# Lab 4D: Formula of a Hydrate

**Name:**____________________________________ **Block:** ________
**Group Members:**__________________________ **Date:** ________/______/2018
**Due Date:**_________________________________ **Drop Date:**________________________

| Criteria | Student Self Evaluation | Teacher Assessment |
|---|---|---|
| **Objective:** Clearly states the purpose of the experiment, written in your **own words** and briefly outlines the related theory.<br>**Procedure:** correctly references textbook or handout making notes of any changes. | - | - |
| **Flow Chart:** a visual representation of the procedure, to be completed *before* the lab!<br>**Pre-Lab Questions:** displays a critical understanding of the background theory. | /8 | /8 |
| **Data, Results & Calculations:**<br>Provides results/observations (and diagrams where appropriate) that are presented in correctly annotated tables and/or graphs. Scientific tables & graphs are numbered *(eg Table 1:… or Graph 1…)* and include descriptive titles. | /12 | /12 |
| **Follow-up Questions:**<br>Correctly identifies and explains the theory relating to the experiment and supports this with accurate observations, data and/or calculations. | /12 | /12 |
| **Conclusion:**<br>Identifies and defines important concepts and principles relevant to the experiment by relating back to the objective and hypothesis. ***Be sure to address the points*** listed in the lab handout when answering the conclusion. | /2 | /2 |
| **Presentation:**<br>Practical report is presented in the **correct format**, is written fluently and provides **appropriate section headings** and accurate referencing. ***Tables & graphs*** have numbered headings. Data & calculations may be hand written, however the remainder of the report is to be **word-processed.** | /2 | /2 |
| **Practical Evaluation:** *(teacher assessed during practical lab work)*<br>Demonstrates an organized and safe approach to experimental work & meticulously executed methodology to a high degree of accuracy. | /10 | /10 |
| **Results Summary** | /46 | /46 |

*We will be doing the lab on _______________________. In order to be ready to go, you need to complete the following sections of your lab report:*

- *Flow Chart*
- *Pre-Lab Questions*
- *Data & Observations: Draw & set-up Table 1 into your lab notebook.*

**<u>Flow Chart</u>**: Summarize the steps that you will follow in the lab. You will find this information on the attached pages, which give the "procedure" for the lab. These steps should be VERY simple, and easy to follow.

**<u>Procedure:</u>** This lab is an excerpt from *Heath Chemistry page 62-64,* a textbook of laboratory experiments. Information regarding the lab and detailed procedure are provided on the following pages.
**Note the following <u>changes to the procedure</u>:**

- We will only be doing ONE trial
- We will not be using a crucible cover
- Step 5, don't worry about increasing the heat and then starting to time. Just heat your crucible for 5 minutes total.
- Step 6: we will not be using a desiccator. We will leave our samples to cool down at our lab station.

*NOTE: all data, observations and calculations are to be completed in numbered data tables with appropriate titles.*

*Safety glasses are to be worn at <u>all times</u>, for <u>all experiments!</u>*

**Reagent Disposal:** All waste from this lab is to be collected in the designated waste container All glassware used must be rinsed *<u>thoroughly</u>* in order to be used in following reactions.

**Clean Up:** clean up all materials, wipe lab bench with disinfectant and wash hands *well* with soap and water before you leave the lab each day.

**<u>Pre-lab Questions:</u>** *(to be answered in <u>full sentences</u>)*
*Carefully read the pre-lab discussion;* ***attached*** *for reference & include supplementary information you may find helpful.*

1. a) What is meant by a *hydrate*?
   b) What is an *anhydrous* compound?

2. What are some changes that often occur when a hydrated salt is heated?

3. a) Give a formula for a hydrated salt. For every molecule of the anhydrous salt, how many water molecules are in that compound?
   b) Write a balanced equation showing the hydrate separating into the anhydrous salt and water.

4. Why is a hydrate considered to be a pure substance containing water rather than a mixture of an anhydrous compound and water?

5. When optical & electronic equipment is packaged at the factory, a small package containing an anhydrous salt, such as $CaCl_2$, is included. Why?

6. a) What container is used for heating the hydrate in this lab?
   b) Why is the salt reheated in step 7?

7. In this experiment, you will find the mass of anhydrous salt left after heating the hydrate, what other information do you need to determine the number of moles of the anhydrous salt that remains?

**Data & Observations** ***(2 marks)***

Copy Table 1 from the lab handout (remember to number and title it).
**We will be doing only Trial One** *(you don't need to make the Trial 2 column).*

**Leave space after the table to record your observations** when adding water to the crucible (ie. colour, smell).

**Questions & Calculations**

1. Calculate the number of moles of the anhydrous salt that you prepared. ***(2 marks)***
2. Calculate the number of moles of water removed by heat from your sample of hydrate. ***(3 marks)***
3. Calculate the moles of water per mole of the anhydrous salt. ***(2 marks)***
4. Calculate the percent of water in the hydrate. ***(2 marks)***
5. What is the empirical formula of the hydrate in each trial? ***(1 mark)***

**Follow-Up Questions**

1. Can you suggest reasons why the procedure used in this experiment might not be appropriate for all hydrates? ***(1 mark)***
2. A substance was found to have the following percentages:

| | |
|---|---|
| Zinc | 23 |
| Sulphur | 11 |
| Oxygen | 22 |
| Water | 44 |

   What is the empirical formula of this compound? ***(4 marks)***

3. If a sample of 2.56 g of the substance in the question above were heated in a crucible as in this experiment, calculate the mass of anhydrous compound that would remain in the crucible. ***(3 marks)***
4. A substance was found to have the following percentages:

| | |
|---|---|
| Sodium | 18.53 |
| Sulphur | 25.87 |
| Oxygen | 19.34 |
| Water | 36.26 |

   What is the empirical formula of this compound? ***(4 marks)***

**Conclusion:**
Your conclusion should summarize your experimental results and answer your objective. Be sure to discuss any experimental errors and how this may/or may not have impacted your results. **(2 marks)**

**Practical Evaluation**

In this lab, you will be given a practical evaluation, based on the quality of your data obtained.

**(10 marks)**

# Formula of a Hydrate

EXPERIMENT 4D

Many salts that have been crystallized from a water solution appear to be dry, but when they are heated, large amounts of water are given off. The crystals often change color when the water is released. This suggests that water is a part of their crystal structure. These compounds are called *hydrates,* meaning that they contain water. When these compounds are heated strongly in a crucible, the water is driven off, leaving an *anhydrous* compound (without water). Usually, the amount of water present in a compound is in a whole-number mole ratio. One common example of a hydrate is copper(II) sulfate. The formula of the hydrate is $CuSO_4 \cdot 5H_2O$. The formula of the anhydrous form of the compound is simply $CuSO_4$. The formula of the hydrate indicates that five moles of water are combined with one mole of the copper(II) sulfate.

Granules of calcium chloride ($CaCl_2$) are often used to take moisture out of the air of damp rooms. They do this by forming the hydrate $CaCl_2 \cdot 6H_2O$. Chemical drying agents such as calcium chloride are called *dessicants.*

In this experiment, you will be given an unknown hydrate and asked to find the percent of water in the hydrate. This calculation will help you to determine the formula of the hydrate.

## OBJECTIVES

1. to determine the percent of water in an unknown hydrate
2. to determine the moles of water present in each mole of the unknown substance
3. to use the molecular mass to find the empirical formula of the hydrate

## MATERIALS

| **Apparatus** | | **Reagents** |
|---|---|---|
| lab burner | centigram balance | 5 g of a hydrate |
| crucible and cover | desiccator | distilled water |
| crucible tongs | medicine dropper | |
| pipestem triangle | safety goggles | |
| ring stand and ring | lab apron | |

## PROCEDURE

1. Put on your safety goggles and lab apron. You will be using the lab burners during this experiment. Use them cautiously.
2. Place a clean, dry crucible with a cover in a pipestem triangle mounted on an iron ring. Leave the cover slightly off so that the heating will drive off any water that remains in the crucible. (See Figure 4D-1.) Heat with the burner for two to three minutes to make sure that the crucible is dry.
3. From this point on, you should not touch the crucible with your hands. Use only the crucible tongs. Allow the crucible to cool for about three minutes, then find the mass of the empty crucible and the cover. Record the mass in your copy of Table 1.
4. Place enough of the hydrate that you are assigned into the crucible so that it is one-fourth to one-third full. Find and record the mass of the crucible, cover, and hydrate.

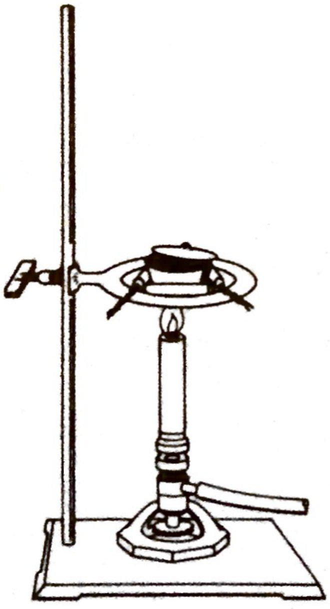

Figure 4D-1

5. Place the crucible, with the cover slightly off, on the pipestem triangle and begin heating. Gradually increase the heat until the bottom of the crucible is a dull red. Maintain this temperature for five minutes.

6. Turn off the burner and bring the crucible, with the cover, to a desiccator for cooling. Allow the crucible to cool for about five minutes, then find and record the mass of the crucible, cover, and contents.

7. Reheat the crucible for another five minutes to make sure that all of the water is driven off. Again, cool it in the desiccator, then find and record the mass. If the masses that you determine in Steps 6 and 7 do not agree within 0.03 g, check with your instructor to see if you need to continue the heating/mass-determination process.

8. Once your masses agree and the crucible is cool, add a few drops of distilled water to the crucible. Note any changes in the substance in Table 1.

9. If enough time remains, repeat the experiment with another hydrate.

## REAGENT DISPOSAL

Place all solids in the designated waste containers.

## POST LAB DISCUSSION

Your instructor will give you the mass of one mole of the anhydrous salt. This should help you in determining the empirical formula of the hydrate. In order to find the mass of water in your sample of hydrate, you will simply subtract the mass of the anhydrous compound from the mass of the hydrate. Using this value, you can then find the mass of water that would be present in one mole of the hydrate. Once you know the mass of water present in one mole of the hydrate, you can calculate the number of moles of water in one mole of anhydrous salt by dividing by the molar mass of water.

Adding water at the end of the experiment rehydrates the compound. In some compounds, there is a noticeable change in texture or color when the water is added. The hydrate should appear as it did before you heated it.

## DATA AND OBSERVATIONS

**Table 1**

| | TRIAL ONE | TRIAL TWO |
|---|---|---|
| Mass of empty crucible and cover | | |
| Mass of crucible, cover and hydrate | | |
| Mass after first heating | | |
| Mass after second heating | | |
| Mass of one mole of the anhydrous salt (from your teacher) | | |

COMPLETE IN YOUR NOTEBOOK

For both trials, describe any changes that you observed when adding water to the crucible.

## QUESTIONS AND CALCULATIONS

1. For both trials, calculate the number of moles of the anhydrous salt that you prepared. (Your teacher will give you the molar mass of the anhydrous salt.)
2. For both trials, calculate the number of moles of water removed by heat from your sample of hydrate.
3. For both trials, calculate the moles of water per mole of the anhydrous salt.
4. For both trials, calculate the percent of water in the hydrate.
5. What is the empirical formula of the hydrate in each trial?

## FOLLOW-UP QUESTIONS

1. Can you suggest reasons why the procedure used in this experiment might not be appropriate for all hydrates?
2. A substance was found to have the following percentages:

   Zinc 23%
   Sulfur 11%
   Oxygen 22%
   Water 44%
   What is the empirical formula of this compound?
3. If a sample of 2.56 g of this substance were heated in a crucible as in this experiment, calculate the mass of anhydrous compound that would remain in the crucible.

## CONCLUSION

State the results of Objective 3.