

# Hydrated Crystals

**H**ydrates 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 copper(II) sulfate pentahydrate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ), the ratio is 5:1. The ratio of moles of water to one mole of a hydrate can be determined experimentally by heating the hydrate to remove water.

## Problem

How can you determine the moles of water in a mole of a hydrated compound?

## Objectives

- **Heat** a known mass of hydrated compound until the water is removed.
- **Calculate** the formula for a hydrate using the mass of the hydrated compound and the mass of the anhydrous compound.

## Materials

Bunsen burner  
ring stand and ring  
crucible and lid  
clay triangle  
crucible tongs  
balance  
Epsom salts (hydrated  $\text{MgSO}_4$ )  
spatula  
spark lighter or matches

## Safety Precautions



- Always wear safety goggles and a lab apron.
- Hot objects will not appear to be hot.
- Use the Bunsen burner carefully.
- Turn off the Bunsen burner when not in use.

## Pre-Lab

1. Read the entire CHEMLAB.
2. Prepare all written materials that you will take into the laboratory. Be sure to include safety precautions and procedure notes. Use the data table on the next page.
3. Explain how you will obtain the mass of water and the mass of anhydrous  $\text{MgSO}_4$  contained in the hydrate.  
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4. How will you convert the masses of anhydrous  $\text{MgSO}_4$  and water to moles?  
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5. How can you obtain the formula for the hydrate from the moles of anhydrous  $\text{MgSO}_4$  and the moles of water?  
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**CHEMLAB****11****Sample Data**

Mass Data and Observations of Epsom Salts	
Observations of hydrated $\text{MgSO}_4$	
Mass of crucible and lid	
Mass of crucible, lid, and hydrated $\text{MgSO}_4$	
Mass of hydrated $\text{MgSO}_4$	
Mass of crucible, lid, and anhydrous $\text{MgSO}_4$	
Mass of anhydrous $\text{MgSO}_4$	
Mass of water in hydrated $\text{MgSO}_4$	
Moles of anhydrous $\text{MgSO}_4$	
Moles of water in hydrated $\text{MgSO}_4$	
Observation of anhydrous $\text{MgSO}_4$	

**Procedure**

1. Measure to the nearest 0.01 g the mass of a clean, dry crucible with a lid. Record the mass.
2. Add about 3 g hydrated  $\text{MgSO}_4$  to the crucible. Measure the mass of the crucible, lid, and hydrate to the nearest 0.01 g and record the mass.
3. Record your observations of the hydrate.
4. Place the triangle on the ring of the ring stand. Carefully place the crucible in the triangle.
5. Place the crucible lid on the crucible slightly cocked to help prevent spattering and allow vapor to escape. Begin heating with a low flame, then gradually progress to a stronger flame. Heat for about 10 minutes.
6. When heating is complete, remove the crucible using tongs. Place the lid on the crucible and allow the crucible and contents to cool.
7. Measure the mass of the crucible, lid, and  $\text{MgSO}_4$  and record the mass in the data table.
8. Observe the anhydrous  $\text{MgSO}_4$  and record your observations.

**Cleanup and Disposal**

1. Discard the anhydrous  $\text{MgSO}_4$  in a trash container or as directed by your teacher.
2. Return all lab equipment to its proper place and clean your lab station.
3. Wash your hands thoroughly when all lab work and cleanup are complete.

**CHEMLAB 11****Analyze and Conclude**

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**1. Using Numbers** Use your experimental data to calculate the formula for hydrated  $\text{MgSO}_4$ .

**2. Observing and Inferring** How did your observations of the hydrated  $\text{MgSO}_4$  crystals compare with those of the anhydrous  $\text{MgSO}_4$  crystals?

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**3. Drawing Conclusions** Why might the method used in this experiment not be suitable for determining the water of hydration for all hydrates?

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**4. Error Analysis** What is the percent error of your calculation of the water of hydration for  $\text{MgSO}_4$  if the formula for the hydrate is  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ? What changes would you make in the procedure to reduce error?

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**5. Predicting** What might you observe if the anhydrous crystals were left uncovered overnight?

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**Real-World Chemistry**

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**1.** Packets of the anhydrous form of a hydrate are sometimes used to keep cellars from being damp. Is there a limit to how long a packet could be used?

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**2.** Gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) is a mineral used for making wallboard for construction. The mineral is stripped of three-quarters of its water of hydration in a process called calcining. Then, after mixing with water, it hardens to a white substance called plaster of paris. Infer what happens as calcined gypsum becomes plaster of paris.

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