Name: _____ Lab Section: _____

EXPERIMENT 2: HYDRATE PRE-LABORATORY ASSIGNMENT

1. A student obtains the following data:

Mass of test tube:	27.29 g
Mass of test tube and hydrate:	28.56 g
Mass of test tube and anhydrous residue after heating:	28.05 g

Your laboratory instructor tells you that your sample is strontium chloride hydrate.

a) What is the percent mass of water in your hydrate?

answer:_____

b) How many moles of water were driven off of your hydrate?

answer:_____

c) Calculate the mole ratio of water to salt in your hydrate.

d) What is the formula for the hydrate?

answer:_____

EXPERIMENT 2: HYDRATES

Introduction.

Chemical experimentation often involves the measurement or observation of changes in macroscopic properties for a system. Analysis and interpretation of the macroscopic properties of matter provides information that leads to understanding at the molecular or atomic scale. In this experiment, you will relate the loss of mass of a hydrate sample upon heating to its molecular formula.

Hydrates are salts with water physically incorporated into the crystal structure. Some hydrates represent familiar substances such as gypsum $CaSO_4 \cdot 2H_2O_{(s)}$ or Plaster of Paris $CaSO_4 \cdot ½\ H_2O$. Simple hydrates have the general chemical formula $MA \cdot x\ H_2O_{(s)}$ where "M" represents a cation (for example Ni^{+2}, Cu^{+2}, Fe^{+3}), "A" represents an anion (Cl^-, SO_4^{-2}, NO_3^-, etc.), and "x" represents the number of moles of water associated with each mole of hydrate $MA \cdot x\ H_2O_{(s)}$.

Heating a hydrate removes the water that is locked inside at room temperature. The substance that remains after the water leaves is called the "anhydrous salt." *(meaning without water)* For example, $CoCl_2$ in its anhydrous form is a blue compound. When $CoCl_2$ is hydrated, forming $CoCl_2 \cdot 6H_2O$, the salt has a pink appearance. $CoCl_2$ is routinely used as a humidity indicator found in small packets stored with electronic equipment to ensure no exposure to water or significant humidity.

The chemical reaction illustrating the dehydration process is:

$$CoCl_2 \cdot 6\ H_2O_{(s)} \rightarrow CoCl_{2(s)} + 6\ H_2O_{(g)}$$

Notice that one mole of the hydrate releases 6 moles of water. The process of dehydrating a hydrate can provide us with information about the chemical formula of the hydrate. More specifically, if we weigh a hydrated compound before dehydration and after dehydration, we can determine the mass of water loss. The mass of water lost can be converted into moles of water released. The molar ratio of moles of water released to moles of dehydrated compound provides us with moles of water per moles of the hydrated compound, namely the factor "x".

In this laboratory experiment, you will determine the molecular formula of a known hydrate and the percent composition of a hydrate in a mixture of a hydrate and an inert salt.

$$\text{Mass Percent of a hydrate in a mixture} = \frac{\text{grams of hydrate in the sample}}{\text{total mass of the sample}} \times 100$$

Experiment Objectives:

1. Experimentally determine the chemical formula of a known hydrate MA · x $H_2O_{(s)}$ given the identity of the anhydrous salt MX.
2. Experimentally determine the percent composition by mass of hydrate in a mixture containing a hydrate and a non-hydrate salt.
3. Understand and be able to utilize the relationships between mass, moles, and molecular structure in chemical calculations.

Experimental Procedures:

I. Percent water and formula of a hydrate

Be sure to record your hydrate number on your data sheet. This number will be assigned to you by your T.A. Clean a 20 × 150 mm test tube, dry it, and weigh it on the analytical balance. Weigh out about 2 grams of your hydrate and record the exact mass. Heat the test tube with a Bunsen burner for about 5-6 minutes. Your lab instructor will demonstrate the correct method. **Be sure to direct the mouth of the test tube away from your face and any others around you.** Be sure you don't overheat, because this may cause the salt to oxidize and/or decompose. An indication of overheating is a yellow glow, which is caused by the glass reacting in the flame. Make sure you drive off any condensed water on the **inside** of the test tube by also heating the sides of the test tube. What is the origin of this condensed water?
Let the test tube cool, and then weigh it with its contents. Repeat the heating to ensure complete dehydration. ***If the mass after the second heating differs from the previous mass by less than 10 milligrams, calculate the percent water and report the value to your instructor.* If not, heat your unknown a third time and then report the percent water. The instructor will then tell you the name of the anhydrous salt, and you can determine the formula of the hydrate.

II. Percent composition of a hydrate in a mixture

Obtain an unknown mixture from your lab instructor and record its number on your data sheet. This mixture contains $BaCl_2 \cdot 2H_2O$ and another non-hydrated salt such as NaCl. Perform the experiment as in part I using this mixture. This time, however, your lab instructor will not tell you when you have lost enough mass to discontinue heating. Use the same guidelines as in part I to make this decision individually. You will determine the percent mass loss and the percent composition of known hydrate in your mixture.

Exp. 2 Data & Results **Name: _____**

Lab Section: _____

Data Part I: *(To be completed and signed by you instructor before leaving lab)*

Unknown hydrate number: _____

Mass of the clean dry test tube: _____

Mass of test tube and hydrate: _____

Mass of test tube and anhydrous residue after first heating: _____

Mass lost after first heating: _____

Mass of test tube and anhydrous residue after second heating: _____

Total mass lost after second heating: _____

Mass of test tube and anhydrous residue after 3rd heating: _____
(if necessary)

Total mass lost after third heating: _____

Calculations and Results Part I (Show your work below.)

Mass of unknown: _____

Mass of water removed: _____

Percent water in unknown: *(report this to instructor)* _____

Name of your known anhydrous salt: *(supplied by instructor)* _____

Formula of the anhydrous salt: _____

Moles H_2O in your sample: *(Show calculation)* _____

Mass of anhydrous salt: _____

Moles of anhydrous salt: _____

$\frac{\text{moles } H_2O}{\text{moles anhydrous salt}}$: *(Show calculation)* _____

Formula of your unknown hydrate: _____

Chemical equation showing the dehydration reaction for your hydrate:

Instructor (date & initial): _____

Data Part II

Mixture number: _____

Mass of the clean dry test tube: _____

Mass of test tube and hydrated mixture: _____

Mass of test tube and anhydrous residue: _____

Percent mass loss: _____

Mass of test tube and anhydrous residue after additional heating: _____

Percent mass loss: _____

Mass of test tube and anhydrous residue after 3rd heating period: _____
(if necessary)

Percent mass loss: _____

Calculations and Results Part II

Mass of mixture before heating: _____

Mass of water removed: _____

Moles of H_2O in sample: *(Show calculation)* _____

Moles of $BaCl_2 \cdot 2H_2O$ in your sample: *(Show calculation)* _____

Grams of $BaCl_2 \cdot 2H_2O$ in your sample: *(Show calculation)* _____
(check the molar mass of the hydrate!)

Percent by mass $BaCl_2 \cdot 2H_2O$ in your original sample: *(Show calculation)* _____

Instructor (date & initial): _____