Chemistry 101
MOLES, CHEMICAL FORMULAS, AND STOICHIOMETRY
Pre-Lab Exercises

Student:__________________________
Date:____________________________
Instructor:__________________________
Section:____________________________

1. Calculate the molar mass of $CoCl_2 \cdot 6H_2O$.

   [g/mol]

2. Calculate the percent by mass of H_2O in $CoCl_2 \cdot 6H_2O$.

   [%]

3. Balance the equation:

   $$KClO_{3(s)} \xrightarrow{\Delta} KCl_{(s)} + O_{2(g)}$$

4. How many moles are in 4.56 g of $KClO_3$?

   [mol]

5. Based upon the balanced chemical equation from #3, how many grams of KCl will form when 4.56 g of $KClO_3$ decompose?

   [g]

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PROCEDURE AND REPORT

Formulas and Dehydration of Hydrates

Hydrates form when water molecules are bound within the crystal structure of a solid compound. A common example of a hydrate is $CuSO_4{\cdot}5H_2O$. In this case, 5 moles of water are bound for every one mole of $CuSO_4$ in the crystal structure. The name of this hydrate is copper (II) sulfate pentahydrate. The water molecules are written separated from the rest of the formula by a dot because they are bound to the $CuSO_4$ compound as regular, distinct water molecules. Although hydrates are quite stable, the water molecules typically can be removed from the crystal structure by applying heat. This process is called **dehydration** and the compound remaining is called an **anhydrous salt**. In the case of $CuSO_4{\cdot}5H_2O$, heating the hydrate to a high enough temperature leads to the anhydrous salt $CuSO_4$ and releases H_2O as indicated by the equation:

$$CuSO_4{\cdot}5H_2O \xrightarrow{\Delta} CuSO_4 + 5H_2O$$

When calculating the **molar mass** of a hydrate, the mass of the water molecules must be included. The molar mass of $CuSO_4$ is 159.61 g/mol. The molar mass of $CuSO_4{\cdot}5H_2O$ is 249.69 g/mol. In one mole of $CuSO_4{\cdot}5H_2O$, there are 159.61 g $CuSO_4$ and 90.1 g (5 x 18.02 g) of H_2O. To find the percent by mass of water in $CuSO_4{\cdot}5H_2O$, simply take the ratio of the mass of H_2O in $CuSO_4{\cdot}5H_2O$ to the mass of $CuSO_4{\cdot}5H_2O$ times 100%:

$$\%water = \frac{mass\ \mathrm{H_2O}}{mass\ \mathrm{CuSO_4{\cdot}5H_2O}} \times 100\% = \frac{90.1g}{249.69g} \times 100\% = 36.1\%$$

Dehydration of a Known Hydrate

Start the experimental procedure outlined below. However, during periods of time when you are waiting for your crucible to cool, perform the following preliminary calculations.

Preliminary Calculations

a. Calculate the molar mass of $MgSO_4$: _____________

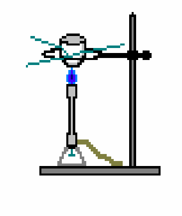
b. Calculate the molar mass of H_2O: _____________

c. Calculate the molar mass of $MgSO_4{\cdot}7H_2O$: _____________

d. Based upon the formula, calculate the percent, by mass, of $MgSO_4$ in $MgSO_4{\cdot}7H_2O$:________

e. Based upon the formula, calculate the percent, by mass, of H_2O in $MgSO_4{\cdot}7H_2O$:_________

Dehydration of a Known Hydrate (continued)



1. Clean and dry a small crucible. Support the crucible using a ringstand and wire triangle. Heat the crucible over a Bunsen burner, gently for a few seconds then strongly for 2 minutes. Turn off the flame and allow 5 minutes for the crucible to cool. Once the crucible has been heated, handle it with tongs to prevent moisture and oil from your hands from changing the mass of the crucible. As long as you touch the crucible only with tongs, you will not have to repeat this step in future trials.
2. When the crucible has cooled, measure and record the mass of the crucible to the nearest 0.001 g. **Never place a hot object on the balance!!**
3. Fill the crucible about ¼ full of $MgSO_4{\cdot}7H_2O$. Measure the mass of the crucible and $MgSO_4{\cdot}7H_2O$ to the nearest 0.001 g.
4. Calculate the mass of $MgSO_4{\cdot}7H_2O$ in the crucible by subtraction.
5. Dehydrate the $MgSO_4{\cdot}7H_2O$ by heating the crucible over a Bunsen burner, gently for about 1 minute then strongly for 5 minutes. Allow the crucible to cool for 5 minutes.
6. When the crucible has cooled, measure and record the mass of the crucible and the anhydrous $MgSO_4$ to the nearest 0.001 g. Discard the crucible contents. If you do not touch the crucible with your hands, you will not need to clean the crucible by heating before future trials.
7. Calculate the mass of dehydrated $MgSO_4$ in the crucible after heating.
8. Calculate the mass of H_2O released from the hydrate during heating.
9. Calculate the percent by mass of H_2O in the original hydrate (mass of H_2O/Mass of $MgSO_4{\cdot}7H_2O$ x 100%). How closely do your experimental results correlate with the theoretical value calculated above in preliminary calculation e?
10. Calculate the moles of dehydrated $MgSO_4$ in the crucible.
11. Calculate the moles of H_2O released from the hydrate.
12. Calculate the ratio of moles of H_2O to moles of $MgSO_4$. Compare your result with the number you expect based upon the formula of $MgSO_4{\cdot}7H_2O$.
13. Perform a second trial if instructed to do so by you instructor.

Dehydration of a Known Hydrate

Steps	Trial #1	Trial #2
2. Mass of crucible		
3. Mass of crucible and $MgSO_4{\cdot}7H_2O$		
4. mass of $MgSO_4{\cdot}7H_2O$ in crucible		
6. Mass of crucible and $MgSO_4$ after heating		
7. Mass of $MgSO_4$ remaining after heating		
8. Mass of H_2O released		
9. % H_2O in $MgSO_4{\cdot}7H_2O$		
10. Moles $MgSO_4$		
11. Moles H_2O released		
12a. Calculated Moles H_2O/Moles $MgSO_4$		
12b. Expected Moles H_2O/Moles $MgSO_4$		

Calculations:

Formula of an Unknown Hydrate

In this section you will determine the value of X in the formula of a hydrate of calcium sulfate, $CaSO_4 \cdot XH_2O$.

1. If necessary, clean a crucible as previously instructed.
2. When the crucible has cooled, measure and record the mass of the crucible to the nearest 0.001 g. **Never place a hot object on the balance!!**
3. Fill the crucible about ¼ full of $CaSO_4 \cdot XH_2O$. Measure the mass of the crucible and $CaSO_4 \cdot XH_2O$ to the nearest 0.001 g.
4. Calculate the mass of $CaSO_4 \cdot XH_2O$ in the crucible.
5. Dehydrate the $CaSO_4 \cdot XH_2O$ by heating the crucible over a Bunsen burner, gently for about 1 minute then strongly for 5 minutes. Allow the crucible to cool for 5 minutes.
6. When the crucible has cooled, measure and record the mass of the crucible and the anhydrous $CaSO_4$ to the nearest 0.001 g. Discard the crucible contents. If you do not touch the crucible with your hands, you will not need to clean the crucible by heating before future trials.
7. Calculate the mass of dehydrated $CaSO_4$ in the crucible after heating.
8. Calculate the mass of H_2O released from the hydrate during heating.
9. Calculate the percent by mass of H_2O in the original hydrate.
10. Calculate the moles of dehydrated $CaSO_4$ in the crucible.
11. Calculate the moles of H_2O released from the hydrate.
12. Find X in $CaSO_4 \cdot XH_2O$ by calculating the ratio of moles of H_2O to moles of $CaSO_4$.
13. Round the value determined in step 12 to the nearest whole number and write the formula for the unknown hydrate.
14. Perform a second trial if instructed to do so by you instructor.

Formula of an Unknown Hydrate

Steps	Trial #1	Trial #2
2. Mass of crucible		
3. Mass of crucible and $CaSO_4 \cdot XH_2O$		
4. Mass of $CaSO_4 \cdot XH_2O$ in crucible		
6. Mass of crucible and $CaSO_4$ after heating		
7. Mass of $CaSO_4$ remaining after heating		
8. Mass of H_2O released		
9. % H_2O in $CaSO_4 \cdot XH_2O$		
10. Moles $CaSO_4$		
11. Moles H_2O released		
12. Moles H_2O/Moles $CaSO_4$		
13. Formula of unknown		

Calculations:

Decomposition of Baking Soda

When baking soda or sodium bicarbonate, $NaHCO_3$, is heated, it decomposes releasing H_2O and CO_2. The third decomposition product is a solid, either sodium carbonate, Na_2CO_3, or sodium oxide, Na_2O. Balanced chemical equations for both of these reactions have been written below even though only one of the reactions occurs. In this section you will determine which of these two decomposition reactions actually occurs.

1. Use the crucible from the previous section. As long as you have not handled the crucible with your hands, it is not necessary to heat the crucible to clean it. Measure the mass of the crucible to the nearest 0.001g.
2. Add about 0.5 gram of baking soda to the crucible and record the new mass.
3. Calculate the mass of the baking soda in the crucible by subtraction.
4. Heat the crucible over a Bunsen burner, gently for about 1 minute then strongly for 2 minutes. Allow the crucible to cool for 5 minutes.
5. When the crucible has cooled, measure and record the mass of the crucible and decomposition product to the nearest 0.001 g. Discard the crucible contents.
6. Calculate the mass of the decomposition product.

1. Mass of crucible	
2. Mass of crucible and $NaHCO_3$	
3. Mass of $NaHCO_3$ in crucible	
5. Mass of crucible and product after heating	
6. Mass of product remaining after heating	

The chemical equations for the two possible decomposition reactions are shown below. Based upon the initial mass of $NaHCO_3$, complete the following two tables to determine the expected mass of each of the potential products. You will then use the expected mass of each product and the measured product mass (line #6) to determine which reaction actually occurred.

$2NaHCO_{3(s)} \xrightarrow{\Delta} H_2O_{(g)} + CO_{2(g)} + Na_2CO_{3(s)}$

Initial mass of $NaHCO_3$ (from line #3)	
Expected mass Na_2CO_3	

$2NaHCO_{3(s)} \xrightarrow{\Delta} H_2O_{(g)} + 2CO_{2(g)} + Na_2O_{(s)}$

Initial mass of $NaHCO_3$ (from line #3)	
Expected mass Na_2O	

Compare the expected mass calculated for Na_2CO_3 and the expected mass calculated for Na_2O with the experimental mass of the product from line #6.

Write the formula for the decomposition product: ___________________

Write the correct decomposition reaction:

Calculations: