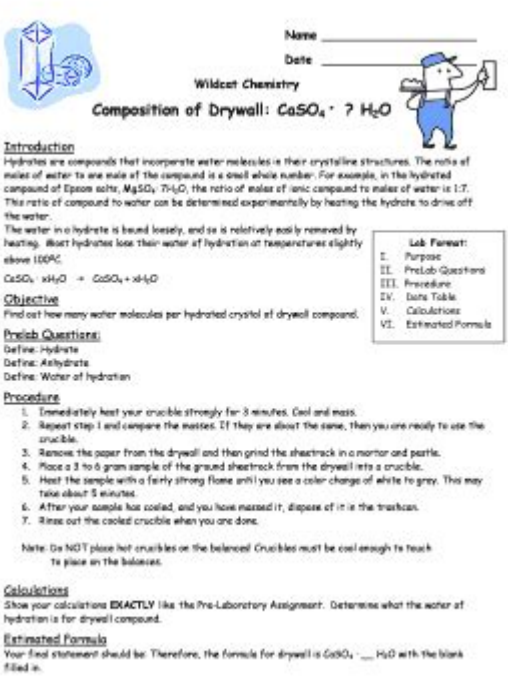
Water In A Hydrate Lab Answer Key



Name _____

Date _____

Wildcat Chemistry

Composition of Drywall: $CaSO_4 \cdot ? H_2O$

Introduction

Hydrates are compounds that incorporate water molecules in their crystalline structures. The ratio of moles of water to one mole of the compound is a small whole number. For example, in the hydrated compound of Epsom salts, $MgSO_4 \cdot 7H_2O$, the ratio of moles of ionic compound to moles of water is 1:7. This ratio of compound to water can be determined experimentally by heating the hydrate to drive off the water.

The water in a hydrate is bound loosely, and so is relatively easily removed by heating. Most hydrates lose their water of hydration at temperatures slightly above 100°C.

$CaSO_4 \cdot xH_2O \rightarrow CaSO_4 + xH_2O$

Lab Format:
I. Purpose
II. PreLab Questions
III. Procedure
IV. Data Table
V. Calculations
VI. Estimated Formula

Objective

Find out how many water molecules per hydrated crystal of drywall compound.

Prelab Questions:

Define: Hydrate

Define: Anhydrate

Define: Water of hydration

Procedure

1. Immediately heat your crucible strongly for 3 minutes. Cool and mass.
2. Repeat step 1 and compare the masses. If they are about the same, then you are ready to use the crucible.
3. Remove the paper from the drywall and then grind the sheetrock in a mortar and pestle.
4. Place a 3 to 6 gram sample of the ground sheetrock from the drywall into a crucible.
5. Heat the sample with a fairly strong flame until you see a color change of white to grey. This may take about 5 minutes.
6. After your sample has cooled, and you have massed it, dispose of it in the trashcan.
7. Rinse out the cooled crucible when you are done.

Note: Do NOT place hot crucibles on the balances! Crucibles must be cool enough to touch to place on the balances.

Calculations

Show your calculations **EXACTLY** like the Pre-Laboratory Assignment. Determine what the water of hydration is for drywall compound.

Estimated Formula

Your final statement should be: Therefore, the formula for drywall is $CaSO_4 \cdot$ __ H_2O with the blank filled in.

Water in a hydrate lab answer key is an essential topic in the study of chemistry, particularly when exploring the properties of hydrates. Hydrates are compounds that contain water molecules integrated into their crystalline structure, and understanding the role of water in these substances is crucial for both academic and practical applications. This article will provide an in-depth look at hydrates, the methods used to determine the water content within them, and a sample answer key for a laboratory experiment that explores these concepts.

Understanding Hydrates

Definition and Characteristics

Hydrates are solid compounds that incorporate water molecules into their crystal lattice. The general formula for hydrates can be represented as:

$$\text{Compound} \cdot n\text{H}_2\text{O}$$

where n is the number of water molecules associated with each formula unit of the compound. Key characteristics of hydrates include:

- Water of Crystallization: The water molecules are not merely trapped within the solid; they play a critical role in maintaining the structure of the crystal.

- Physical Properties: Hydrates usually have distinct physical properties, such as color, solubility, and melting points, which can differ significantly from their anhydrous counterparts.
- Reversibility: Many hydrates can lose their water content upon heating, transforming into anhydrous compounds, which can then regain water upon exposure to moisture.

Examples of Common Hydrates

Some common examples of hydrates include:

1. Copper(II) sulfate pentahydrate: $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
2. Magnesium sulfate heptahydrate: $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
3. Calcium chloride dihydrate: $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$

These compounds are often studied in laboratory settings to understand the relationship between water and chemical composition.

Laboratory Investigation of Hydrates

Objective of the Experiment

The primary objective of a hydrate lab is to determine the amount of water present in a given hydrate sample. This involves heating the hydrate to drive off the water and measuring the mass changes before and after heating.

Materials Required

To conduct this experiment, the following materials are typically needed:

- A hydrate sample (e.g., copper(II) sulfate pentahydrate)
- A balance for measuring mass
- A crucible and lid
- A Bunsen burner or heating element
- Desiccator (optional, for storing the anhydrous sample)
- Safety goggles and gloves

Experimental Procedure

1. Weigh the Crucible: Measure and record the mass of an empty, dry crucible.
2. Add the Hydrate: Add a known amount of the hydrate to the crucible and record this mass.

3. Heat the Sample: Place the crucible on a heat source and gently heat it to drive off the water. Ensure that the heating is uniform to prevent splattering.
4. Cool and Weigh: Once the sample is heated, allow it to cool in a desiccator (if available) or let it cool in the air. Weigh the crucible with the anhydrous compound and record the mass.
5. Calculate Water Content: Determine the mass of water lost by subtracting the mass of the anhydrous compound from the mass of the hydrated sample.

Calculations and Data Analysis

Data Collection

The data collected during the experiment will typically include:

- Mass of empty crucible (g)
- Mass of crucible + hydrate (g)
- Mass of crucible + anhydrous compound (g)

From this data, you can derive the following:

1. Mass of Hydrate:
$$ \text{Mass of Hydrate} = \text{Mass of crucible + hydrate} - \text{Mass of empty crucible} $$

2. Mass of Anhydrous Compound:
$$ \text{Mass of Anhydrous Compound} = \text{Mass of crucible + anhydrous compound} - \text{Mass of empty crucible} $$

3. Mass of Water Lost:
$$ \text{Mass of Water} = \text{Mass of Hydrate} - \text{Mass of Anhydrous Compound} $$

Calculating the Molar Ratio

To find the molar ratio of water to the anhydrous compound, use the following formulas:

1. Calculate moles of the anhydrous compound using its molar mass.
2. Calculate moles of water using the molar mass of water.
3. Determine the ratio of moles of water to moles of the anhydrous compound.

$$ \text{Molar Ratio} = \frac{\text{Moles of } \text{H}_2\text{O}}{\text{Moles of Anhydrous Compound}} $$

Sample Answer Key for the Lab Experiment

Below is a sample answer key to guide students in their lab reports.

1. Mass of empty crucible: 25.00 g
2. Mass of crucible + hydrate: 30.00 g
3. Mass of crucible + anhydrous compound: 28.00 g

Calculations:

- Mass of Hydrate:
$$ 30.00 \, \text{g} - 25.00 \, \text{g} = 5.00 \, \text{g} $$

- Mass of Anhydrous Compound:
$$ 28.00 \, \text{g} - 25.00 \, \text{g} = 3.00 \, \text{g} $$

- Mass of Water Lost:
$$ 5.00 \, \text{g} - 3.00 \, \text{g} = 2.00 \, \text{g} $$

- Moles of Anhydrous Compound (assuming molar mass is 159.5 g/mol for $CuSO_4$):
$$ \frac{3.00 \, \text{g}}{159.5 \, \text{g/mol}} \approx 0.0188 \, \text{mol} $$

- Moles of Water:
$$ \frac{2.00 \, \text{g}}{18.0 \, \text{g/mol}} \approx 0.1111 \, \text{mol} $$

- Molar Ratio:
$$ \frac{0.1111 \, \text{mol}}{0.0188 \, \text{mol}} \approx 5.91 $$

This final ratio suggests that the hydrate is likely to be a pentahydrate, consistent with the known formula for copper(II) sulfate pentahydrate.

Conclusion

The investigation of water in hydrates is a fundamental aspect of chemistry that helps students understand the significance of water in chemical compounds. By conducting laboratory experiments, students can appreciate the quantitative relationships between hydrates and their water content. Moreover, mastering these concepts lays the groundwork for more advanced studies in physical chemistry, material science, and related fields. Understanding hydrates not only enhances theoretical knowledge but also prepares students for practical applications in various scientific domains.

Frequently Asked Questions

What is a hydrate in the context of chemistry?

A hydrate is a compound that contains water molecules bound to its crystal structure, often represented by the formula: compound·nH2O, where n is the number of water molecules.

How is the water content in a hydrate determined in the lab?

The water content in a hydrate can be determined by heating the hydrate to drive off the water, then measuring the mass before and after heating to find the mass of water lost.

Why is it important to accurately measure the mass of the hydrate before and after heating?

Accurate mass measurements are crucial to determine the percent composition of water in the hydrate and to ensure that the calculations for moles of water and the formula of the hydrate are correct.

What safety precautions should be taken when performing a hydrate experiment?

Safety precautions include wearing safety goggles, gloves, and a lab coat, using a fume hood if necessary, and handling hot equipment with care to avoid burns.

What is the significance of the stoichiometric ratio in hydrates?

The stoichiometric ratio in hydrates indicates the fixed proportion of water molecules to the formula units of the compound, which is important for understanding the compound's properties and behavior.

How can the formula of a hydrate be derived from experimental data?

The formula of a hydrate can be derived by calculating the moles of the anhydrous compound and the moles of water lost during heating, allowing for the determination of the ratio between them.

What is the role of desiccants in relation to hydrates?

Desiccants are substances that absorb moisture from the air; they are often hydrates themselves and are used to keep environments dry by preventing the formation of unwanted hydrates.

What challenges might arise during the heating of hydrates in the lab?

Challenges include ensuring complete removal of water without decomposing the anhydrous compound, accurately measuring the temperature, and preventing

contamination from the environment.

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