P D2 (pg 1 of 3) Mass Ratios and % Composition

Name_____Per____

1. In the lab, 0.846 g of calcium reacted to produce 2.340 g of calcium chloride.
   a. Calculate the experimental mass of chlorine.
   b. Calculate the experimental mass ratio of choride to calcium.
   c. Would you expect the chemical formula of calcium chloride to be CaCl or $CaCl_2$? Explain how you decided.

2. The theoretical mass ratio of copper to oxygen in a copper oxide compound is 3.91 / 1.
   a. If you burned a 1.850 g piece of copper in oxygen, what mass of oxygen would combine with the copper?
   b. What would be the total mass of the copper oxide compound after the burn?
   c. Would you expect that the chemical formula for this compound is CuO or CuO_2 ? Explain how you decided.

3. A student determnined that 2.850 g of nickel reacted with 2.343 g of sulfur to produce a nickel sulfide compound.
   a. What is the mass ratio of nickel to copper?
   b. If the student ran a second trial and reacted 0.749 g of nickel, what would be the mass of the nickel sulfide compound?
   c. The student knows that this compound contains three sulfur atoms. Do you suspect the compound contains 1, 2, or 3 nickel atoms?

4. Consider water, H_2O.
   a. Calculate the theoretical mass % composition of water. (That is to say….determine the mass % of each element using the mass values from the periodic table.)
   b. In a 2.86 g sample of water, what is the mass of the oxygen?

5. Consider the compound aluminum nitrate, $Al(NO_3)_3$
   a. Using the mass values from the periodic table, calculate the theoretical mass % composition of each element in this aluminum nitrate, $Al(NO_3)_3$ compound.
   b. In a 12.73 g sample of aluminum nitrate, $Al(NO_3)_3$ what is the mass of the nitrogen in that 12.73 g sample?

6. You experimentally analyzed magnesium oxide and found that it was made of 0.180 g of magnesium and 0.119 g of oxygen.
   a. Calculate the % (by mass) of each compound.
   b. A chemist knew that they had 14.84 g of magnesium oxide, MgO what mass of oxygen is present in the compound?

7. A student studied and aluminum oxygen compound Al_2O_3 .
   a. What mass of aluminum would you be able to extract from 1.65 g of aluminum oxide, Al_2O_3 ?
   b. If you knew that there was 3.62 g of oxygen in another sample of the same aluminum oxide compound, what would expect for the mass of the aluminum oxide that contained that amount of oxygen?

8. Barium hydroxide has the formula, $Ba(OH)_2$.
   a. What is the mass of barium in 26.02 g of barium hydroxide, $Ba(OH)_2$?
   b. If you had 5.78 g of barium, what mass of hydroxide would combine with this barium.
   c. What would be the total mass of barium hydroxide?

9. An 8.55 g sample of copper(II) sulfate pentahydrate, $CuSO_4 \bullet 5\ H_2O$ was heated just as you did in the lab D2 to drive off all the water. The sample lost 3.04 g of water.
   a. Identify the solid, S part of the compound.
   b. Identify the gas, G part of the compound.
   c. Calculate the experimental mass ratio of S/G.
   d. Calculate the theoretical mass ratio of S/G
   e. Calculate the percent error to compare the experimental and theoretical mass ratios.
   f. Look back at your post lab questions, and propose a source of error that could have caused this error.

 Mass Ratios and % Composition ***ANSWERS***

1. For a calcium chloride compound
   a. A simpe subtraction: 2.34 g − 0.846 g = **1.494 g Cl**
   b. $\frac{1.494 gCl}{0.846 gCa} = 1.77$
   c. The chemical formula would be $CaCl_2$. You can tell by looking at the theoretical ratio of the two compounds:
   $CaCl: \frac{35.45 gCl}{40.08 gCa} = 0.88 \qquad CaCl_2: \frac{70.9 gCl}{40.08 gCa} = 1.76$
2. For a copper oxygen compound
   a. Set up a ratio with the given mass ratio $\frac{3.91 gCu}{1 gO} = \frac{1.850 gCu}{x gO} \qquad x = 0.473 gO$
   b. Simply add the mass of the two elements together 3.91 g Cu + 0.473 g O = **4.38 g for the compound**
   c. The chemical formula would be **CuO**. You can tell by calculation at the theoretical ratios
   $CuO: \frac{63.55 gCu}{16 gO} = 3.97 \qquad Cu_2O: \frac{127.1 gCu}{16 gO} = 7.94$
3. Nickel and sulfur compound
   a. Experiemental ratio $\frac{2.850 gNi}{2.343 gS} = 1.216$
   b. $\frac{1.216 gNi}{1 gS} = \frac{0.749 gNi}{x gS} \qquad S = 0.616 gS$ Thus the compound would weigh 1.216 g Ni + 0.616 g S = **1.832 g total**

4. Water, H_2O *Remember, percent is still part out of total.*
   a. **11.1% hydrogen and 88.8% oxygen** $\frac{2.02}{18.02} \times 100 = 11.1\% H$ and 100% – 11.1%
   b. Since water is 88.8 % oxygen $2.86 gH_2O \times 0.888 = 2.54 gOxygen$

5. $Al(NO_3)_3$ *Remember the 3 outside the parentheses distributes into both the N and the O_3.*
   a. $Al(NO_3)_3$ **12.7% aluminum, 19.7% nitrogen, and 67.6% oxygen** MM = [26.98 + 3(14.01) + 9(16) = 213.01]
   $\frac{26.98}{213.01} \times 100 = 12.7\% Al \quad \frac{42.02}{213.01} \times 100 = 19.7\% N \quad \frac{144}{213.01} \times 100 = 67.6\%)$
   b. Since the compound is 19.7% nitrogen $12.73 g \times 0.197 = 2.51 gNitrogen$

6. Analysis of a magnesium oxygen compound
   a. $\frac{0.180 g}{0.299 g} \times 100 = 60.2\% Magnesium$ and thus 100% − 60.2% Mg = 39.8% oxygen
   b. $14.84 g \times 0.398 = 5.91 gOxygen$

7. For the formula, Al_2O_3 you would first need to calculate the percent of aluminum
   $\frac{2 \times 26.98 gAl}{(2 \times 26.98 gAl) + (3 \times 16 gO)} \qquad \frac{53.96 gAl}{101.96 gAl_2O_3} \times 100 = 52.9\% Al$
   a. Now use the 52.9% aluminum $1.65 gTotal \times 0.529 Al = 0.873 gAl$

 Mass Ratios and % Composition ***ANSWERS***

8. For the formula $Ba(OH)_2$ with a total mass of **171.34 g/mole** [137.32 g Ba+ 2(16 g O) + 2(1.01 g H)]

   You can calculate the percentage of barium $\frac{137.32 gBa}{171.34 gTotal} \times 100 = 80.14\% Ba$

   a. Thus $26.02 gTotal \times 0.8014 Ba = 20.85 gBa$

   b. Since the barium is 80.14%, the hydroxide, (OH) must make up 19.86%, thus
   $\frac{5.78 gBa}{x gOH} = \frac{80.14 gBa}{19.86 gOH}$ $x = 1.43 gOH$ *combines*

   c. Total mass wouold be 5.78 g Ba + 1.43 g OH = 7.21 g total

9. Just Like LAD D1, but using copper(II) sulfate pentahydrate, instead of potassium aluminum sulfate dodecahydrate.

   a. S would be the copper(II) sulfate portion, $CuSO_4$

   b. G would be the water, 5 H_2O

   c. The experimental mass ratio would be **1.95/1** $8.55 gSG - 3.04 gG = 5.51 gS$ $\frac{5.51 gG}{3.04 gG} = 1.81$

   d. The theoretical mass ratio would be $\frac{65.55 gCu + 32.07 gS + (4 \times 16 gO)}{5 \times (2 \times 1.01 gH + 16 gO)} = 1.59$

   e. The percent error is $\frac{1.81 - 1.59}{1.59} \times 100 = 13.8\% tooHigh$

   f. The two error suggestions in the Post Lab Questions, were not heating long enough, or heating too aggressively.
   Not heating long enough would make the SG measurement too large, which would make the calculated S too large, which makes the subtracted mass of G too large, and thus the experimental calculated mass ratio too large,

Measurements and Calculations in a Picture