# Sharyland ISD
# Study Guide

# Chemistry
# Semester 2

Student Name: _____

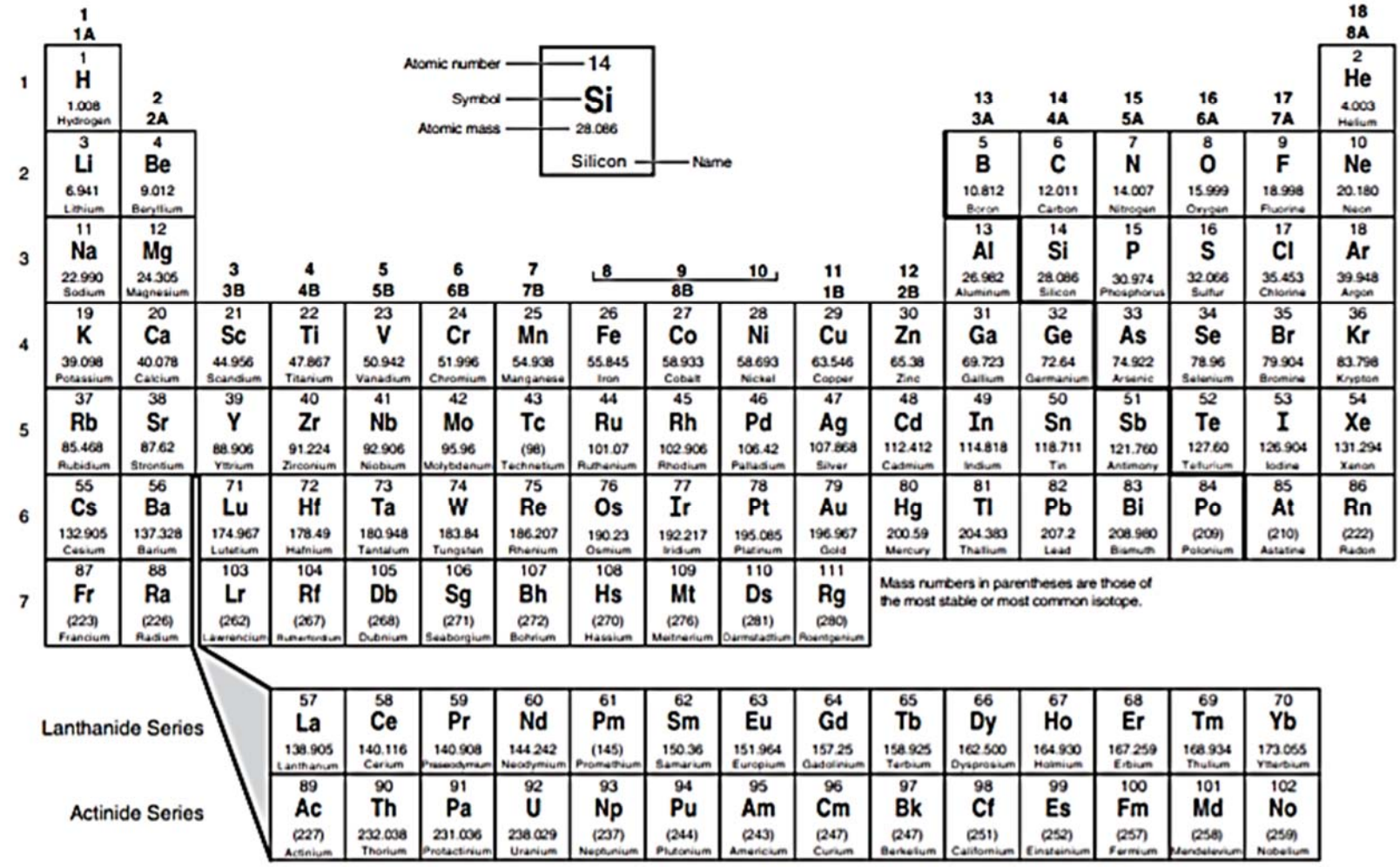
Student ID: _____

In order to be successful in passing the Biology Credit by exam it is recommended that you spend some time working and studying on this review. The following resources can help you review for the exam. This review contains vocabulary as well as practice problems.

- ***Textbook:*** Modern Chemistry © 2015 by Houghton Mifflin Harcourt Publishing Company (available at HS) ISBN: 978-0-544-02376-5
- ***Scientific Calculator*** – will **NOT** be provided and must bring your own on the day of the exam.
- ***Periodic Table of Elements (See Below)*** – Table will be allowed as reference on the day of the exam.
- ***Ionic Reference Sheet (See Below)*** – Sheet will be allowed as reference on the day of the exam.
- ***Solubility Reference Sheet (See below)*** – Sheet will be allowed as reference on the day of the exam.
- ***Formula and Consstants Sheet (See below)*** – Sheets will be allowed as reference on the day of the exam.

****Please keep in mind that the following review has guiding questions and vocabulary that will help you get ready for the exam, however, Semester 1 covers chapters 8-16 of the book aforementioned and it would be a good idea to read and study the chapters in their entirety.**

## PERIODIC TABLE OF THE ELEMENTS



# IONS AND THEIR CHARGES

## Cations

| ±1 | ±2 | ±3 | ±4 |
|---|---|---|---|
| All Group IA | All Group 2A | $Fe^{+3}$ iron(III) | $Pb^{+4}$ lead(IV) |
| $Ag^{+}$ silver (I) | $Cu^{+2}$ copper(II) | $Cr^{+3}$ chromium(III) | $Sn^{+4}$ tin(IV) |
| $NH_4^{+}$ ammonium | $Fe^{+2}$ iron(II) | $Al^{+3}$ aluminum | |
| $H_3O^{+}$ hydronium | $Hg_2^{+2}$ mercury(I) | $Mn^{+3}$ manganese(III) | |
| $Cu^{+}$ copper(I) | $Hg^{+2}$ mercury(II) | $Co^{+3}$ cobalt(III) | |
| | $Pb^{+2}$ lead(II) | | |
| | $Sn^{+2}$ tin(II) | | |
| | $Cr^{+2}$ chromium(II) | | |
| | $Mn^{+2}$ manganese(II) | | |
| | $Co^{+2}$ cobalt(II) | | |
| | $Zn^{+2}$ zinc(II) | | |
| | $Cd^{+2}$ cadmium(II) | | |

## Anions

| -1 | -2 | -3 |
|---|---|---|
| $H^-$ hydride | $O^{-2}$ oxide | $PO_4^{-3}$ phosphate |
| $F^-$ fluoride | $O_2^{-2}$ peroxide | $PO_3^{-3}$ phosphite |
| $Cl^-$ chloride | $S^{-2}$ sulfide | $N^{-3}$ nitride |
| $Br^-$ bromide | $HPO_4^{-2}$ hydrogen phosphate | $P^{-3}$ phosphide |
| $I^-$ iodide | $C_2O_4^{-2}$ oxalate | |
| $HCO_3^-$ hydrogen carbonate | $SO_4^{-2}$ sulfate | |
| $C_2H_3O_2^-$ acetate | $SO_3^{-2}$ sulfite | |
| $NO_3^-$ nitrate | $CO_3^{-2}$ carbonate | |
| $NO_2^-$ nitrite | $CrO_4^{-2}$ chromate | |
| $CN^-$ cyanide | $Cr_2O_7^{-2}$ dichromate | |
| $OH^-$ hydroxide | | |
| $MnO_4^-$ permanganate | | |
| $HSO_4^-$ hydrogen sulfate | | |
| $HSO_3^-$ hydrogen sulfite | | |
| $ClO_4^-$ perchlorate | | |
| $ClO_3^-$ chlorate | | |
| $ClO_2^-$ chlorite | | |
| $ClO^-$ hypochlorite | | |

## Common Acids

Hydrochloric Acid — $HCl$
Sulfuric Acid — $H_2SO_4$
Nitric Acid — $HNO_3$
Acetic Acid — $HC_2H_3O_2$
Phosphoric Acid — $H_3PO_4$

## POLYATOMIC IONS

| | |
|---|---|
| Acetate | $C_2H_3O_2^-$, $CH_3COO^-$ |
| Ammonium | $NH_4^+$ |
| Carbonate | $CO_3^{2-}$ |
| Chlorate | $ClO_3^-$ |
| Chlorite | $ClO_2^-$ |
| Chromate | $CrO_4^{2-}$ |
| Cyanide | $CN^-$ |
| Dichromate | $Cr_2O_7^{2-}$ |
| Hydrogen carbonate | $HCO_3^-$ |
| Hydroxide | $OH^-$ |
| Hypochlorite | $ClO^-$ |
| Nitrate | $NO_3^-$ |
| Nitrite | $NO_2^-$ |
| Perchlorate | $ClO_4^-$ |
| Permanganate | $MnO_4^-$ |
| Phosphate | $PO_4^{3-}$ |
| Sulfate | $SO_4^{2-}$ |
| Sulfite | $SO_3^{2-}$ |

## SOLUBILITY OF COMMON IONIC COMPOUNDS IN WATER

| Soluble compounds contain | Common exceptions |
|---|---|
| $C_2H_3O_2^-$, $CH_3COO^-$ | None |
| $NH_4^+$ | None |
| $NO_3^-$ | None |
| $CN^-$ | None |
| $ClO^-$ | None |
| $ClO_2^-$ | None |
| $ClO_3^-$ | None |
| $ClO_4^-$ | None |
| $Br^-$ | Compounds of $Ag^+$, $Pb^{2+}$, and $Hg_2^{2+}$ |
| $Cl^-$ | Compounds of $Ag^+$, $Pb^{2+}$, and $Hg_2^{2+}$ |
| $I^-$ | Compounds of $Ag^+$, $Pb^{2+}$, and $Hg_2^{2+}$ |
| $SO_4^{2-}$ | Compounds of $Sr^{2+}$, $Ba^{2+}$, $Pb^{2+}$, and $Hg_2^{2+}$ |

| Insoluble compounds contain | Common exceptions |
|---|---|
| $CO_3^{2-}$ | Compounds of $NH_4^+$ and the alkali metal cations |
| $PO_4^{3-}$ | Compounds of $NH_4^+$ and the alkali metal cations |
| $CrO_4^{2-}$ | Compounds of $NH_4^+$ and the alkali metal cations |
| $Cr_2O_7^{2-}$ | Compounds of $NH_4^+$ and the alkali metal cations |
| $OH^-$ | Compounds of $NH_4^+$, the alkali metal cations, $Ca^{2+}$, $Sr^{2+}$, and $Ba^{2+}$ |
| $S^{2-}$ | Compounds of $NH_4^+$, the alkali metal cations, $Ca^{2+}$, $Sr^{2+}$, and $Ba^{2+}$ |

## ACTIVITY SERIES

**Metal**

Lithium
Potassium
Barium
Calcium
Sodium
Magnesium
Aluminum
Manganese
Zinc
Chromium
Iron
Cobalt
Nickel
Tin
Lead
(Hydrogen)
Copper
Mercury
Silver
Platinum
Gold

Increasing Activity

( theoretical yield )

## CONSTANTS AND CONVERSIONS

Avogadro's number = $6.02 \times 10^{23}$ particles per mole

$h$ = Planck's constant = $6.63 \times 10^{-34}$ J · s

$c$ = speed of light = $3.00 \times 10^8 \frac{m}{s}$

$K_w$ = ionization constant of water = $1.00 \times 10^{-14} \left(\frac{mol}{L}\right)^2$

alpha particle ($\alpha$) = ${}^4_2He$ beta particle ($\beta$) = ${}^0_{-1}e$ neutron = ${}^1_0n$

standard temperature and pressure (STP) = 0°C and 1 atm

0°C = 273 K

volume of ideal gas at STP = $22.4 \frac{L}{mol}$

$1\ cm^3 = 1\ mL = 1\ cc$

1 atm = 760 mm Hg = 101.3 kPa

$R$ = ideal gas constant = $0.0821 \frac{L \cdot atm}{mol \cdot K} = 8.31 \frac{L \cdot kPa}{mol \cdot K} = 62.4 \frac{L \cdot mm\ Hg}{mol \cdot K}$

1 calorie (cal) = 4.18 joules (J)

1000 calories (cal) = 1 Calorie (Cal) = 1 kilocalorie (kcal)

(wavelength) photon $\lambda$

## BEHAVIOR OF GASES

Total pressure of a gas = (sum of the partial pressures of the component gases) $P_T = P_1 + P_2 + P_3 + \ldots$

(Pressure)(volume) = (moles)(ideal gas constant)(temperature) $PV = nRT$

$$\frac{(\text{Initial pressure})(\text{initial volume})}{(\text{Initial moles})(\text{initial temperature})} = \frac{(\text{final pressure})(\text{final volume})}{(\text{final moles})(\text{final temperature})} \qquad \frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

(Initial pressure)(initial volume) = (final pressure)(final volume) $P_1V_1 = P_2V_2$

$$\frac{(\text{Initial volume})}{(\text{Initial temperature})} = \frac{(\text{final volume})}{(\text{final temperature})} \qquad \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{(\text{Initial volume})}{(\text{Initial moles})} = \frac{(\text{final volume})}{(\text{final moles})} \qquad \frac{V_1}{n_1} = \frac{V_2}{n_2}$$

## SOLUTIONS

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liter of solution}} \qquad M = \frac{\text{mol}}{\text{L}}$$

Ionization constant of water = (hydrogen ion concentration)(hydroxide ion concentration) $K_w = [H^+][OH^-]$

(Volume of solution 1)(molarity of solution 1) = (volume of solution 2)(molarity of solution 2) $V_1M_1 = V_2M_2$

pH = –logarithm (hydrogen ion concentration) $pH = -\log[H^+]$

## THERMOCHEMISTRY

Heat gained or lost = (mass)(specific heat)(change in temperature) $Q = mc_p\Delta T$

Enthalpy of reaction = (enthalpy of products) – (enthalpy of reactants) $\Delta H = \Delta H_f^o(\text{products}) - \Delta H_f^o(\text{reactants})$

# Chapter 8 – Chemical Equations and Reactions

***Vocabulary***

| | | |
|---|---|---|
| Chemical Equation | Precipitate | Coefficient |
| Synthesis Reaction | Decomposition Reaction | Single-Replacement Reaction |
| Double-Replacement Reaction | Combustion Reaction | Activity Series |

***Questions***

1. Write formulas for each of the following compounds:
   a. Postassium hydroxide  b. calcium nitrate  c. sodium carbonate
   d. carbon tetrachloride  e. magnesium bromide

2. How many atoms of each type are represented in each of the following:
   a. $3N_2$  b. $2H_2O$  c. $4HNO_3$  d. $2Ca(OH)_2$  e. $3Ba(ClO_3)_2$
   d. $5Fe(NO_3)_2$  e. $4Mg_3(PO_4)_2$  h. $2(NH_4)2SO_4$  i. $6Al_2(SeO_4)_3$
   j. $4C_3H_8$

3. Translate each of the following chemical equations into a sentence.
   a. $2ZnS\ (s) + 3O_2\ (g) \rightarrow 3ZnO\ (s) + 2SO_2\ (g)$
   b. $CaH_2\ (s) + 2H_2O\ (l) \rightarrow Ca(OH)_2\ (aq) + 2H_2\ (g)$
   c. $AgNO_3\ (aq) + KI\ (aq) \rightarrow AgI\ (s) + KNO_3\ (aq)$

4. Balance each of the following
   a. $H_2 + Cl_2 \rightarrow HCl$
   b. $Al + Fe_2O_3 \rightarrow Al_2O_3 + Fe$
   c. $Pb(CH_3COO)_2 + H_2S \rightarrow PbS + CH_3COOH$

5. Write balanced chemical equations for each of the following sentences:
   a. Aluminum reacts with oxygen gas to produce aluminum oxide
   b. Phosphoric Acid is produced through the reaction between tetraphosphorus decoxide and water
   c. Iron (III) oxide reacts with carbon monoxide to produce iron and carbon dioxide

6. Complete and balance the equation for the following single replacement reactions:
   a. $Zn + Pb(NO_3)_2 \rightarrow$ _____
   b. $Al + Hg(CH_3COO)_2 \rightarrow$ _____
   c. $Al + NiSO_4 \rightarrow$ _____
   d. $Na + H_2O \rightarrow$ _____

7. Complete and balance the equations for the following double replacement reactions:
   a. $AgNO_3\ (aq) + NaCl\ (aq) \rightarrow$ _____
   b. $Mg(NO_3)_2\ (aq) + KOH\ (aq) \rightarrow$ _____
   c. $LiOH\ (aq) + Fe(NO_3)_3\ (aq) \rightarrow$ _____

8. Complete and balance the equations for the following combustion reactions:
    a. $CH_4 + O_2 \rightarrow$ _____
    b. $C_3H_6 + O_2 \rightarrow$ _____
    c. $C_5H_{12} + O_2 \rightarrow$ _____

9. Using the activity series provided in the reference in this review, predict whether each of the possible reactions listed below will occur. For the reactions that will occur, write the products and balance the equation.
    a. Ni (s) + $CuCl_2$ (aq) → _____
    b. Zn (s) + $Pb(NO_3)_2$ (aq) → _____
    c. Cu (s) + $FeSO_4$ (aq) → _____
    d. Ba (s) + $H_2O$ (l) → _____

10. Write and balance each of the following equations, and then identify each type.
    a. copper + chlorine gas → copper (II) chloride
    b. calcium chlorate → calcium chloride + oxygen gas
    c. lithium + water → lithium hydroxide + hydrogen gas
    d. lead (II) carbonate → lead(II)oxide + carbon dioxide

## Chapter 9 – Stoichiometry

***Vocabulary***

| | | |
|---|---|---|
| Mole Ratio | Limiting Reactant | Excess Reactant |
| Theoretical Yield | Actual Yield | Percentage Yield |

***Questions***

1. Hydrogen and oxygen react under a specific set of conditions to produce water according to the following: $2H_2$ (g) + $O_2$ (g) → $2H_2O$ (g)

    a. How many moles of hydrogen would be required to produce 5.0 mol of water?
    b. How many moles of oxygen would be required?

2. Sodium chloride is produced from its elements through the following synthesis reaction: 2Na (s) + $Cl_2$ (g) → 2NaCl (aq). What mass in grams of each reactant would be required to produce 25.0 mol of sodium chloride.

3. During lightning flashes, nitrogen gas combines with oxygen gas in the atmosphere to form nitrogen monoxide, NO, which then react further with $O_2$ to produced nitrogen dioxide, $NO_2$.

    a. What mass of Now is formed when NO reacts with 384 g of $O_2$?
    b. How many grams of NO are required to react with this amount of $O_2$?

4. Sulfuric acid reacts with sodium hydroxide according to the following:

$$H_2SO_4 + NaOH \rightarrow Na_2SO_4 + H_2O$$

a. Balance the equation for this reaction.
b. What mass in grams of $H_2SO_4$ would be required to react with 0.75 mol NaOH?
c. What mass in grams of each product is formed by this reaction?

5.

a. If 2.50 mol of copper and 5.50 mol of silver nitrate are available to react by single replacement, identify the limiting reactant.
b. Determine the amount in moles of excess reactant remaining.
c. Determine the amount in moles of each product formed.
d. Determine the mass in grams of each product formed.

6. Sulfuric acid reacts with aluminum hydroxide by double replacement.

a. If 30.0 g of sulfuric acid reacts with 25.0 g of aluminum hydroxide, identify the limiting reactant.
b. Determine the mass in grams of excess reactant remaining.
c. Determine the mass in grams of each produce formed.

7. Chlorobenzene, $C_6H_5Cl$, is used in the production of many important chemicals, such as aspirin, dyes, and disinfectants. One industrial method of preparing chlorobenzene is to react benzene, $C_6H_6$, with chlorine., as represented by the following equation:

$$C_6H_6 (l) + Cl_2 (g) \rightarrow C_6H_5Cl (l) + HCl (g)$$

When 36.8 g of benzene reacts with an excess of $Cl_2$, the actual yield of chlorobenzene is 38.8 g. What is the percentage yield of chlorobenzene?

## Chapter 10 – States of Matter

***Vocabulary***

| | | |
|---|---|---|
| Kinetic Molecular Theory | Ideal Gas | Evaporation |
| Freezing | Melting | Condensation |
| Boiling | | |

# Chapter 11 – Gases

***Vocabulary***

| | | |
|---|---|---|
| Pressure | atmospheres of pressure | Dalton's Law of Partial Pressures |
| Boyle's Law | Charles's Law | Gay-Lussac's Law |
| Combined Gas Law | Avogadro's Law | STP |
| Ideal Gas Law | Ideal Gas Constant | mm Hg |
| Kelvin Temperature | Celsius Temperature | Fahrenheit Temperature |

***Questions***

1. Convert each of the following into a pressure reading expressed in torrs.
   a. 1.25 atm  b. $2.48 \times 10^{-3}$ atm  c. $4.75 \times 10^{4}$ atm  d. $7.60 \times 10^{6}$ atm

2. Convert each of the following into the unit specified.
   a. 123 mmHg into atmospheres
   b. 3.20 atm into pascals
   c. 5.38 kPa into mm Hg

3. A sample of air has a volume of 140 mL at 67°C. At what temperature would its volume be 50.0 mL at constant pressure?

4. The pressure exerted on a 240.0 mL sample of hydrogen gas at constant temperature is increased from 0.428 atm to 0.724 atm. What will the final volume of the sample be?

5. A sample of hydrogen at 47°C exerts a pressure of 0.329 atm. The gas I heated to 77°C at constant volume. What will the new pressure be?

6. A sample of gas at 47°C and 1.03 atm occupies a volume of 2.20 L. What volume would this gas occupy at 107°C and 0.789 atm?

7. How many molecules would be contained in each of the following at the same temperature and pressure?
   a. 5.0 L $H_2$  b. 5.0 L $CO_2$  c. 10.0 L $NH_3$

8. How many moles are contained in each of the following at STP?
   a. 22.4 L $N_2$  b. 5.60 L $Cl_2$  c. 0.125 L Ne

9. Find the mass in grams of each of the following at STP.
   a. 11.2 L $H_2$  b. 2.80 L $CO_2$

10. Find the volume, in liters, of each of the following at STP.
    a. 8.00 g $O_2$  b. 3.50 g CO  c. 0.0170 g $H_2S$

11. Determine the number of moles of gas contained in each of the following:
    a. 1.25 L at 250.0 K and 1.06 atm
    b. 0.80 L at 27°C and 0.925 atm

12. Find the mass of each of the following:
    a. 5.60 L $O_2$ at 1.75 atm and 250.0 K
    b. 3.50 L $NH_3$ at 0.921 atm and 27°C

## Chapter 12 – Solutions

***Vocabulary***

| | | |
|---|---|---|
| soluble | solution | solvent |
| solute | electrolyte | nonelectrolyte |
| saturated solution | unsaturated solution | supersaturated solution |
| solubility | immiscible | miscible |
| concentration | molarity | dilution |

***Questions***

1.
    a. Suppose you wanted to dissolve 106 g of $Na_2CO_3$ in enough $H_20$ to make 6.00 L of solution.
        i. What is the molar mass of $Na_2CO_3$?
        ii. What is the molarity of the solution?
    b. What is the molarity of a solution of 14.0 g of $NH_4Br$ in enough water to make 150.mL of solution?
2.
    a. Suppose you wanted to prepare 1.00 L of a 3.50 M aqueous solution of $H_2SO_4$.
        i. What is the solute?
        ii. What is the solvent?
        iii. How many grams of solute are needed to make this solution?
    b. How many grams of solute are needed to make 3.50 L of a 1.75 M solution of $Ba(NO_3)_2$?

3. How many moles of NaOH are contained in 65.0 mL of a 2.20 M solution of NaOH in water?

4. A solution is made by dissolving 26.42 g of $(NH_4)_2SO_4$ in enough water to make 50.00 mL of solution.
    a. What is the molar mass of $(NH_4)_2SO_4$?
    b. What is the molarity of the solution?

## Chapter 13 – Ions in Aqueous Solutions and Colligative Properties

***Vocabulary***

| | | |
|---|---|---|
| net ionic equation | spectator ions | strong electrolyte |
| weak electrolyte | | |

***Questions***

1. Use the reference sheet provided at the beginning of this review to predict whether each of the following compounds is considered soluble or insoluble.

   a. KCl b. $NaNO_3$ c. AgCl d. $BaSO_4$ e. $Ca_3(PO_4)_2$ f. $Pb(ClO_3)_2$
   g. $(NH_4)_2S$ h. $PbCl_2$ (in cold water) i. FeS j. $Al_2(SO_4)_3$

2. Using the reference sheet provided at the beginning of this review, write the balanced chemical equation , write the overall ionic equation, identify the spectator ions and possible precipitates, and write the net ionic equation for each of the following reactions:

   a. Mercury(II) chloride (aq) + potassium sulfide (aq) →
   b. Sodium carbonate (aq) + calcium chloride (aq) →
   c. Copper(II) chloride (aq) + ammonium phosphate (aq) →

## Chapter 14 – Acids and Bases

***Vocabulary***

| | | |
|---|---|---|
| strong acid | weak acid | Arrhenius Acid |
| Arrhenius Base | monoprotic acid | diprotic acid |
| triprotic acid | neutralization | salt |

***Questions***

1. Complete the following neutralization reactions
   a. HCl (aq) + NaOH (aq) → _____
   b. $HNO_3$ (aq) + KOH (aq) → _____
   c. $Ca(OH)_2$ (aq) + $HNO_3$ (aq) → _____
   d. $Mg(OH)_2$ (aq) + HCl (aq) → _____

# Chapter 15 – Acid-Base Titration and pH

***Vocabulary***

| | | |
|---|---|---|
| pH | pOH | pH meter |
| pH scale | Acid Properties | Base Properties |

***Questions***

1. Identify each of the following solutions as acidic, basic, or neutral at room temperature:

   a. $[H_3O^+] = 1.0 \times 10^{-7}$ M  b. $[H_3O^+] = 1.0 \times 10^{-10}$ M
   c $[OH^-] = 1.0 \times 10^{-7}$ M  d. $[OH^-] = 1.0 \times 10^{-11}$ M
   e $[H_3O^+] = [OH-]$  f. pH = 3.0  g. pH = 13.0

2. Calculate the $[H_3O^+]$ and the $[OH^-]$ for each of the following:

   a. 0.030 M HCl  b. $1.0 \times 10^{-4}$M NaOH  c. $5.0 \times 10^{-3}$ $HNO_3$  d. 0.010 M $Ca(OH)_2$

3. Determine the pH of each of the following solutions:

   a. $1.0 \times 10^{-2}$ M HCl  b. $1.0 \times 10^{-3}$ $HNO_3$  c. $1.0 \times 10^{-5}$ M HI  d. $1.0 \times 10^{-4}$ M HBr

4. Given the following $[OH^-]$ values, determine the pH of each solution.

   a. $1.0 \times 10^{-6}$ M  b. $1.0 \times 10^{-9}$ M  c. $1.0 \times 10^{-2}$ M  d. $1.0 \times 10^{-7}$ M

5. Determine the pH of each solution.

   a. $1.0 \times 10^{-2}$ M NaOH  b. $1.0 \times 10^{-3}$ M KOH  c. $1.0 \times 10^{-4}$ M LiOH

6. Given the following pH values, determine the [OH-] for each solution:

   a. 7.00  b. 11.00  c. 4.00  d. 6.00

7. Determine [H3O+] for solutions with the following pH values
   a. 4.23  b. 7.65  c. 9.48

8. What is the pH of a solution in which $[OH^-]$ equals $6.9 \times 10^{-10}$M?

## Chapter 16 – Reaction Energy

***Vocabulary***

| | | |
|---|---|---|
| thermochemistry | temperature | joule |
| heat | specific heat | enthalpy change |
| enthalpy of reaction | thermochemical equation | endothermic |
| exothermic | | |

***Questions***

1. How much energy is needed to raise the temperature of a 55 g sample of aluminum from 22.4 °C to 94.6°C? The specific heat for aluminum is 0.897 j/g°C.

2. If 3.5 kJ of energy are added to a 28.2 g sample of iron at 20. °C, what is the final temperature of the iron in kelvins? The specific heat of iron is 0.449 J/g°C.

3. You need 70.2 J to raise the temperature of 34.0 g of ammonium from 23.0°C to 24.0°C. Calculate the specific heat for ammonia.

4. For each equation listed below, determine the ΔH and type of reaction (endothermic or exothermic).
   a. $C(s) + O_2(g) \rightarrow CO_2(g) + 393.51\ kJ$
   b. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) + 890.31\ kJ$
   c. $CaCO_3(s) + 176\ kJ \rightarrow CaO(s) + CO_2(g)$
   d. $H_2O(g) \rightarrow H_2O(l) + 44.02\ kJ$

5. Use the Heat of Formation reference sheet provided below to calculate the enthalpy of reaction for each of the following (if the heat of formation for a compound is not found on the sheet provided please refer to Appendix Table B-14 in the book):

   a. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
   b. $Ca(OH)_2(s) \rightarrow CaO(s) + H_2O(g)$
   c. $Fe_2O_3(s) + 3CO(g) \rightarrow 2\ Fe(s) + 3CO_2(g)$

| Substance | $\Delta H_f^0$ (kJ/mol) | Substance | $\Delta H_f^0$ (kJ/mol) | Substance | $\Delta H_f^0$ (kJ/mol) |
|---|---|---|---|---|---|
| $Al_2O_3$ (s) | -1676.0 | Fe (s) | 0.0 | NO (g) | 90.37 |
| $Br_2$ (g) | 30.91 | $Fe_2O_3$ (s) | -822.1 | $NO_2$ (g) | 33.85 |
| $Br_2$ (l) | 0.0 | $H_2$ (g) | 0.0 | $Na_2CO_3$ (s) | -1131.1 |
| C (s, diamond) | 1.9 | $H_20$ (g) | -241.8 | NaCl (s) | -411.2 |
| C (s, graphite) | 0.0 | $H_20$ (l) | -285.8 | $O_2$ (g) | 0.0 |

| | | | | | |
|---|---|---|---|---|---|
| $CH_4$ (g) | -74.86 | $H_2O_2$ (l) | -187.8 | $O_3$ (g) | 142.0 |
| CO (g) | -110.5 | HCl (g) | -92.31 | P (s, white) | 0.0 |
| $CO_2$ (g) | -393.5 | $H_2S$ (g) | -20.1 | P (s, red) | -18.4 |
| $CaCO_3$ (s) | -1207.0 | $I_2$ (g) | 62.4 | S (s, rhombic) | 0.0 |
| CaO (s) | -635.1 | $I_2$ (s) | 0.0 | S (s, monoclinic) | 0.30 |
| $Cl_2$ (g) | 0.0 | $N_2$ (g) | 0.0 | $SO_2$ (g) | -296.8 |
| $F_2$ (g) | 0.0 | $NH_3$ (g) | -46.19 | $SO_3$ (g) | -395.7 |

ANSWERS:

Chapter 8

1.
   a. KOH  b. $Ca(NO_3)_3$  c. $Na_2CO_3$  d. $CCl_4$  e. $MgBr_2$
2.
   a. 6N  b. 4H, 2O  c. 4H, 4N, 12O  d. 2Ca, 4O, 4H  e. 3Ba, 5Cl, 18O
   f. 5Fe, 10N, 30O  g. 12Mg, 8P,32O  h. 4N, 16H, 2S, 8O
   i. 12Al, 18Se, 72O  j. 12C, 32H

3.
   a. Solid zinc sulfide reacts with oxygen gas to form solid zinc oxide and sulfur dioxide gas.
   b. When solid calcium hydride is added to water, aqueous calcium hydroxide and hydrogen gas are formed.
   c. Aqueous silver nitrate mixed with aqueous potassium iodide produces a precipitate of silver iodide and aqueous potassium nitrate.
4.
   a. $H_2 + Cl_2 \rightarrow 2HCl$
   b. $2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$
   c. $Pb(CH_3COO)_2 + H_2S \rightarrow PbS + 2CH_3COOH$
5.
   a. $4Al + 3O_2 \rightarrow 2Al_2O_3$
   b. $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$
   c. $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
6.
   a. $Zn + Pb(NO_3)_2 \rightarrow Pb + Zn(NO_3)_2$
   b. $2Al + 3Hg(CH_3COO)_2 \rightarrow 3Hg + 2Al(CH_3COO)_3$
   c. $2Al + 3NiSO_4 \rightarrow 3Ni + Al_2(SO_4)_3$
   d. $2Na + 2H_2O \rightarrow 2NaOH + H_2$
7.
   a. $AgNO_3\ (aq) + NaCl\ (aq) \rightarrow NaNO_3\ (aq) + AgCl\ (s)$
   b. $Mg(NO_3)_2\ (aq) + 2KOH\ (aq) \rightarrow Mg(OH)_2\ (s) + 2KNO_3\ (aq)$
   c. $3LiOH\ (aq) + Fe(NO_3)_3\ (aq) \rightarrow Fe(OH)_3\ (s) + 3LiNO_3\ (aq)$
8.
   a. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
   b. $2C_3H_6 + 9O_2 \rightarrow 6CO_2 + 6H_2O$
   c. $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$
9.
   a. $Ni\ (s) + CuCl_2\ (aq) \rightarrow NiCl_2\ (aq) + Cu\ (s)$
   b. $Zn\ (s) + Pb(NO_3)_2\ (aq) \rightarrow Zn(NO_3)_2\ (aq) + Pb\ (s)$
   c. $Cu\ (s) + FeSO_4\ (aq) \rightarrow$ no reaction
   d. $Ba\ (s) + 2H_2O\ (l) \rightarrow H_2\ (g) + Ba(OH)_2\ (s)$

10.

a. $Cu\ (s) + Cl_2\ (g) \rightarrow CuCl_2\ (s)$; synthesis reaction
b. $Ca(ClO_3)_2\ (s) \rightarrow CaCl_2\ (s) + 3O_2\ (g)$; decomposition reaction
c. $2Li\ (s) + 2H_2O\ (l) \rightarrow 2LiOH\ (aq) + H_2\ (g)$; single replacement reaction
d. $PbCO_3\ (s) \rightarrow PbO\ (s) + CO_2\ (g)$; decomposition reaction

## Chapter 9

1.

a. 5.0 mol $H_2$ b. 2.5 mol $O_2$

2. 575 g Na, 886 g $Cl_2$
3.

a. $1.10 \times 10^3$ g $NO_2$ b. 720. g NO

4.

a. $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$
b. 37 g $H_2SO_4$
c. 53 g $Na_2SO_4$, 14 g $H_2O$

5.

a. Cu is the limiting reactant.
b. 0.50 mol $AgNO_3$
c. 2.5 mol $ZnCl_2$, 2.5 mol $H_2$
d. 2.0 mol $Fe2(SO_4)_3$, 12 mol $H_2O$

6.

a. $H_2SO_4$ is the limiting reactant
b. 9.05 g excess $Al(OH)_3$
c. 34.9 g $Al_2(SO_4)_3$, 11.0 g $H_2O$

7. 73.2%

## Chapter 11

1.

a. 950. Torr b. 1.88 Torr c. $3.61 \times 10^7$ Torr d. $5.78 \times 10^9$ Torr

2.

a. 0.164 atm b. $3.24 \times 10^5$ Pa c. 40.4 mmHg

3. 121 K or -152°C
4. 142 mL
5. 0.360 atm
6. 3.41 L
7.

a. $1.08 \times 10^{23}$ molecules $H_2$ b. $1.08 \times 10^{23}$ molecules $CO_2$ c. $2.16 \times 10^{23}$ molecules $NH_3$

8.

a. 1.00 mol $N_2$ b. 0.250 mol $Cl_2$ c. $5.58 \times 10^{-3}$ mol Ne

9.

a. 1.01 g $H_2$ b. 5.50 g $CO_2$

10.

a. 5.60 L $O_2$ b. 2.80 L CO c. 0.0112 L $H_2S$

11.

a. 0.0646 mol b. 0.030 mol

12.

a. 15.3 g $O_2$ 2.23 g $NH_3$

## Chapter 12

1. a(i). 105.1 g/mol a(ii). 0.167 M b. 0.953 M $NH_4Br$

2. a(i). $H_2SO_4$ a(ii). $H_20$ a(iii). 343 g b. 1140 g

3. 0.143 mol NaOH

4. a. 132.16 g/mol b. 3.998 M

## Chapter 13

1. a. soluble b. soluble c. insoluble d. insoluble e. insoluble f. soluble
   g. soluble h. insoluble i. insoluble j. soluble

2.

   a. $HgCl_2\ (aq) + K_2S\ (aq) \rightarrow HgS\ (s) + 2KCl\ (aq)$
   $Hg^{+2}\ (aq) + 2Cl^-\ (aq) + 2K^+\ (aq) + S^{-2}\ (aq) \rightarrow HgS\ (s) + 2K^+\ (aq) + 2Cl^-\ (aq)$
   Spectator Ions: $Cl^-$ and $K^+$
   Precipitate: HgS
   $Hg^{+2}\ (aq) + S^{-2}\ (aq) \rightarrow HgS$

   b. $Na_2CO_3\ (aq) + CaCl_2\ (aq) \rightarrow 2NaCl\ (aq) + CaCO_3\ (s)$
   $2Na^+\ (aq) + CO_3^{-2}\ (aq) + Ca^{+2}\ (aq) + 2Cl^-\ (aq) \rightarrow CaCO_3\ (s) + 2Na^+\ (aq) + 2Cl^-\ (aq)$
   Spectator Ions: $Na^+$ and $Cl^-$
   Precipitate $CaCO_3$
   $Ca^{+2}\ (aq) + CO_3^{-2}\ (aq) \rightarrow CaCO_3\ (s)$

   c. $3CuCl_2\ (aq) + 2(NH_4)_3PO_4\ (aq) \rightarrow Cu_3(PO_4)_2\ (s) + 6NH_4Cl\ (aq)$
   $3Cu^{+2}\ (aq) + 6Cl^-\ (aq) + 6NH_4^+\ (aq) + 2PO_4^{-3}\ (aq) \rightarrow Cu_3(PO_4)_2\ (s) + 6NH_4^+\ (aq) + 6Cl^-(aq)$
   Spectator Ions: $NH_4^+$ and $Cl^-$
   Precipitate: $Cu_3(PO_4)_2$
   $3Cu^{+2}\ (aq) + 2PO_4^{-3}\ (aq) \rightarrow Cu_3(PO_4)_2\ (s)$

## Chapter 14

1.
   a. $HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$
   b. $HNO_3\ (aq) + KOH\ (aq) \rightarrow KNO_2\ (aq) + H_2O\ (l)$
   c. $Ca(OH)_2\ (aq) + 2HNO_3\ (aq) \rightarrow Ca(NO_3)_2\ (aq) + H_2O\ (l)$
   d. $Mg(OH)_2\ (s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + 2H_2O\ (l)$

## Chapter 15

1.
   a. Neutral  b. basic  c. neutral  d. acidic  e. neutral
   f acidic  g. basic

2.
   a. $[H_3O^+] = 3.0 \times 10^{-2}$ M  $[OH^-] = 3.3 \times 10^{-13}$ M
   b. $[H_3O^+] = 1.0 \times 10^{-10}$ M  $[OH^-] = 1.0 \times 10^{-4}$ M
   c. $[H_3O^+] = 5.0 \times 10^{-3}$ M  $[OH^-] = 2.0 \times 10^{-12}$ M
   d. $[H_3O^+] = 5.0 \times 10^{-13}$ M  $[OH^-] = 2.0 \times 10^{-2}$ M

3. a. 2.00  b. 3.00  c. 5.00  d. 4.00
4. a. 8.00  b. 5.00  c. 12.00  d. 7.00
5. a. 12.00  b. 11.00  c. 10.00
6. a. $1.0 \times 10^{-7}$  b. $1.0 \times 10^{-3}$  c. $1.0 \times 10^{-10}$  d. $1.0 \times 10^{-8}$
7. $5.9 \times 10^{-5}$ M  b. $2.2 \times 10^{-8}$ M  c. $3.3 \times 10^{-10}$ M
8. 4.84

## Chapter 16

1. 3.6 x103J
2. 549K
3. 2.1 J/g°C
4.
   a. -393.51 kJ; exothermic
   b. -890.31 kJ; exothermic
   c. +176 kJ; endothermic
   d. -44.01 kJ; exothermic
5.
   a. +179.2 kJ  b. +106.5 kJ  c. -23.5 kJ