Chemistry CP

Name:

Putting It All Together II

Date:

Calculations in Chemistry

It's time to pull out your calculators! In the first review sheet, you were able to write formulas of compounds when different atoms bonded. There are two ways of describing the composition of a compound: a) in terms of the numbers of each atom, or b) in terms of the % of mass of each element (% composition).

Part I: Empirical Formulas, Molecular Formulas, and Percent Composition

Refer to pp. 226-233 in your textbook.

A. Calculate the *percent composition* of the following compounds for each element present.
   1. Propane, C_3H_8 (As a check, the percentages should add up to 100%!)

   2. Sodium sulfate

We can do the reverse now, and find the empirical formula (simplest formula) of a compound from the mass percent.

B. Determine the *empirical formulas* for compounds with the following percent composition.
   1. 27.3% C, 72.3% O

   2. 79.96% C, 9.394%H, 10.65% O

   3. A compound was found to contain 71.65% Cl, 24.27% C and 4.07% H. Use this information to first find its empirical formula.

The empirical formula gives the simplest ratio of atoms, but it may not be the actual number of each atom. For example, 2:1 is the simplest ratio of 4:2 or 6:3. The molecular formula indicates the exact number of each atom.

4. The compound from #3 has a known gram formula mass of 98.96 g/mol. What is its *molecular (true) formula*?

Part II: Stoichiometry

A *balanced* equation allows one to determine the _____ ratio between molecules and atoms in a reaction. Always compare molecules in a balanced equation by using the _____ ratio. Never compare masses! Refer to pp. 275-287 in your textbook.

A. Finding Limiting Reagents—Refer to pp. 288-292 in your textbook.

1. a) Write a balanced equation for the combustion of liquid ethanol, C_2H_5OH.

b) Circle the limiting reagent in each of the following pairs of reagents:

1 mol C_2H_5OH	1 mole O_2
1 mole C_2H_5OH	4 mole O_2
10 g C_2H_5OH	10 g O_2

2. When lithium oxide is added to water, they combine to form lithium hydroxide. If 35.0 g of lithium oxide completely react, how many grams of water also react?

3. If 40.0 g of HCl and 15.0 g of $Al(OH)_3$ react according to the following equation, how many grams of water will be produced? (Hint: first find the limiting reagent)

$3\ HCl + Al(OH)_3 \rightarrow AlCl_3 + 3\ H_2O$

B. Stoichiometry and the Gas Laws—Refer to pp. 333-337 in your textbook.

4. When 50.0 g of toluene, C_7H_8, are burned, how many liters of oxygen gas are being consumed at STP?

C. Stoichiometry and Solutions—Refer to pp. 412-418 in your textbook.

5. When aqueous solutions of lead (II) nitrate and potassium iodide are mixed, a bright yellow precipitate forms.
   a) Write a balanced equation for this reaction.

   b) What is the formula of the precipitate?

   c) If 75.0 mL of 0.50 M lead (II) nitrate are mixed with excess potassium iodide, how many grams of the precipitate should be formed?

D. Stoichiometry and Titrations—Refer to pp. 493-503 in your textbook.

6. A student titrates a hydrochloric acid sample of unknown concentration with a 0.119 M potassium hydroxide solution and obtains the following data.

	Trial 1	Trial 2	Trial 3
Initial acid volume (mL)	0.24	10.35	20.55
Final acid volume (mL)	10.35	20.55	30.34
Total acid volume (mL)			
Initial base volume (mL)	1.54	11.45	21.72
Final base volume (mL)	11.67	21.72	31.55
Total base volume (mL)			

   a. Write a balanced equation to represent the *neutralization* reaction that occurs in this titration.

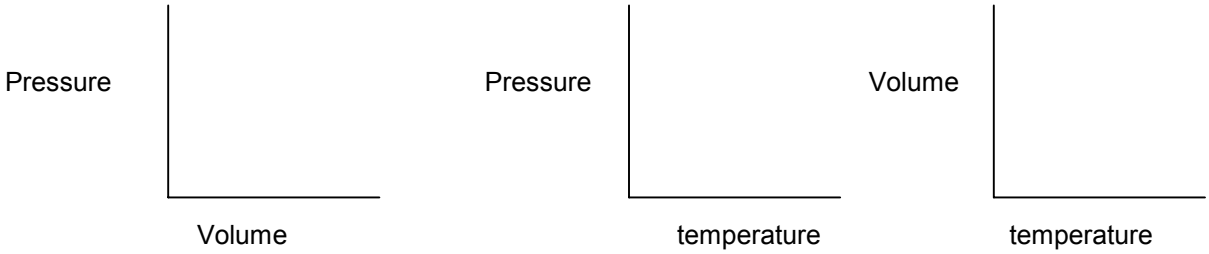
   b. Calculate the molarity of the acid.

Trial 1 Trial 2 Trial 3

Part III: The Gas Laws

A. Summarizing Gas Behavior
There are several properties of gases that can be measured: pressure (force/area), volume, and temperature.

1. The relationships between these properties can be graphed to visualize the relationships:



2. Summarize with equations the relationships between: P & V; P & T; P, V & T; P, V, T & n.

3. Summarize the four points of the kinetic-molecular theory of gases, which are used to explain the behavior of gases.

B) Gas Law Problems

4. Determine the total pressure of a gas mixture that contains oxygen, nitrogen, and helium if the partial pressures of the gases are P_{O2} = 150 mm Hg, P_{N2} = 350 mM Hg, and P_{He} = 200 mm Hg. Give your answer in mm Hg, kPa, and atm.

5. The pressure on 2.50 L of gas is changed from 760 mm Hg to 304 mm Hg. What will be the new volume if the temperature remains constant?

6. If a sample of gas occupies 6.8 L at 327^{o}C, what will be its volume at –35^{o}C if the pressure does not change?

7. A gas has a pressure of 50.0 mm Hg at 540 K. What will be the pressure at 200K if the volume does not change?

8. A container with an initial volume of 1.0 L is occupied by a gas at a pressure of 1.5 atm at 25^{o}C. By changing the volume, the pressure of the gas increases to 6.0 atm as the temperature is raised to 100^{o}C. What is the new volume?

9. A rigid hollow sphere containing 680 L of helium gas has a temperature of 600K and a pressure of 18 atm. How many moles of gas are in the sphere?

<u>Part IV: Actual, Theoretical, and Percent Yield</u>

Throughout the year, you have worked on labs which asked you to calculate actual, theoretical, and percent yields. First, you need to distinguish between the three yields.

Actual yield:
Theoretical yield:
Percent yield: (combination of the above)
Which of these yields depends on the balanced equation?

One lab that you performed several times is reacting hydrochloric acid with a base, either soidum hydrogen carbonate or sodium carbonate. For both reactions, you formed carbon dioxide, water, and sodium chloride. Of the three products formed, you recovered and weighed only the sodium chloride. The carbon dioxide bubbled out and left as the reaction occurred, and the water was removed by heating the solution on a hot plate, leaving only solid sodium chloride in the beaker.

1. Write formulas and calculate the gram formula masses of:
   a) sodium hydrogen carbonate b) sodium carbonate

2. Write the two balanced equations for the above reactions.
   a)

   b)

3. Calculate the theoretical yields for the two above reactions.
   a) How much sodium chloride should *theoretically* be made reactions if you start with 15 g of sodium hydrogen carbonate?

   b) How much sodium chloride should be made if you start with 15 g of sodium carbonate?

4. Below is a sample data table for this lab. For both beakers, calculate the theoretical, actual, and percent yield. Show all calculations.

	Beaker #1 (base = $NaHCO_3$)	Beaker #2 (base = Na_2CO_3)
Mass of empty beaker	45.815	42.030
Mass of beaker & base	47.125	43.115
Mass of base		
Mass of beaker & NaCl	46.450	42.990
Mass of NaCl		

Part V: Radioactive Decay (Refer to pp. 708-710 in your textbook)
What is a half-life?

The carbon in a bone from an ancient campsite is found to contain only one-eighth the proportion of carbon-14 that occurs in organisms living today. Approximately how old is the bone? (The half life of carbon is 5730 years).

Other examples of Calculations in Chemistry covered this term:

- Equilibrium: K_{eq}, K_{sp}
- Energy: Hess' Law (to be covered in a future review sheet)
- Acids/Bases: pH, pOH, $[H_3O^+]$, $[OH^-]$
- Redox: voltaic cells