9 EMPIRICAL FORMULA DETERMINATION

EXPERIMENT

PURPOSE

Text Reference
Section 7.3

To determine the empirical formula of magnesium oxide.

BACKGROUND

Carbon dioxide (CO_2), water (H_2O), and ammonia (NH_3) are just a few of many chemical compounds that you are familiar with. Have you ever seen a compound with a formula such as $Na_{.23}Cl_{3.9}$? In fact, such a formula is impossible. Only whole atoms, not fractions of atoms, react with each other to form products. Also, although elements may react in different proportions to form more than one compound, the proportions of atoms in those compounds will always be a ratio of small whole numbers.

An empirical formula gives the simplest whole-number ratio of the different atoms in a compound. For example, while the molecular formula for hydrogen peroxide is H_2O_2, the simplest whole-number ratio of hydrogen and oxygen atoms can be expressed as HO. Thus, the empirical formula of hydrogen peroxide is HO.

In this lab you will experimentally determine the empirical formula of magnesium oxide, the compound formed when magnesium metal reacts with oxygen.

MATERIALS (PER PAIR)

safety goggles
1 crucible
1 crucible lid
1 crucible tongs
1 clay triangle
1 ring stand
1 ring support
centigram balance
1 gas burner
2 pieces of exposed film
magnesium ribbon, Mg $\boxed{F}$

SAFETY FIRST!

In this lab, the crucible you are working with will become quite hot and could cause a severe burn if handled improperly. Observe all precautions, especially the ones listed below. If you see a safety icon beside a step in the procedure, refer to the list below for its meaning.

Caution: Wear your safety goggles. (All steps.)

Caution: Do not look directly at burning magnesium. Do not inhale the smoke produced when the magnesium is burned. (Steps 3, 4.)

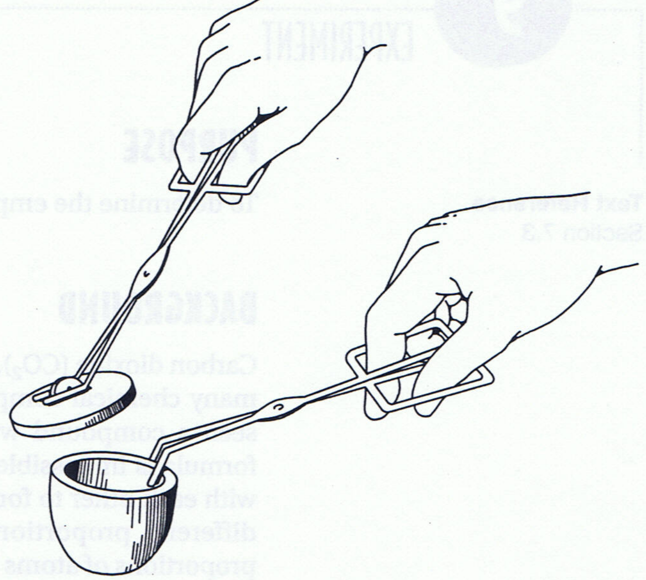

Figure 9.1

Caution: Always handle the crucible and crucible lid with crucible tongs, as shown in Figure 9.1. (Steps 3, 4.)

Note: Return or dispose of all materials according to the instructions of your teacher (Step 7.)

PROCEDURE

As you perform the experiment, record your data in Data Table 1.

1. Set up the equipment as shown in Figure 9.2. Clean a crucible and its cover with water. Dry them by heating in the hottest part of the flame for 5 minutes. Allow them to cool for at least 10 minutes. Measure and record the combined mass of the crucible and lid to the nearest 0.01 g.
2. Place a coiled 25-cm length of magnesium ribbon in the crucible. Measure and record the combined mass of the crucible, lid, and magnesium.
3. **CAUTION:** *Do not look directly at the burning magnesium. View the reaction through the pieces of film provided by your teacher.* Over a high flame, heat the uncovered crucible on the triangle until the magnesium ignites. **CAUTION:** *Do not inhale the smoke produced.* When the magnesium begins to burn, immediately cover the crucible (using tongs) and remove the burner.
4. After smoke production has ceased, replace the burner and continue heating the crucible. **CAUTION:** *Do not lean over the crucible.* Remove the burner and carefully lift the lid and check the reaction every 2 or 3 minutes. After heating for a total of 10 minutes, check to see if the reaction is complete. The magnesium should be wholly converted to a light gray powder, magnesium oxide. If ribbonlike material remains in the crucible, replace the burner and continue heating.

5. Turn off and remove the burner. Allow the crucible to cool completely (at least 10 minutes).
6. Measure and record the combined mass of the crucible, crucible lid, and magnesium oxide.
7. Follow your teacher's instructions for proper disposal of the materials.

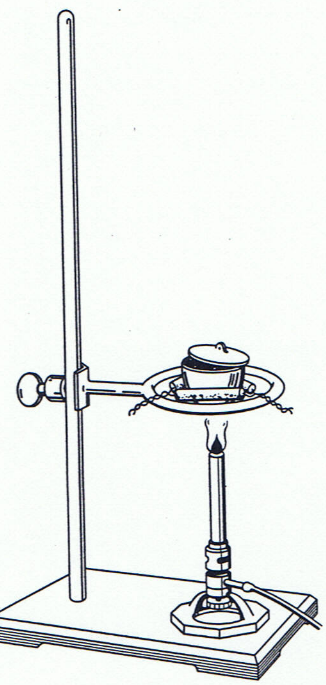

Figure 9.2

Name ______________________ Class ______________ Date ______________

OBSERVATIONS

DATA TABLE 1: MASS MEASUREMENTS	
Item	Mass
empty crucible and lid	26.31
crucible, lid, and Mg (before heating)	26.75
crucible, lid, and combustion product (Mg_xO_y)	27.05

ANALYSES AND CONCLUSIONS

1. Determine the mass of magnesium used.

0.44g

2. Determine the number of moles of magnesium used.

Hint: mol Mg = (mass Mg/molar mass Mg)

0.44g / 25.305 => 0.017

3. Determine the mass of magnesium oxide formed.

0.74

4. Determine the mass of oxygen that combined with the magnesium.

0.3

5. Calculate the number of moles of oxygen atoms that were used.

0.3/16 => 0.018

6. Calculate the ratio between moles of magnesium used and moles of oxygen used. Express this ratio in simplest whole number form.

0.017/0.017 => 1 => 1
0.018/0.017 => 1.06 => 1

Name ______________________ Class ____________ Date ____________

7. Based on your experimental data, write the empirical formula for magnesium oxide.

MgO

8. Calculate the percent error in your determination of the magnesium:oxygen mole ratio, using the accepted value provided by your teacher.

$$\text{Percent error} = \frac{|\text{accepted value} - \text{experimental value}|}{\text{accepted value}} \times 100 \text{ percent}$$

((1 - 1.06) / 1) * 100 => 6% error

9. Identify major sources of error in this experiment. Explain how the magnesium: oxygen ratio would be affected by each error you identify.

The major source of error in this experiment was rounding. I rounded the whole number ratio of the Mg to 1 from 1.06, because you can not have .06 of an atom.

10. Is there agreement among the results obtained by others in the class? What does the class data tell you about the empirical formula of a compound?

N/A

Name ______________________ Class ____________ Date ____________

11. Interpret, in terms of atoms and in terms of moles, the subscripts in a chemical formula such as C_2H_6.

C2H6 would contain 2 atoms of carbon and 6 atoms of hydrogen. It would also contain 2 moles of carbon and 6 moles of hydrogen. From this, we can say that the ratios of atoms and moles are the same for the same molecular formula.

GOING FURTHER

Develop a Hypothesis

At the high temperature at which this reaction takes place, a green-yellow solid may also be formed. Propose a hypothesis about the chemical nature of this product.

Design an Experiment

Propose an experiment to test your hypothesis. If resources are available and you have your teacher's permission, perform the experiment