Name: _____ **Lab Section: _____**

EXPERIMENT 2: HYDRATE PRE-LABORATORY ASSIGNMENT **Score: ___ /10**

(To be completed prior to lab, read the experiment before attempting)

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

The laboratory instructor identifies the sample as strontium chloride hydrate. ($SrCl_2 \cdot nH_2O$)

a) Calculate the mass percent of water in the hydrate?

Answer: _____

b) Calculate the number of moles of water in the hydrate sample that were driven off by heating?

Answer: _____

c) Calculate the mole ratio of water to salt in the hydrate, round to the nearest whole number.
("n" in $SrCl_2 \cdot nH_2O$)

Answer: _____

d) Write the correct formula for the hydrate?

Answer: _____

EXPERIMENT 2: HYDRATES

Introduction: (You will work alone for this experiment)

Experiments in chemistry often involve the measurements and observation of changes in macroscopic properties for a system. Analysis and interpretation of these 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 $MX \cdot nH_2O_{(s)}$ where "M" represents a cation (for example Ni^{+2}, Cu^{+2}, Fe^{+3}), "X" represents an anion (Cl^-, SO_4^{-2}, NO_3^-, etc.), and "n" represents the number of moles of water associated with each mole of hydrate $MX \cdot n\ H_2O_{(s)}$.

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 "n".

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 $MX \cdot n\ H_2O(s)$ given the identity of the anhydrous salt MX.
2. Experimentally determine the percent composition by mass of hydrate in a mixture containing unknown proportions of 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 Procedure:

1. Percent water in a hydrate

- Weigh a clean and dry 20 x 150mm test tube on an analytical balance to ± 0.0001g. (There are clean test tubes in drawers at the front of the lab if you need one)
- Weigh approximately two grams (1.8 to 2.2g) of a hydrate sample (labeled I, II or III), record the mass on your data sheet. (± 0.0001g)
    - Note: The mass doesn't have to be exactly two grams. Just record your value.
    - Be sure to record the sample number!
- Grasp the test tube with your test tube holder and heat the test tube using a Bunsen burner for 5-6 minutes. Move the test tube around to heat the entire sample and drive of the ensuing water vapor that condenses at the test tube opening. Make sure the test tube opening is not facing you or anybody near you.
    - Note: Overheating the test tube will cause the glass to melt or break.
    - Over heating may cause the salt to oxidize and/or decompose.
    - Avoid overheating your metal test tube holder, it will get hot!
- Allow the test tube to cool to the touch (at least 5 minutes). Weigh the test tube and dehydrated salt on the same analytical balance. (± 0.0001g)
- Record the mass on your data sheet and calculate the mass percent of water lost.
- Heat the test tube a second time and measure the mass of the test tube and dehydrated salt on the same analytical balance.
- Record the mass on your data sheet and calculate the percent of water lost.
    - Note: If the change in mass after your second heating is less than ± 0.010g, ask your instructor for the identify of your anhydrous salt.
    - You may need to heat your test tube a third time if you have not sufficiently dehydrated your sample.
- Heat your test tube a third time if you were told to do so.
- After all the water has been displaced, calculate the formula of your hydrated salt.

2. Percent composition of a hydrate in a mixture

- Obtain an unknown mixture of $BaCl_2 \cdot 2H_2O$ and a non-hydrated salt (such as NaCl) from your laboratory instructor. Record the sample number on your data sheet.
- Repeat the procedure from above to dehydrate your salt.
    - Note: Your instructor will not tell you when you have completely dehydrated your salt.
- Using the same guidelines from part one; determine the percent mass loss and percent composition of your 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)*

Mass of the clean dry test tube: _____g

Mass of test tube and hydrate: _____g

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

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

Mass after 1st heating – mass after 2nd heating: (must be < ± 0.010g) _____g

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

Total mass lost after last heating: *(use the last mass)* _____g

Name of anhydrous salt (*supplied by instructor after heating)* _____

Formula of the anhydrous salt: _____

Calculations and Results Part I

Mass of unknown sample: _____g

Mass of water removed: _____g

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

Moles H_2O in your sample: *(Show calculation below)* _____mol

Mass of anhydrous salt: _____g

Moles of anhydrous salt: *(Show calculation)* _____mol

$$n = \frac{\text{moles } H_2O}{\text{moles anhydrous salt}}:$$ _____

Formula of your unknown hydrate: _____

Instructor (date & initial): _____

Data Part II

Mixture number: _____

Mass of the clean dry test tube: _____g

Mass of test tube and hydrated mixture: _____g

Mass of test tube and anhydrous residue after 1st heating: _____g

Mass of test tube and anhydrous residue after 2nd heating: _____g

Mass after 1st heating – mass after 2nd heating: (must be < ± 0.010g) _____g

Mass of test tube and anhydrous residue after 3rd heating : _____g

(if necessary)

Mass of water lost: *(use the last mass)* _____g

Percent mass loss: *(use the last mass)* _____%

Calculations and Results Part II

Mass of mixture before heating: _____g

Mass of water removed: _____g

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

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

Grams of $BaCl_2 \cdot 2H_2O$ in your sample: *(Show calculation)* _____g
(244.26 g/mol)

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

Instructor (date & initial): _____

Data Summary page:
(Place this page on top of your data pages)

Name: _____
Lab Section: _____

Score: _____

Part 1: Unknown Hydrate Sample

Sample Number: (I, II or III) _____

Name of anhydrous salt _____

Formula of the anhydrous salt: _____

% water lost in sample: _____

Formula of your unknown hydrate: _____

Chemical equation showing the dehydration reaction for your hydrate:

_____

Part 2: Hydrate Sample Mixture

Mixture number: _____

Percent by mass $BaCl_2 \cdot 2H_2O$ in your original sample: _____%

Instructor Comments: