Assigned on Wed, Oct 8, 2025

8.3 Lab: Experimental Determination of an Empirical Formula

Due Wed, Oct 15, 2025

Background

During the latter half of the 18th century, the French chemist Antoine Lavoisier performed numerous combustion experiments, meticulously measuring the masses of all reactants and all products, including those which were gases. Time after time, Lavoisier observed that while the physical and chemical properties of the products and reactants differed, the total mass of the products was always the same as the total mass of the reactants. Lavoisier summarized his discoveries in **the law of conservation of mass** which states "In a chemical reaction, matter is neither created nor destroyed." In today's experiment, you will measure the mass of your reactant magnesium, chemically transform it to magnesium oxide, and measure the mass of your product. Will the mass of magnesium atoms change from reactant to product? If your product has a greater mass than your reactant, where did the extra mass come from?

Today's experiment will demonstrate the law of conservation of mass, and more specifically, how the law can be used to determine the empirical formula of our intended product, magnesium oxide. While the molecular formula of a substance gives the actual number of atoms of each element in the substance, the empirical formula is the simplest, whole number ratio of atoms of each element in the substance. For instance, the empirical formula of glucose (molecular formula = $C_6H_{12}O_6$) is CH_2O, and the empirical formula of hydrogen peroxide (molecular formula = H_2O_2) is HO. To determine the empirical formula of magnesium oxide, you will react elemental magnesium with elemental, atmospheric oxygen, to generate magnesium oxide.

$$Mg(s) + O_2(g) \rightarrow Mg_xO_y(s)$$

The lowest whole number ratio of moles of magnesium atoms to moles of oxygen atoms present in magnesium oxide will give the empirical formula of magnesium oxide.

$$\frac{\text{moles of Mg}}{\text{moles of O}} = \frac{x}{y}$$

You will have recorded the mass of magnesium used as a reactant, and the mass of the magnesium oxide product, but how can you know the moles of magnesium in the product? Worse yet, how can you know the moles of oxygen in the product when you never measured the mass of oxygen at any point? Use your knowledge of mass conservation, and a little logic!

Materials

crucible with lid	wire gauze	scoopula
iron ring	crucible tongs	
clay triangle	Bunsen burner	

Procedure

1. Obtain a porcelain crucible, crucible lid, and a clay triangle. Clean the crucible, removing any loose particulate matter, and check the crucible for cracks. It is not necessary to remove all debris from the crucible as most of it has been fused to the porcelain and cannot be removed. Set up the apparatus as shown in Figure 1.

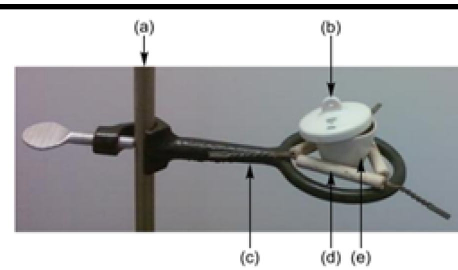

Figure 1: Crucible setup
(a) ring stand
(b) crucible lid
(c) iron ring
(d) clay triangle
(e) crucible

2. Using your crucible tongs, practice the following techniques on the cool crucible:
   - lifting the lid from the crucible
   - placing the lid ajar so that the crucible is slightly open, but the lid will not fall off, as in Figure 1.
   - quickly, but gently pushing the lid from its ajar position to completely cover the crucible
   - lifting the crucible, with its lid, from the clay triangle
   - carrying the crucible and lid while supporting from underneath with your wire gauze as in Figure 2.

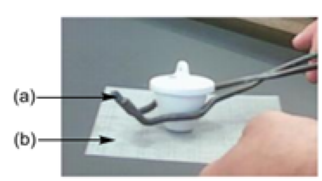

Figure 2: Proper technique for carrying a cool crucible. Never, ever attempt to carry a hot crucible!
(a) crucible tongs
(b) wire gauze

Practicing these techniques may seem silly, but it is worth your time to do so. Would you rather repeat a trial because you dropped a crucible, shattering it into a million pieces?

3. With your covered crucible in the clay triangle, fire the crucible for about 3 minutes. "Firing a crucible" is the process of heating the crucible with a Bunsen burner to remove water, oils from your hands, and any other potentially volatile contaminants. Use a soft flame; hot enough to turn the bottom of the crucible orange, but not so hot that you risk cracking the crucible.

4. After 3 minutes of firing, turn off your burner and allow the crucible and lid to completely cool to room temperature. You should allow the crucible to cool for about 10 minutes. You can test whether the crucible is cool by placing your hand one inch over the crucible and sensing for radiant heat. At no point after firing the crucible should you touch the crucible with your hands, even after it has cooled.

5. As the crucible is cooling, obtain a sample of magnesium ribbon from your teacher. Use your spatula to scrape the surface oxidation from both sides of the magnesium ribbon to expose the shiny metal. Coil the magnesium ribbon into a tight spiral that will be capable of sitting flat on the bottom of the crucible.

6. Determine the mass of the coiled magnesium ribbon and record this value on your data table.

7. Once the crucible and lid have cooled to room temperature, determine mass of the crucible and the mass of the lid (separately) and record these values on the data table. Be sure to use your crucible tongs to lift and hold the crucible and use your wire gauze to support it from underneath as in Figure 2.

8. Return the crucible and lid to the clay triangle and place the coiled magnesium ribbon into the crucible. The magnesium will burn most efficiently if the coil is sitting flat on the bottom of the crucible. Adjust the crucible lid so that it is ajar, but not at risk of falling off (Figure 1). This will allow atmospheric oxygen to enter the crucible.

9. Heat the bottom of the crucible with the Bunsen burner. Be sure that no white smoke comes out of the crucible as this smoke is part of the fluffy magnesium oxide product you are making. If smoke does come out, create a smaller opening with the lid.

10. After about 5 minutes of heating, slide the lid slightly more open and see if you notice any bright orange “flare-ups”. If so, slide the lid back and continue heating as these flare-ups indicate that the magnesium has not completely reacted. Repeat this check every minute or two until when you slide the lid open you do not see any flare-ups but instead just a constant orange glow. This indicates that all of the magnesium has reacted.

11. Turn the gas off when all of the magnesium has reacted and allow the crucible to cool for about 10 minutes to room temperature.

12. Once the crucible has cooled to room temperature, record the combined mass of the crucible, lid, and magnesium oxide product.

13. Dispose of the magnesium oxide in the trash, brushing out any loose particulate matter from the crucible.

Names: ________________________________ Period: ________ Assigned on Tuesday, September 12, 2023

5.2 Lab: Experimental Determination of an Empirical Formula **Due Monday, September 18, 2023**

Data

Initial mass of Mg	
Mass of crucible	
Mass of lid	
Mass of crucible, lid, and product after heating	

Calculations (show all work NEATLY and be sure to include units on ALL numbers)

1. Calculate the mass of magnesium oxide formed.

2. Calculate the mass of oxygen present in your magnesium oxide.

3. Calculate the moles of magnesium present in your magnesium oxide.

4. Calculate the moles of oxygen present in your magnesium oxide.

5. Calculate the lowest whole number ratio of $\frac{moles\ of\ Mg}{moles\ of\ O}$.

6. Determine the empirical formula of your magnesium oxide.

Conclusion:

Report your empirical formula for magnesium oxide and compare it to the accepted empirical formula. Identify some specific sources of error which might have affected your result. Even if your result was the correct ratio, list some potential sources of error as your result was not exact but was rounded. How might you fix these sources of error if you were to repeat the experiment?

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Don't forget the practice problems on the back of this page.

Determine the empirical formula for each compound with the given composition below.

1. 4.12 g hydrogen; 65.88 g oxygen

2. 19.98 g copper; 5.03 g oxygen

3. 49.63 g potassium; 7.66 g carbon; 30.71 g oxygen

Determine the empirical formula for each compound with the given percent composition below.

4. 92.3% carbon; 7.7% hydrogen

5. 70.0% iron; 30.0 % oxygen

6. 40.0% carbon; 6.7% hydrogen; 53.3% oxygen