius will increase relative to a Cl atom.

7. The structure shown in the question implies covalent bonds between Al and F, since the lines represent shared electrons. Solid AlF_3 is an ionic compound and therefore probably exists as an Al^{3+} ion and three F^- ions. Only valence electrons are shown in Lewis structures.

8. Carbon has four valence electrons; it needs four electrons to form a noble gas electron structure. By sharing four electrons, a carbon atom can form four covalent bonds.

9. NCl_3 is pyramidal. The presence of three pairs of electrons and a lone pair of electrons around the central atom (N) gives the molecule a tetrahedral structure and a pyramidal shape. BF_3 has three pairs of electrons and no lone pairs of electrons around the central atom (B), so both the structure and the shape of the molecule are trigonal planar.

10. The atom is Br ($35e^-$), which should form a slightly polar covalent bond with sulfur. The Lewis structure of Br is $:\!\ddot{\underset{\cdot\cdot}{\mathrm{Br}}}\!\cdot$.

Chapters 12–14

Multiple Choice: **1.** b **2.** a **3.** b **4.** c **5.** a **6.** d **7.** d **8.** b **9.** a
10. b **11.** c **12.** a **13.** c **14.** c **15.** d **16.** a **17.** c **18.** a **19.** a
20. d **21.** b **22.** c **23.** a **24.** a **25.** d **26.** d **27.** a **28.** b **29.** c
30. a **31.** a **32.** c **33.** c **34.** c **35.** a **36.** b **37.** b **38.** c **39.** d
40. a **41.** c **42.** d **43.** b **44.** c **45.** c **46.** c **47.** a **48.** c **49.** d
50. b **51.** a **52.** c **53.** d **54.** b **55.** b **56.** a **57.** d **58.** c **59.** b
60. b

Free Response:

1. 10.0% (m/v) has 10.0 g KCl per 100. mL of solution:

Therefore, KCl solution contains

$$\left(\frac{10.0\text{ g KCl}}{100.\text{ mL}}\right)(215\text{ mL})\left(\frac{1\text{ mol}}{74.55\text{ g}}\right) = 0.288\text{ mol KCl}$$

NaCl solution contains $\left(\frac{1.10\text{ mol NaCl}}{\text{L}}\right)\left(\frac{1\text{ L}}{1000\text{ mL}}\right)(224\text{ mL}) = 0.246\text{ mol NaCl}$

The KCl solution has more particles in solution and will have the higher boiling point.

2. Mass of CO_2 in solution

$$= (\text{molar mass})(\text{moles}) = (\text{molar mass})\left(\frac{PV}{RT}\right)$$

$$= \left(\frac{44.01\text{ g }CO_2}{\text{mol}}\right)\left(\frac{1\text{ atm} \times 1.40\text{ L}}{\frac{0.08206\text{ L atm}}{\text{mol K}} \times 298\text{ K}}\right)$$

$$= 2.52\text{ g }CO_2$$

$$\text{mass of soft drink} = (345\text{ mL})\left(\frac{0.965\text{ g}}{\text{mL}}\right) = 333\text{ g}$$

$$\text{ppm of }CO_2 = \left(\frac{2.52\text{ g}}{333\text{ g} + 2.52\text{ g}}\right)(10^6) = 7.51 \times 10^3\text{ ppm}$$

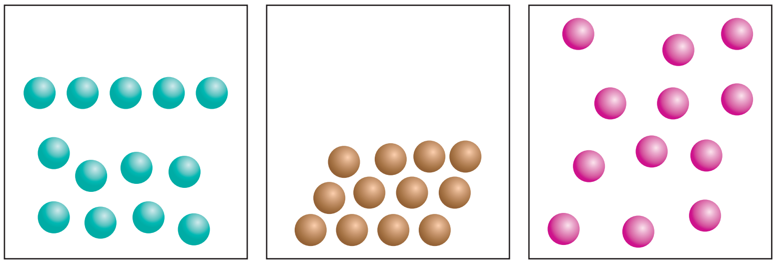
3. 10% KOH m/v solution contains 10 g KOH in 100 mL solution.
10% KOH by mass solution contains 10 g KOH + 90 g H_2O.
The 10% by mass solution is the more concentrated solution and therefore would require less volume to neutralize the HCl.

4. (a) $\frac{0.355\text{ mol}}{0.755\text{ L}} = 0.470\text{ M}$

(b) The lower pathway represents the evaporation of water; only a phase change occurs; no new substances are formed. The upper path represents the decomposition of water. The middle path is the ionization of water.

5. Zack went to Ely, Gaye went to the Dead Sea, and Lamont was in Honolulu. Zack's b.p. was lowered, so he was in a region of lower atmospheric pressure (on a mountain). Lamont was basically at sea level, so his b.p. was about normal. Since Gaye's boiling point was raised, she was at a place of higher atmospheric pressure and therefore was possibly in a location below sea level. The Dead Sea is below sea level.

6. The particles in solids and liquids are close together (held together by intermolecular attractions), and an increase in pressure is unable to move them significantly closer to each other. In a gas, the space between molecules is significant, and an increase in pressure is often accompanied by a decrease in volume.



7. (a) The CO_2 balloon will be heaviest, followed by the Ar balloon. The H_2 balloon would be the lightest. Gases at the same temperature, pressure, and volume contain the same number of moles. All balloons will contain the same number of moles of gas molecules, so when moles are converted to mass, the order from heaviest to lightest is CO_2, Ar, H_2.

(b) Molar mass: O_2, 32.00; N_2, 28.02; Ne, 20.18

Using equal masses of gas, we find that the balloon containing O_2 will have the lowest number of moles of gas. Since pressure is directly proportional to moles, the balloon containing O_2 will have the lowest pressure.

8. Ray probably expected to get 0.050 moles $Cu(NO_3)_2$, which is

$$(0.050 \text{ mol Cu(NO}_3)_2)\left(\frac{187.6 \text{ g}}{\text{mol}}\right) = 9.4 \text{ g Cu(NO}_3)_2$$

The fact that he got 14.775 g meant that the solid blue crystals were very likely a hydrate containing water of crystallization.

9. For most reactions to occur, molecules or ions need to collide. In the solid phase, the particles are immobile and therefore do not collide. In solution or in the gas phase, particles are more mobile and can collide to facilitate a chemical reaction.

10. $\Delta t_b = 81.48°\text{C} - 80.1°\text{C} = 1.38°\text{C}$

$$K_b = 2.53 \frac{°\text{C kg solvent}}{\text{mol solute}}$$

$$\Delta t_b = mK_b$$

$$1.38°\text{C} = m\left(2.53 \frac{°\text{C kg solvent}}{\text{mol solute}}\right)$$

$$0.545 \frac{\text{mol solute}}{\text{kg solvent}} = m$$

Now we convert molality to molarity.

$$\left(\frac{5.36 \text{ g solute}}{76.8 \text{ g benzene}}\right)\left(\frac{1000 \text{ g benzene}}{1 \text{ kg benzene}}\right)\left(\frac{1 \text{ kg benzene}}{0.545 \text{ mol solute}}\right) = 128. \text{ g/mol}$$

Chapters 15–17

Multiple Choice: **1.** c **2.** d **3.** d **4.** c **5.** c **6.** d **7.** a **8.** d **9.** b **10.** c **11.** a **12.** d **13.** c **14.** b **15.** b **16.** d **17.** c **18.** a **19.** a **20.** a **21.** b **22.** c **23.** a **24.** c **25.** c **26.** d **27.** a **28.** b **29.** a **30.** b **31.** a **32.** c **33.** a **34.** b **35.** c **36.** c **37.** b **38.** d **39.** a **40.** c **41.** a **42.** b **43.** a **44.** b **45.** a **46.** a **47.** d **48.** a **49.** c **50.** d **51.** b **52.** a **53.** a **54.** b

Balanced Equations:

55. $3\,P + 5\,HNO_3 \longrightarrow 3\,HPO_3 + 5\,NO + H_2O$

56. $2\,MnSO_4 + 5\,PbO_2 + 3\,H_2SO_4 \longrightarrow 2\,HMnO_4 + 5\,PbSO_4 + 2\,H_2O$

57. $Cr_2O_7^{2-} + 14\,H^+ + 6\,Cl^- \longrightarrow 2\,Cr^{3+} + 7\,H_2O + 3\,Cl_2$

58. $2\,MnO_4^- + 5\,AsO_3^{3-} + 6\,H^+ \longrightarrow 2\,Mn^{2+} + 5\,AsO_4^{3-} + 3\,H_2O$

59. $S^{2-} + 4\,Cl_2 + 8\,OH^- \longrightarrow SO_4^{2-} + 8\,Cl^- + 4\,H_2O$

60. $4\,Zn + NO_3^- + 6\,H_2O + 7\,OH^- \longrightarrow 4\,Zn(OH)_4^{2-} + NH_3$

61. $2\,KOH + Cl_2 \longrightarrow KCl + KClO + H_2O$

62. $4\,As + 3\,ClO_3^- + 6\,H_2O + 3\,H^+ \longrightarrow 4\,H_3AsO_3 + 3\,HClO$

63. $2\,MnO_4^- + 10\,Cl^- + 16\,H^+ \longrightarrow 2\,Mn^{2+} + 5\,Cl_2 + 8\,H_2O$

64. $Cl_2O_7 + 4\,H_2O_2 + 2\,OH^- \longrightarrow 2\,ClO_2^- + 4\,O_2 + 5\,H_2O$

Free Response:

1. $2\,Bz + 3\,Yz^{2+} \longrightarrow 2\,Bz^{3+} + 3\,Yz$
Bz is above Yz in the activity series.

2. (a) $2\,Al(s) + 3\,Fe(NO_3)_2(aq) \longrightarrow 2\,Al(NO_3)_3(aq) + 3\,Fe(s)$
(b) The initial solution of $Fe(NO_3)_2$ will have the lower freezing point. It has more particles in solution than the product.

3. (a) $pH = -\log[H^+] = -\log[0.10] = 1.00$
(b) $\text{mol HCl} = 0.050\text{ L} \times \dfrac{0.10\text{ mol}}{\text{L}} = 0.0050\text{ mol HCl}$

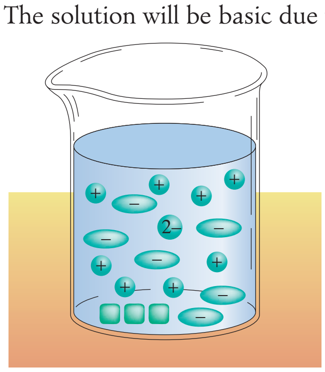
Flask A
$Zn(s) + 2\,HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$
HCl is the limiting reactant, so no HCl will remain in the product.
pH = 7.0

Flask B
No reaction occurs in flask B, so the pH does not change.
pH = 1.00

4. (a) $2\,NaOH(aq) + H_2S(aq) \longrightarrow Na_2S(aq) + 2\,H_2O(l)$
(b) $H_2S \rightleftharpoons 2H^+ + S^{2-}$ (aqueous solution)
$Na_2S \longrightarrow 2\,Na^+ + S^{2-}$ (aqueous solution)
The addition of S^{2-} to a solution of H_2S will shift the equilibrium to the left, reducing the $[H^+]$ and thereby increasing the pH (more basic).

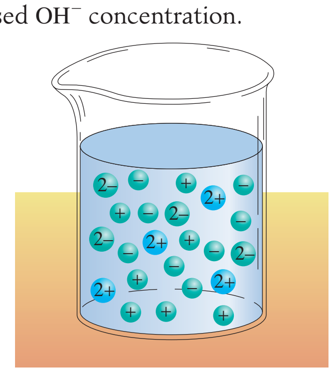
5. (a) Yes. The K_{eq} of AgCN indicates that it is slightly soluble in water, so a precipitate will form.
Net ionic equation: $Ag^+(aq) + CN^-(aq) \rightleftharpoons AgCN(s)$
(b) NaCN is a salt of a weak acid and a strong base and will hydrolyze in water.
$CN^-(aq) + H_2O(l) \rightleftharpoons HCN(aq) + OH^-(aq)$
The solution will be basic due to increased OH^- concentration.

6. (a)



= $PbSO_4(s)$

(b)



No reaction—contents are merely mixed.

7. (a) $2\,A_3X \rightleftharpoons 2\,A_2X + A_2$

$$K_{eq} = \frac{(A_2X)^2(A_2)}{(A_3X)^2} = \frac{(3)^2(6)}{(4)^2} = 3.375$$

(b) The equilibrium lies to the right. $K_{eq} > 1$

(c) Yes, it is a redox reaction because the oxidation state of A has changed. The oxidation state of A in A_2 must be 0, but the oxidation state of A in A_3X is not 0.

8. (a) $X_2 + 2\,G \rightleftharpoons X_2G_2$

$$K_{eq} = \frac{(X_2G_2)}{(X_2)(G)^2} = \frac{(1)}{(3)(2)^2} = 8.33 \times 10^{-2}$$

(b) Exothermic. An increase in the amount of reactants means that the equilibrium shifted to the left.

(c) An increase in pressure will cause an equilibrium to shift by reducing the number of moles of gas in the equilibrium. If the equilibrium shifts to the right, there must be fewer moles of gas in the product than in the reactants.

9. The pH of the solution is 4.5. (Acid medium)

$$5\,Fe^{2+} + MnO_4^- + 8\,H^+ \longrightarrow 5\,Fe^{3+} + Mn^{2+} + 4\,H_2O$$