Objective

To determine the percent of water in copper (II) sulfate containing water of hydration.

Guiding questions

- What steps in your procedure described may lead to higher than expected percent water?
- What might lead to low percent water? Discuss based on your results.
- What common household substances are inorganic hydrates?

Watch YouTube video

https://www.youtube.com/watch?v=5fZILEBAfEU

Introduction

Most materials, including inorganic chemicals used in the laboratory, will take up water if they are exposed to a humid atmosphere. This process, called adsorption, forms a film of water on the substance’s surface. An example is silica gel, small packets labeled “do not eat” often packed in clothing and pharmaceuticals to keep them dry. Many inorganic substances form hydrates. These differ from substances with adsorbed water in that the water is chemically bound to the substance as part of its crystal structure. This water is called water of hydration and can sometimes be removed by heating, leaving behind an anhydrous salt, i.e., the salt without water attached. Hydrates are written with a raised dot in the formula. For example, magnesium sulfate heptahydrate is MgSO₄ • 7H₂O – seven water molecules are included in the formula weight.

Some hydrates spontaneously lose their water of hydration without heating – this is called efflorescence. Other substances have such a strong tendency to absorb water that they are useful as desiccants or drying agents. These are known as hygroscopic substances. Some take up so much water from the air that they dissolve in the water they absorb. This process is called deliquescence.

In today’s lab, you will be working with a hydrated salt. Heating the salt drives off the water of hydration, so weighing it before and after heating allows you to find the percent water in the hydrate, and its chemical formula.

Safety

Hot crucibles look the same as cold crucibles – be very careful not to touch them.

Bunsen burners must be used with caution. While the flame is lit, be sure the lab bench is free of unnecessary materials, and be sure the gas port is fully closed when no longer in use.

Dispose of salts in waste container provided
**Procedure**

Prepare the crucible: Obtain a clean porcelain crucible and cover. After ensuring there are no cracks or flaws, support the crucible with lid slightly open on a clay triangle and heat strongly for 5 minutes. Allow it to cool. From this point on, use crucible tongs to handle the crucible to avoid contaminating it with oils from your skin.

Use the analytical balance to measure the mass of the empty crucible and lid. Then add approximately 2 - 3 grams of sample and, using the same balance, record the mass of the crucible, lid and hydrate sample.

Place the crucible on the clay triangle and heat with a burner flame, gently at first, and then strongly for about 10 minutes. Do not allow the crucible to get red-hot to avoid decomposing the salt. Keep the lid slightly open to allow water to escape. Remove it from the flame to cool on a wire gauze, and start on a second trial (you should conduct 3 trials).

When the first crucible is cool, record the mass of the crucible, lid and anhydrous sample, again being sure to use the same balance.

Reheat the anhydrous salt for 2 minutes, cool and re-weigh. If the mass of this sample decreases by more than 0.03 g, additional water was driven off. Repeat the heating and cooling process until the mass no longer changes by more than 0.01 g.

You should have time to make 3 complete measurements using a new sample of the same hydrate. Several samples can be heated concurrently.

**Data**

The following data were collected during a gravimetric analysis of the hydrated salt CuSO₄:

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of fired crucible and lid (g)</td>
<td>23.42</td>
<td>23.40</td>
<td>23.43</td>
</tr>
<tr>
<td>Mass of fired crucible, lid and hydrate (g)</td>
<td>25.72</td>
<td>25.25</td>
<td>25.55</td>
</tr>
<tr>
<td>Mass of fired crucible, lid and anhydrous salt (g)</td>
<td>24.93</td>
<td>24.62</td>
<td>24.79</td>
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</tbody>
</table>

**Table 1.**

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
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<tbody>
<tr>
<td>Mass of hydrated salt (g)</td>
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<tr>
<td>Mass of anhydrous salt (g)</td>
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<tr>
<td>Mass of water lost (g)</td>
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<td>Percent water in salt</td>
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<tr>
<td>Moles of salt</td>
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<td>Average % water</td>
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<td>Standard Deviation</td>
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<td>Relative Standard Deviation</td>
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<td>Error</td>
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</table>
Address the following:
- Calculate the percent water in your sample and show all calculations.
- Calculate the number of moles of copper (II) sulfate and water.
- Divide the number of moles of water by the number of moles of copper (II) sulfate to get the number of water molecules in the formula.
- Does your percent water agree with the expected percent?
- How many moles of water are in the formula of your salt?
- What is the expected chemical formula of the hydrate?

Lab supplies for one group
- 10 grams of salt (enough for 3 trials) CuSO$_4$·5H$_2$O.
- 3 sets: crucibles, lids, rings and clay triangles
- Ring stands
- Bunsen burner and striker
- Crucible tongs