Chemistry 3A

Introductory General Chemistry

Experiment 5a

Empirical Formula

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Introduction

Observe reaction of solid magnesium with atmospheric oxygen to produce magnesium oxide

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

Note the chemical reaction (equation) is not balanced

solid Mg as an ingot

solid Mg reagent

magnesium shavings

Background

- The atom is the physical form of the element. Atoms of one type/identity will exist in very specific ratios with atoms of other elements to form compounds.
- Compounds are generally of two types: ionic or molecular
- Ionic compounds in solid form are characterized by a crystal lattice of ions held by strong electrostatic forces, resulting in hardness, high melting points, and brittleness
- Molecular compounds in solid form consist of discrete molecules held by weaker intermolecular forces, leading to softer structures, lower melting points, and diverse physical states

Background

- Ionic compounds that are crystal solids consist of a large network of cations and anions in a formula unit, with the ratio of elements being an empirical formula
- Molecular formula of a molecular compound will be a multiple of the empirical formula
- For this experiment, the goal is to determine empirical formula of an oxide of magnesium (Mg_xO_y)

Experimental Variation/Error

- With every experiment before the data is collected and the reaction done, it is useful to anticipate what might influence your results different from the ideal. For this experiment:

1. Incomplete combustion: perhaps only magnesium on surface of metal solid reacts with oxygen

   Break up ash to expose unreacted metal, reheat to avoid this

2. The atmosphere is 78% N_2 and 21% O_2, and at very high temperatures (2000°C), some Mg can react with $N_{2:}$ $3\ Mg\ (s) + N_2\ (g) \rightarrow Mg_3N_2\ (s)$

   Adding water to magnesium nitride would produce ammonia gas, but it is probably not enough to detect its odor

   $$Mg_3N_2\ (s) + 6\ H_2O\ (l) \rightarrow 3\ Mg(OH)_2\ (aq) + 2\ NH_3\ (g)$$

Equipment You Will Use

crucible

Bunsen Burner

iron ring on ring stand

clay triangle

watch glass

gauzed wire mesh

steel wool

crucible tongs

Lab Safety

- **Goggles**
- **Correct Laboratory Coat**
- **Gloves (nitrile of proper size)**

Magnesium turnings/shavings can burn hot and can possibly burn through gloves, so you will keep your gloved hands a very respectable distance from crucible and use tongs to hold any crucible that has a burning reaction

Magnesium can burn BRIGHTLY so do not look directly at burning Mg for any long time

Procedure

Cleaning the Crucible *(Yes, we've done this before)*

1. NO WATER—crucible not to be cleaned with H_2O
2. If crucible dirty, use small steel wool piece to scrape out solids. Wipe with dry paper towel
3. Put crucible on stand and heat with blue-coned flame until slightly red hot
4. Use tongs to set crucible on wire mesh and let cool to room temperature (~5 minutes)

DO NOT SET ANY **HOT** CRUCIBLE ON COUNTERTOP OR ON PAPER OR THEY CAN BURN!

Procedure

Setup for crucible heating

Just as in a previous experiment

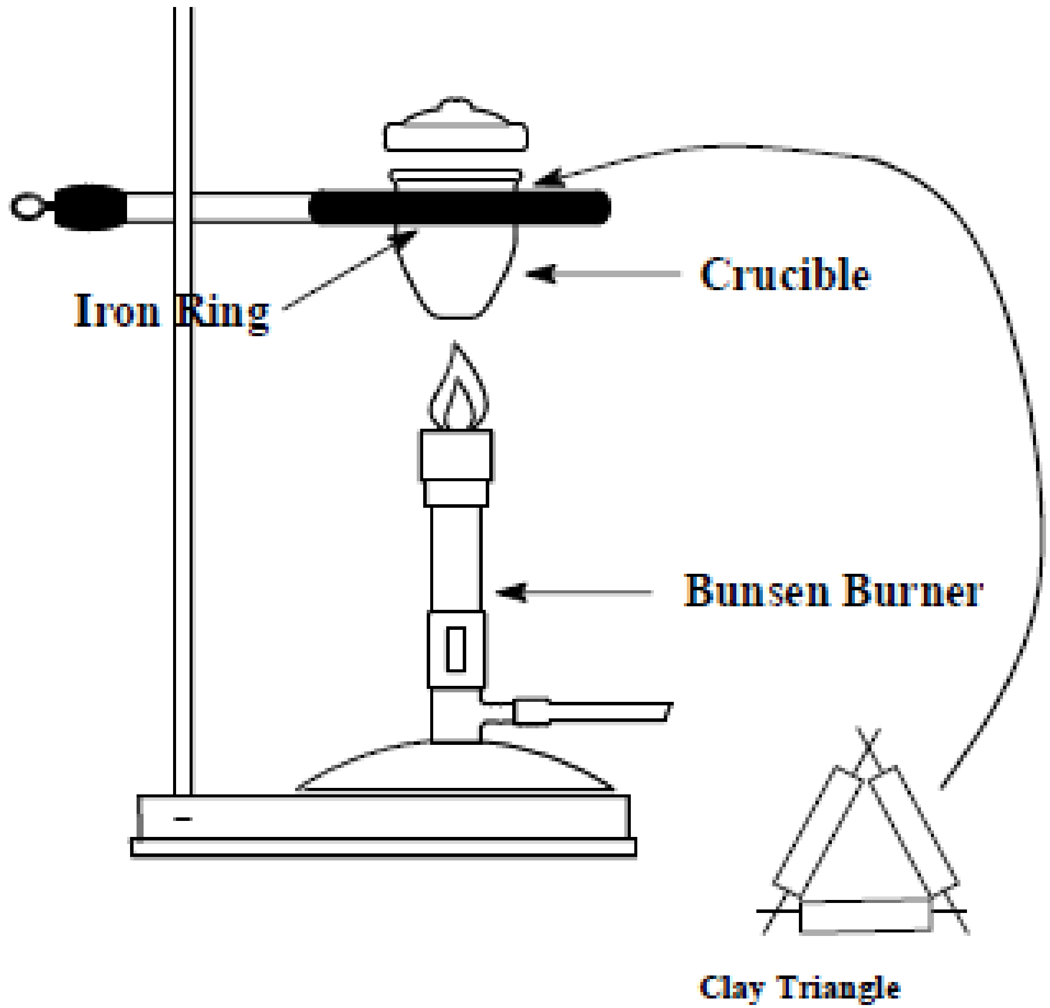

Figure 2: Crucible Heating

Procedure

Before Reaction

1. Determine mass of empty crucible **AND NOT THE LID!** → **All digits of the balance**
2. On glassine paper, use a scoopula to obtain **0.10** to **0.15 g** Mg turnings and transfer to crucible
3. Record mass of Mg on tared balance (NO LID)
4. In the fume hood as for previous experiment, set up the stand with iron right, clay triangle, Bunsen burner with gas hose connected
5. Strike the gas to a flame & adjust the burner
6. Have the wire mesh ready to set the crucible on it for cooling

Procedure

Reaction

1. Place lid on crucible **slightly ajar**
2. Carefully hold or set the Bunsen burner to burn the magnesium. Do this for about 5 minutes
3. Take the lid off, which lets more air (oxygen) in
4. Continue to heat for another 15 min, but be prepared to put lid back on ajar temporarily if more “flaring” occurs
5. Let crucible cool on wire mesh about 5 minutes
6. MAKING SURE crucible has cooled, record mass of the reaction on balance (Post-reaction reading #1)
7. Reheat crucible (NO LID) for 10 min more and let cool. Record mass (Post-reaction reading #2)

Procedure

Post-Reaction

8. If the difference between Reading #1 and #2 are within ±0.001 g, proceed with the results. Use the GREATER value of the two mass readings
9. If the two readings have differences larger than 0.001 g, repeat the heating step to get the difference down. Magnesium oxide is a white powder, but could be light gray because of impurities

Clean Up

- The magnesium oxide product goes in the Solid Waste container
- WITHOUT AT ALL GETTING CRUCIBLE WET WITH ANY WATER, wipe crucible with dry paper towel or use steel wool to clean

Data

- All mass readings in Data should be ALL the digits of the balance. All quantities should be numbers with units (g)
- If your "2nd weighing" required reheating to get a "3rd weighing" and even more then you should have a "first weighing" and "last weighing"

DATA

Mass Values from Balance

1. Mass of Crucible (Empty) ____________
2. Mass of Crucible + Mg ____________
3. Mass of Crucible + MgxOy Compound ____________ (1st weighing)

   ____________ (2nd weighing)

RESULTS

Calculated Masses

4. Mass of Mg used: ____________
5. Mass of the MgxOy compound: ____________

   (use highest of your weighings)
6. Mass of Oxygen in MgxOy compound: ____________

_____ 3rd weighing
_____ 4th weighing
_____ last weighing

My Open Math Form

- The Canvas app contains an Assignment (check Modules too) for Experiment 5a
- This contains a form you can use to assist in your data analysis

  The form should not be connected to the Gradebook

- The form will not be able to help you answer the thought questions (#5 and #6 on the online form, Post-Lab questions #2 and #3 in the printed Chem 3A Lab manual)

  To answer those questions, consider what you have learned in lecture and reading the book

Results

- All calculations should show number values with proper significant digits (for multiplication/division operations) and decimal places (for addition/subtraction operations)
- Remember to use the GREATEST / HIGHEST value of any multiple mass readings you took in the post-reaction material

Question 1 ☑ 12 pts ↺ 9 ⓘ Details

Question submitted.

You can retry this question below

▼ Part 1 of 2

Enter your mass values from the balance:

	Mass Measurement (g)
Mass of empty crucible (empty)	17.4334 — 17.4334
Mass of crucible, and Mg	17.5634 — 17.5634
Mass of crucible, and Mg_xO_y (1st weighing)	17.6402 — 17.6402
Mass of crucible, and Mg_xO_y (2nd weighing)	17.6409 — 17.6409

Did you complete a 3rd or 4th weighing?

- (●) No, I stopped after the 2nd weighing
- ( ) Yes, 3rd weighing.
- ( ) Yes, 3rd and 4th weighing.

No, I stopped after the 2nd weighing or Yes, 3rd weighing. or Yes, 3rd and 4th weighing.

Part 2 of 2

For each weighing you completed, enter your mass measurement. For each mass measurement you did not complete, type 'DNE' (for "does not exist")

	Mass Measurement (g)
Mass of crucible, Mg_xO_y (3rd weighing)	DNE — DNE
Mass of crucible, Mg_xO_y (4th weighing)	DNE — DNE

Submit Question

Question 2 33 pts 9 Detai

Question submitted.

You can retry this question below

Calculated Masses

Use the highest mass of all your weighings for your calculations.

	Mass (g)
Mass of Mg used	0.1300
Mass of the Mg_xO_y compound	0.2075
Mass of Oxygen in the Mg_xO_y compound	0.0775

Moles

Calculate the moles of Mg present	0.00534 mol
Calculate the moles of O present	0.00484 mol

Empirical Formula

Report the mole ratio (from above), without reducing, to the indicated number of significant figures.

- Example: $Mg_{0.006767}O_{0.006151}$

Mg 0.00534 O 0.00484

Simplify the mole ratio from above and report the empirical formula of magnesium oxide.

- Example: $Mg_{1.1}O_{1.0}$
- *For the purposes of this question, report each subscript two significant figures*

Mg 1.10 O 1.00

Based on the common ion charges of magnesium and oxygen, what should the empirical formula of magnesium oxide be?

Mg O

Submit Question

Mass Percent Composition

Question 3

20 pts 9 Details

Question submitted.

You can retry this question below

Based on your experimental masses, what is the mass percent Mg in your product?

62.65 | 62.65 %

Based on your experimental masses, what is the mass percent O in your product?

37.3 | 37.3 %

Submit Question

Postlab Questions

Question 4

10 pts 9 Details

Question submitted.

You can retry this question below

Part 1 of 2

Cross out the values and compounds on your paper data report and replace them with the values and compounds below.

You just found a bottle labeled "copper sulfide". Oh dear, what is that?! That metal forms Type II Ionic compounds. Type II Ionic compounds are supposed to be named with a roman numeral indicating the charge of the cation because the cation charges aren't predictable. You'll have to determine the empirical formula of this compound using experimental data so that you can fix the name on the label.

A 6.1009 g sample of "copper sulfide" was found to contain 3.0367 g of Cu and 3.0642 g of S. Use this data to determine the following:

Moles of Cu in the sample	0.047787	0.047787
Moles of S in the sample	0.095547	0.095577
Mass % of Cu, based on experimental data.	49.774	49.775
Mass % of S, based on experimental data.	50.225	50.225

Part 2 of 2

Empirical formula of copper sulfide: $Cu\,S_2$ | CuS_2

Corrected name of copper sulfide: copper(IV) sulfide | copper(IV) sulfide

Submit Question