Empirical Formula Lab

Chemistry Name

**INTRODUCTION**

Chemical formulas indicate the composition of compounds. A formula that gives only the simplest ratio of the relative number of atoms in a compound is the empirical formula or simplest formula. The ratio usually consists of small whole numbers. We call a formula that gives the actual numbers of each type of atom in a compound the molecular formula. The numbers in a molecular formula will be whole number multiples of the numbers in an empirical formula. To determine the molecular formula of a compound, we need to know both the empirical formula and the molar mass of the compound.

In this experiment, you will react a known mass of magnesium (Mg) with hydrochloric acid, HCl (aq), to form a compound containing only the elements Mg and Cl (magnesium chloride). The mass of Cl reacting with the Mg will be found from the difference in the mass of the product and the mass of Mg used. By following the same sequence of calculations used in the Al2O3 example, you will be able to experimentally verify the empirical formula of magnesium chloride.

The reaction of magnesium with hydrochloric acid is an example of a single replacement reaction. Can you write the balanced equation for the reaction using the known formula of magnesium chloride?

**Experimental Procedure**

**Safety Note:** *Hydrochloric acid is a strong acid that is harmful to the skin and especially to your eyes. Wear your safety glasses or goggles during the entire procedure to protect your eyes, and avoid inhaling vapors of HCl during the drying procedure (use a fume hood if possible). The reaction also produces flammable hydrogen gas (H2), so Bunsen burners* ***should not*** *be used while the reaction is in progress.*

1) Obtain a clean, dry evaporating dish and weigh it to the nearest 0.01 g. Record this value on the report form.

2) Place a small piece of magnesium ribbon into the evaporating dish and record the mass on the report form. From the difference in masses, record the mass of magnesium used. Note: The mass of magnesium should not exceed 0.15 grams, or the product may be difficult to dry (see below).

3) Measure 3 mL of 6 M HCl\* in a 10 mL graduated cylinder (or you may use a pipet) and carefully add the HCl solution to the evaporating dish containing the Mg ribbon (Caution: Vigorous reaction!). Allow the reaction to proceed until the reaction is complete, giving a clear solution with no magnesium particles remaining.

4) Place the evaporating dish on an electric hot plate and heat to nearly boiling. Avoid excessive heat that can cause dangerous splattering of hot HCl!

5) Heat the solution until evaporation of the water is complete. The white, solid product that remains is magnesium chloride. It is difficult to tell by appearance when the product is completely dry, so we will use a method called heating to constant weight. When the product appears thoroughly dry, carefully remove the hot evaporating dish from the hot plate (you may use crucible tongs to handle the hot dish), allow it to cool, and record the weight on the report sheet under “first weighing.” Then, place the dish back on the hot plate and heat for 10 additional minutes. Allow the dish to cool and record the weight under “second weighing.” If the second weighing agrees with the first weighing, you may reasonably assume that drying is complete. If the second weighing is less than the first weighing, place the dish back on the hot plate and heat for 10 more minutes and obtain a third weighing. Repeat this process until successive weighings agree to within 0.01 g.

An evaporating dish is much better container than a beaker for this process for two reasons: a) The solid product spreads out more in the evaporating dish as the liquid evaporates, facilitating drying. b) In a beaker, the vapors of liquid tend to condense on the walls and run back down, inhibiting drying.

6) From your data, calculate the moles of Mg and the moles of Cl in the product. From the number of moles of each element, determine the empirical formula of magnesium chloride.

7) Wash your evaporating dish with water (the product may be washed down the sink) and return your equipment to their proper storage locations before leaving the lab. \* The “M” in “6 M HCl” stands for molarity. This is a standard concentration unit in chemistry, and it means moles of solute per liter of solution, mol/L. One liter of 6 M HCl solution contains 6 moles of HCl.

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**ANALYSIS and RESULTS**

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| --- | --- | --- |
| 1. Mass of empty evaporating dish  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g | 2. Mass of evaporating dish and magnesium  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g | 3. Mass of magnesium [2] – [1]  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g |

4. Mass of evaporating dish and magnesium chloride

First weighing \_\_\_\_\_\_\_\_ g (after heating and cooling) Second weighing \_\_\_\_\_\_\_\_ g (if necessary)

Third weighing \_\_\_\_\_\_\_\_ g (if necessary) Fourth weighing \_\_\_\_\_\_\_\_ g

5. Mass of magnesium chloride [4] – [1] \_\_\_\_\_\_\_\_ g

6. Mass of chlorine in magnesium chloride [5] – [3] \_\_\_\_\_\_\_\_ g

7. Moles of magnesium (show your calculation) \_\_\_\_\_\_\_\_ mol

8. Moles of chlorine (show your calculation) \_\_\_\_\_\_\_\_ mol

9. Moles of magnesium divided by the smaller number of moles (3 sig. figures) \_\_\_\_\_\_\_\_ (show your calculation)

10. Moles of chlorine divided by the smaller number of moles (3 sig. figures) \_\_\_\_\_\_\_\_ (show your calculation)

11. Your experimental empirical formula of magnesium chloride \_\_\_\_\_\_\_\_\_\_ (whole number subscripts)

12. True (known) empirical formula of magnesium chloride

**POST-LABORATORY QUESTIONS**

1. Why was an evaporating dish more suitable for this lab procedure, rather than using a beaker?

2. How would your experimental formula of magnesium chloride “MgClx” have been affected if your product was not dried completely before weighing it? Would “x” be too high or two low? Explain.

3. Why was it necessary to weigh the product many times?

4. Would another method of drying work better? Explain.