EXPERIMENT 3

Empirical Formula of Magnesium Oxide

Objectives:

To determine the empirical formula of Magnesium oxide

Introduction:

The empirical formula of a compound gives the relative number of atoms of each element present in a formula unit. It is usually determined on the basis of some experimental analysis. The amount of information given by empirical formula is useful, but is certainly less than that given by the molecular or the structural formula.

It must be clear that the empirical formula gives the relative number of moles of each element in the compound. To derive the empirical formula of a compound, one must determine the number of moles of each of its elements in a sample of this compound. The next step is to calculate the simplest ratio (which must be expressed as whole numbers) of the moles and this will correspond to the subscripts[1 Martin S. Silberberg, Principle of General Chemistry, 3rd, pp 80.].

Magnesium metal is a moderately reactive elementary substance. At room temperature, magnesium reacts only very slowly with oxygen and can be kept for long periods of time without appreciable oxide build up. On the other hand, when magnesium is heated to a high temperature, it reacts with oxygen in the air to form magnesium oxide according to the following reaction:

$$2Mg_{(s)} + O_2(g) + \text{heat} \rightarrow 2MgO(s)$$

Because air contains other gaseous elements such as nitrogen, a portion of the magnesium being heated reacts with the nitrogen in the air to form magnesium nitride rather than magnesium oxide according to the following reaction:

$$3Mg(s) + N_2\,(g) + \text{heat} \rightarrow Mg_3N_2(s)$$

In this experiment, we are interested in making only the oxide and not the nitride. To accomplish this, we will react the mixture of the magnesium oxide and the magnesium nitride with water. Upon heating the mixture of magnesium oxide and magnesium nitride, the nitride reacts with the water to form magnesium hydroxide and ammonia gas. The ammonia produced by this reaction can be detected by its odor and is driven off in the heating process. As magnesium hydroxide is heated to high temperature it decomposes to magnesium oxide and water as shown by the following reactions:

$$Mg_3N_2(s) + 6H_2O\,(l) + \text{heat} \rightarrow 3Mg\,(OH)_2(s) + 2NH_3(g)$$

$$Mg\,(OH)_2(s) + \text{heat} \rightarrow MgO\,(s) + H_2O(l\,)$$

Thus, at the end of the experiment, all of the magnesium has been converted to the desired product, magnesium oxide.

In this experiment, you will heat a measured mass of magnesium in an open crucible to form magnesium oxide. You will use the masses of magnesium and of the product to calculate the mass of oxygen in the product. Finally, you will determine the percentage composition and the empirical formula of the product.

Procedure:

1. Obtain a clean crucible and cover and examine them. The crucible and cover are extremely fragile and expensive
2. Set up a clay triangle on a ring stand. Allow sufficient height to place a Bunsen burner beneath the ring
3. Transfer the crucible and cover to the triangle. The crucible should sit firmly in the triangle to approximately half its depth. Consult with your lab instructor for appropriate set up.
4. Light the Bunsen burner and begin heating the crucible and the cover with small flame to dry them. Heat the crucible and the cover for 10 minutes.
5. Remove the crucible and the cover from the flame and allow them to cool down to room temperature. Place on a clean dry wire gauze. DO NOT place crucible directly on the lab bench.
6. Transfer the crucible and the cover to the balance and record the mass of the crucible and the cover to the nearest 0.01 g.
7. Obtain a piece of magnesium coil(0.70-10.0) g and place in the crucible.
8. Using tongs transfer the crucible, magnesium and cover to the balance. Record the mass to the nearest 0.01 g
9. Transfer the crucible with its contents to the clay triangle using the tongs and begin heating with very small flame with the cover slightly open.
10. After a minute or two increase the intensity of the flame and watch the crucible for any smoke.
11. When white smoke begins to appear, cover the magnesium completely and remove from the heat for 2-3 minutes. The smoke consists of magnesium oxide product and must not be lost from the crucible

12. Continue the process of uncovering, heating, and covering the crucible until you no longer observe white smoke
13. Position the cover on the crucible and apply strong heating for 10 minutes. The crucible should be slightly red throughout the 10 minutes period. Remove the crucible from the heat. Examine the contents of the crucible. At this stage there should no free magnesium left. If portions of the magnesium still demonstrate the shiny appearance of magnesium, return the cover and heat with hot flame for additional 5 minutes
14. When all the content in the crucible has been converted to magnesium oxide as indicated by the gray color product, remove the crucible from the Bunsen burner and place it on a clean dry wire gauze and allow the crucible and the contents to cool down to room temperature
15. Using a clean dry glass rod, break up any large chunks of the solid in the crucible
16. Using a disposable dropper, add 20 drops of distilled water to the content of the crucible , spreading the water evenly throughout the sample
17. Light the Bunsen burner and heat the crucible without cover with its content to evaporate the excess water. Heat for 5 minutes using gentle flame. Then heat using strong flame for another10 minutes. Avoid overheating because it could cause spattering which results in loss of magnesium oxide from the crucible
18. Remove the crucible from the triangle and place it on the wire gauze to cool. When the crucible is cool, transfer the crucible and the cover to the balance. Record the mass to the nearest 0.01 g
19. Clean out the crucible and return it to the instructor

Report Sheet

Empirical Formula of Magnesium Oxide

Student Name:____________________________________

Student No.__________

Unknown No.______________

DATA:

1. Mass of crucible + cover ____________

2. Mass of crucible + cover + magnesium ____________

3. Mass of crucible + cover + magnesium oxide ____________

4. Mass of magnesium used ____________

5. Mass of magnesium oxide formed ____________

Calculations:

1. Mass of oxygen in magnesium oxide ____________

2. Moles of magnesium ____________

3. Moles of oxygen ____________

4. Empirical formula for magnesium oxide ____________

5. Percentage of oxygen in magnesium oxide ____________

6. Percentage of oxygen based on formula ____________

7. Percent error ____________

Questions:

1. How would your result for the empirical formula be affected by each of the following:
   A. The crucible was wet for the initial weighing but was dry for the subsequent weighing's?

   B. Magnesium was only partially converted to oxide.

   C. A flake of the final oxide was blown out of the crucible just before the final weighing, explain.

   D. If you forgot to add water to the contents of the crucible, would your experimental percent of magnesium have been too high or too low? Explain

2. A compound containing only carbon and hydrogen is analyzed, and is found to contain 74.88 % carbon on a mass basis. Calculate the empirical formula of the compound