

## The Percentage of Copper In Malachite

### Purpose:

1. To determine the percentage of copper in the naturally occurring copper ore, malachite.
2. To determine the relative number of moles of copper atoms in malachite.

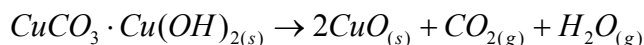
**Principles:** Malachite is a naturally occurring green mineral used as an ore of copper for ornamental objects. The chemical name of malachite is basic copper (II) carbonate, and its formula is  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ . The most familiar form of malachite is the green coating that forms on copper objects, statues and buildings (patina) due to the result of prolonged weathering. This green film acts as a protective coating and as a result the copper object covered with a layer of malachite resists further corrosion, as long as this layer is not removed.



The deliberate production of coatings such as malachite is called "artificial antiquing" and is a technique used in interior decorating. Natural antiquing is often prevented by coating the copper surface with a thin layer of plastic. As long the layer of plastic is not scratch or removed by vigorous cleaning, the copper will be protected and malachite will form on its surface.

**Method:** In this experiment the percentage of copper in basic copper (II) carbonate,  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ , will be determined experimentally by the thermal decomposition of the compound. The experimental result will then be compared with the theoretical value calculated from the formula. From the experimentally obtained percentage of copper in malachite, the number of moles of copper per one mole of malachite will be calculated.

When basic copper (II) carbonate (malachite) is heated to high temperatures (above  $400^\circ\text{C}$ ), it decomposes according to the following equation:



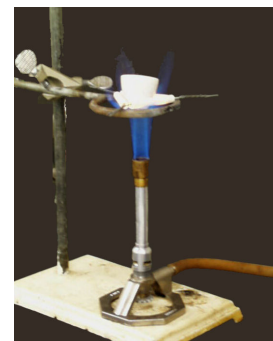
*Green Malachite  $\rightarrow$  Black Solid + Clear Gas + Clear Gas*

The method used here is to mass a quantity of basic copper (II) carbonate, heat it to drive off the carbon dioxide and the water vapor and then mass the residue, which will assumed to be copper (II) oxide.

In a thermal decomposition such as this, the product must be **heated to constant mass** before you can be sure the decomposition is complete. After the first heating, cooling and massing of the decomposed product, the crucible is heated a second time and is cooled and massed again. If the two masses are the same, within the experimental limits of the equipment used (0.02 g in this case), it may be assumed that all of the carbon dioxide and all of the water vapor was removed in the first heating. If not, it must be assumed that the first decomposition was incomplete and some of the original basic copper (II) carbonate may still be present after the second heating. The procedure is repeated as many times as necessary until there is no further mass loss. This is where we get the expression **heating to constant mass**.

## Procedure:

- Place a clean, dry crucible on a clay triangle and heat for a minimum of two minutes at maximum flame temperature.
  - The tip of the sharply defined inner blue cone of the flame should almost touch the crucible bottom.
  - The purpose of this heating is to remove contaminations from the crucible. Touching the crucible will introduce contaminations.
  - Be sure to use your crucible tongs for the remainder of the experiment.
- Allow the crucible to cool to room temperature.
  - The quickest method to cool the crucible is to place it on the bottom of the ring stand.
  - Make sure that the crucible is cool using either temperature sensitive paper or the back of your hand prior to proceeding.
- Mass the cooled crucible to the nearest 0.01g.
  - If you mass the crucible while it is hot, your massing will be incorrect due to convection currents caused by the hot crucible.
- Add between 2.3 and 2.5 g of basic copper (II) carbonate to the cool crucible.
- Mass the cooled crucible and the basic copper (II) carbonate to the nearest 0.01g.
- Place the crucible and the basic copper (II) carbonate on a clay triangle and heat for a minimum of five minutes at maximum flame temperature
  - The tip of the sharply defined inner blue cone of the flame should almost touch the crucible bottom.
  - The bottom of the crucible should be heated to a dull red color during this step.
- Allow the crucible to cool to room temperature for a minimum of ten minutes.
- Mass the cooled crucible and the copper (II) oxide to the nearest 0.01g.
- Place the crucible and the copper (II) oxide on a clay triangle and heat for a minimum of five minutes at maximum flame temperature
  - The tip of the sharply defined inner blue cone of the flame should almost touch the crucible bottom.
  - The bottom of the crucible should be heated to a dull red color during this step.
- Allow the crucible to cool to room temperature for a minimum of ten minutes.
- Mass the cooled crucible and the copper (II) oxide to the nearest 0.01g.
- If the mass from step 8 and step 11 do not agree within 0.02g, repeat steps 9 through 11.
  - The last two heatings of the crucible must agree within 0.02g.



## Hints and Calculations

---

How to determine the percent of one element in a compound? To show this, we will use an example. In this example, we will determine the mass percentage of Ag in AgO.

- To make things easy, let us assume we are using one mole of AgO.
- Mass of one mole of Ag: 107.87 g/mole
- Mass of one mole of O: 16.00 g/mole
- Mass of one mole of AgO: 123.87 g/mole

$$\text{Percent Ag in AgO} = \left( \frac{\text{Mass of Ag}}{\text{Mass of AgO}} \right) = \left( \frac{107.87 \text{ g}}{123.87 \text{ g}} \right) = 87.083\%$$

---

$$\text{Percent Error} = \left( \frac{\text{Experimental Value} - \text{Theoretical Value}}{\text{Theoretical Value}} \right) \times 100\%$$

---

**This page is intentionally left blank**

**The Percentage of Copper in Malachite  
Datasheet  
Part I – Percentage of Cu in  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$**

**Name:** \_\_\_\_\_

**Date:** \_\_\_\_\_

**Partner:** \_\_\_\_\_

Mass of empty crucible \_\_\_\_\_ g

Mass of crucible and  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$  \_\_\_\_\_ g

Mass of  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$  \_\_\_\_\_ g

Mass of crucible and CuO (1<sup>st</sup> heating) \_\_\_\_\_ g

Mass of crucible and CuO (2<sup>nd</sup> heating) \_\_\_\_\_ g

Mass of crucible and CuO (3<sup>rd</sup> heating) \_\_\_\_\_ g (if necessary)

Mass of crucible and CuO (4<sup>th</sup> heating) \_\_\_\_\_ g (if necessary)

Mass of CuO (best) \_\_\_\_\_ g

Mass of copper in CuO formed \_\_\_\_\_ g  
(Show your calculations)

Percentage of copper in  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$  (experimental) \_\_\_\_\_ %  
(Show your calculations)

Percentage of copper in  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$  (theoretical) \_\_\_\_\_ %  
(Show your calculations)

Percent Error \_\_\_\_\_ %  
(Show your calculations)

**The Percentage of Copper in Malachite  
Datasheet  
Part II – Relative Number of Cu Atoms in  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$**

Mass of  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$  (from part I) \_\_\_\_\_ g

Mass of one mole of  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$  \_\_\_\_\_ g/mole

Number of moles of  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$  \_\_\_\_\_ moles  
(Show your calculations)

Mass of Cu (from part I) \_\_\_\_\_ g

Mass of one mole of Cu \_\_\_\_\_ g/mole

Number of moles of Cu \_\_\_\_\_ moles  
(Show your calculations)

Experimental mole ratio  $\left( \frac{\text{moles of Cu}}{\text{moles of } \text{CuCO}_3 \cdot \text{Cu(OH)}_2} \right)$  \_\_\_\_\_

Theoretical mole ratio from formula  $\left( \frac{\text{moles of Cu}}{\text{moles of } \text{CuCO}_3 \cdot \text{Cu(OH)}_2} \right)$  \_\_\_\_\_

Percent Error \_\_\_\_\_ %  
(Show your calculations)