Formula of a Hydrate

Name_______________________Per_____

Introduction to Hydrates

Many ionic compounds have water molecules incorporated into their crystal structures. Such compounds are called hydrates. An ionic compound without any water locked inside its crystal structure is called an anhydrate. To emphasize the presence of discrete water molecules in the chemical structure, the formula of all hydrates shows the water of hydration separated from the rest of the chemical formula by a dot. The dot does not mean "multiply by", it means "loosely attached to." A coefficient before the H_2O indicates the number of water molecules inside the compound for each anhydrate unit.

Two examples are:

- sodium acetate trihydrate $NaC_2H_3O_2 \cdot 3\ H_2O$ (1 mole of salt (or anhydrate) for every 3 moles of water, ***tri***hydrate)
- iron(III) phosphate tetrahydrate $FePO_4 \cdot 4\ H_2O$ (1 mole of salt for every four moles of water, ***tetra***hydrate)

PRE-LAD - Do this on this page (in pencil) before coming to class. *Show your work in the space. NWNCNK*

1. On a separate sheet make a Data/Results table - In your Google Lab Sheet please.
2. Calculate the *theoretical* percentage of water in the iron(III) phosphate tetrahydrate shown above.
3. If a student measured 9.72 g of a sodium carbonate hydrate and 3.61 g of sodium carbonate anhydrate (without the water attached, Na_2CO_3)
   a. calculate the mass of water removed from this hydrate during heating.
   b. Calculate the moles of water removed during heating.
   c. Calculate the moles of the anhydrate that resulted from this heating.
   d. From your calculation in b & c, determine the whole number mole ratio of moles of water/moles of anhydrate.
   e. Write the correct formula
4. In the lab a student measured 13.30 g of a barium chloride, $BaCl_2$ hydrate and after heating, the anhydrate weighed 11.16 g,
   a. calculate the *experimental* percent of water in this hydrate.
   b. Later you were told that this compound is a dihydrate ($\cdot$ 2 H_2O), calculate the *theoretical* percent of water in this hydrate.
   c. Do you suppose the error source for the experimental trial was caused by anhydrate falling out of the dish on the way to the balance, or your goofy lab partner drooling into the dish after heating the hydrate to dryness? Justify.

Materials

On the tray shared by 2 groups

- vial of copper(II) sulfate hydrate ×2 (do NOT use it all)
- evaporating dish ×2
- tongs & scoop ×2
- ring stand, ring, & burner ×2
- lighter or matches
- tile for cooling evaporating dish

Procedure - In this Lab the salt (or anhydrate) part of the hydrate that you are testing is *copper(II) sulfate,* $CuSO_4$

A. Measure the mass of a clean dry evaporating dish

B. After using the tare button, put all of the hydrate into the evaporating dish and measure the mass of the hydrate. (It doesn't matter what mass, but whatever amount you use, you need to record the exact amount.)

C. Place the evaporating dish over the burner and heat the hydrate for 5 to 10 or ust a few minutes beyond when the color change is complete. Do NOT allow the hydrate to turn black and melt. Ease back on the heating if that appears to be happening.
Observation: Do you see any of the water leaving?

D. Allow the dish to cool and measure the mass of the dish and its anhydrate contents.

E. Heat as many more times as necessary to be sure you have heated to a constant mass. (We are hopeful for only two heatings.)

Process the Data - Part A - *Go to the web site: Unit E page to the LD E1 Data Entry Link to enter the data requested.*

In this Lab the salt (or anhydrate) part of the hydrate that you tested was *copper(II) sulfate* $CuSO_4$

1. Calculate the mass of the anhydrate.
2. Convert the mass of anhydrate from #1 to moles of anhydrate.
3. Calculate the mass of the water that was removed during the heating.
4. Convert the mass of water from #3 to moles of water.
5. Calculate the mole ratio: moles of water to moles of anhydrate. (water/anhydrate)
6. Use the information from the ratio in #5 to write the formula for this hydrate in the format as shown by the examples in the introduction.

Process the Data - Part B

An alternative method of analyzing the data with mass percentages (include this in your data table)

7. Use calculation #1 from above to calculate the *experimental* % water in the hydrate.
8. After having seen the class data and having established the known formula for the compound, use the formula to calculate the *theoretical* % water in the hydrate.

LAD E1 (pg 3 of 3) Formula of a Hydrate

Post-LAD Questions

1. List two reasons as to why is it important to wait until the dish cools before weighing?
(Do NOT answer that we are waiting for all of the water to leave. If the water didn't leave while heating…it's not going to leave while cooling. Do NOT answer that the hot dish will break the balance. That is not likely. Don't tell me you will burn your hand, that's what the tongs are for.)

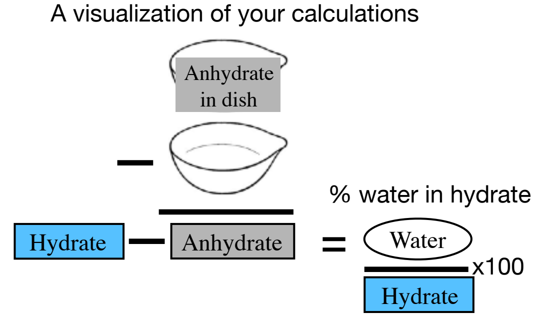
2. Did you observe any water escaping during the heating process? Why can or can't you see it?

3. Are there any visual changes to the salt as it changes from a hydrate to an anhydrate? What are those changes?

4. Mark each item in the picture to the right with an "m" for measurement and "c" for calculation.

- If your flame was too hot at the very beginning of the heating process, some of the chemical might pop out of the dish, would you expect the percentage of water in the hydrate to be larger, smaller, or no change than the theoretical percent? ***** Circle one *****
- Justify your response by putting ↑, ↓, or = to indicate what measurements change and the resulting effect on any calculations.

A visualization of your calculations



5. If you had a flame that was not adjusted properly with enough air, the methane may not completely combust. Incomplete combustion caused the formation of soot (unburned carbon) which may stick to the bottom of the evaporating dish.

- Would this source of error cause your percentage of water in the hydrate appear too small, too large, or have no effect? ***** Circle one *****
- Justify your response by putting ↑, ↓, or = to indicate what measurements change and the resulting effect on any calculations.

A visualization of your calculations