

# EXPERIMENT 7

## **MASSIVE REACTIONS**



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### **ACKNOWLEDGEMENTS**

The creation of this experiment and its support materials would not have been possible without the scientific and pedagogical expertise of dedicated educators active in the field. Adam Equipment extends both acknowledgement and appreciation to the following teachers for their assistance in making this classroom activity available to the education community:

Penney Sconzo (Westminster High School, Atlanta, GA) – project leader and experiment author

Maureen Miller (Westminster High School, Atlanta, GA) – peer reviewer and advisor

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# 1

## Teacher Guide

# MASSIVE REACTIONS

## AGE LEVEL

This experiment is designed for ages 13-18. It can be adapted for physical science or introductory chemistry classes.

## TIME NEEDED

One laboratory period.

## ACTIVITY OVERVIEW

Chemical reactions can be classified into major categories of reactions: synthesis, decomposition, single replacement, double replacement, and combustion. This lab illustrates different types of reactions. Students will write a balanced equation for each reaction and predict the identity of the products. After writing a balanced chemical equation for the reaction, they will respond to additional questions.

## HELPFUL ADVICE TO MAXIMIZE SAFETY AND STUDENT SUCCESS

- Use precaution when lighting and operating a gas burner. When heating a test tube, aim the mouth of the test tube AWAY from yourself and others.
- Burning magnesium produces a very bright, hot flame. Be sure to hold the burning metal away from your body. Intense light may damage your eyes so do NOT look directly at the flame.
- Never smell a chemical directly. Waft any gas products (teacher illustrated).
- Wear safety goggles and protective clothing when working in the lab.
- Discuss the accuracy of the balances used for this experiment.

## SCIENCE SKILLS AND ABILITIES

### SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry
  1. Formulate scientific explanations and models using logic and evidence (ages 14-18).
  2. Use technology and mathematics to improve investigations and communications (ages 10-18).

### PHYSICAL SCIENCE

- Understanding chemical reactions (ages 14-18).
- Understanding conservation of energy and increase in disorder (ages 14-18).

### DATA ANALYSIS, PROBABILITY AND DISCRETE MATHEMATICS

- Understand and apply data collection, organization and representation to analyze and sort data (ages 10-18).

### GEOMETRY AND MEASUREMENT

- Understand and apply appropriate units of measure, measurement techniques, and formulas to determine measurements (ages 10-18).

## TEACHERS' TIPS

When elements or molecules combine in chemical reactions, the resulting product(s) remain electrically neutral overall. It's dynamic and attention-grabbing to start a unit on chemical reactions by illustrating five different types of chemical reactions: synthesis, decomposition, single replacement (or displacement), double replacement and combustion reactions.

Teachers each have various budgets and classroom situations to consider. Having students go into the laboratory and perform chemical reactions might be prohibitive because of cost factors, disposal concerns or an unproductive use of classroom time. An alternative approach that can provide students the experience they need with chemical reactions would be to have the teacher demonstrate the types of reactions. The teacher, while acting like a lab partner, can carefully point out important aspects of the reaction that students often miss or fail to consider when working on their own. Proper investment of the teacher's time can make all the difference in understanding chemical reactions. On the other hand, nothing can beat having the students perform the experiments if they can come to the same level of understanding the reactions.

Remind students that when writing a molecular equation, it is necessary to complete a series of steps.

1. Write good formulas for the reactants and products. Formulas of compounds must be written correctly. The sum of the oxidation numbers must equal zero. In other words, all compounds must be electrically neutral. The positive charges and the negative charges must total zero in a compound. Formulas for the seven diatoms also must show the elements in pairs.
2. Balance the equation. The number of atoms of any given elements must be the same on both sides of the equation. Multiplying the coefficient and the subscript of an element must yield the same number of atoms on both sides of the equation. In most cases, polyatomic ions can be considered the same as an atom for balancing purposes.

Here are a few additions to the experiments:

### Part A: Burning copper in the Bunsen burner flame

1. Have a sample of copper II oxide on hand to show the students. Compare the purchased sample with the one produced in the lab.
2. When you first place the copper into the flame, look for a green coloration to the flame. Relate this to flame tests and the color of copper II ions when their excited electrons drop back down to the ground state.
3. Be sure to scrape the dark product off the surface to reveal the unreacted copper below. The amount of surface area affects the amount of product formed (kinetics).
4. Measurements in a combustion experiment can be difficult. Why do so many people believe burning yields products with less mass than the starting material? Think of burning a piece of wood. The mass of the ash that remains is obviously less than the mass of the piece of wood burned. Is ash the only product of the combustion? What about the carbon dioxide that escapes into the air?

A typical combustion reaction adds oxygen,  $O_2$ , to the starting material. Adding oxygen to a reactant should always increase the total mass. The problem is keeping up with all the products and measuring their masses so the results might comply with the law of Conservation of Mass.

In these two combustion reactions involving copper wire and magnesium ribbon, a decrease in mass can be observed when burning the metal. Using copper wire gives better measurements than copper strips. The smooth, rounded surface of the wire is less likely to have the copper oxide flake off the surface, thus reducing the mass when both copper and oxygen atoms are lost.

After burning magnesium ribbon, be sure to observe the tongs used to hold the ribbon in the Bunsen burner flame. The tips of the tongs are coated with a white powder,  $MgO$ , which is the product of the magnesium combustion. The mass of the magnesium oxide collected and measured is not the mass of the total magnesium oxide produced. Much of the product's mass is unaccounted for when only the mass of the powder in the dish can be massed.

## TEACHERS' TIPS (continued)

### Part B: Copper wire in silver nitrate

1. Students should know why the silver nitrate is soluble (nitrates are soluble) and why the solution is colorless (white crystalline solids tend to be colorless in solution).
2. What happens to a silver nitrate solution if it is exposed to sunlight or if you get it on your skin? The solution darkens, your skin will have dark spots where it came in contact with the silver nitrate.
3. What are some practical uses of substances containing silver ions? Silver has germicidal effects and kills many lower organisms effectively without harm to higher animals.
  - Silver is capable of rendering stored drinking water potable for a long period of time (several months). Water tanks on ships and airplanes are often "silvered."
  - Disposal of even small quantities of silver nitrate connected to a septic tank is guaranteed to destroy the septic bacteria and require pumping out, flushing and seeding with fresh bacteria.
  - Silver Nitrate has antiseptic properties. A very dilute solution is sometimes dropped into newborn babies' eyes at birth to prevent contraction of gonorrhea or chlamydia from the mother. Many medical antimicrobial uses of silver are now controlled by antibiotics.
  - Fused silver nitrate, molded into sticks, was traditionally called lunar caustic. It is used as a cauterizing agent. Blood vessels can be cauterized to stop severe blood loss.
  - Photography used 30.98 percent of the silver consumed in 1998 in the form of silver nitrate and silver halides. Since digital technology has been the growing trend in photography, the use of silver in photography has rapidly declined. One of the earliest references to the concept of silver-based black and white photography is that of J. H. Schulze who observed in 1727 that a mixture of silver nitrate and chalk darkened on exposure to light. In the early 1830s, Louis Daguerre discovered that mercury vapor was capable of developing an image on a silver-plated copper sheet that had been previously sensitized by iodine vapor. The image, which was called a daguerreotype, could be made permanent by washing the plate with hot concentrated salt solution.

Note color changes during the reaction:

- The colorless solution of silver nitrate turns blue as copper II nitrate is formed.
- A solid forms on the surface of the copper wire as silver is deposited,  $\text{Ag}^+(\text{aq}) \rightarrow \text{Ag}(\text{s})$ .

### Part C: Burning magnesium

Do not look directly at the light produced when burning magnesium. When working with powdered magnesium, safety glasses with welding eye protection are used because the bright white light produced by burning magnesium contains ultraviolet light that can permanently damage the retinas of the eyes. Magnesium flares consist of powdered magnesium and an oxidizer (material that contains oxygen); the oxidizer is how they work underwater. Magnesium also burns very hot, another requirement for underwater flares since water is a good heat sink.

1. This is a great opportunity to point out how you know a chemical reaction has occurred.
  - There is some form of heat/and or light associated with the reaction.
  - The reactants and products have very different properties. Mg solid, malleable, shiny ribbon, is converted into a white powder, MgO.

### Part D: Decomposition of copper II carbonate

1. Compare the copper II oxide produced in the test tube with the solid produced on the surface of the copper metal in Part A.
2. Emphasize how you can test for different gases in the laboratory. If carbon dioxide is bubbled through a solution of limewater, a white precipitate is observed as calcium carbonate precipitates. Another lab test for carbon dioxide gas is placing a burning splint into the top portion of the test tube where the gas is produced. The flame will be extinguished as the flame is deprived of oxygen. Remember, carbon dioxide is heavier than air.

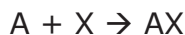
### Part E: Baking soda and vinegar solutions are mixed

1. The interesting part of this experiment is the course of the gas produced. A balanced chemical equation yields two products, sodium acetate and hydrogen carbonate (aq), or carbonic acid. The carbonic acid decomposed into water and carbon dioxide gas. Talk about carbonated beverages!

## BACKGROUND INFORMATION

When elements or molecules combine in chemical reactions, the resulting products remain electrically neutral overall. Let's look at five different types of chemical reactions: synthesis, decomposition, single replacement (or displacement), double replacement and combustion reactions.

In a synthesis reaction, two or more substances (elements or compounds) combine to form a more complex substance. Using A, B, C to represent positive cations and X, Y, Z, to represent negative anions,

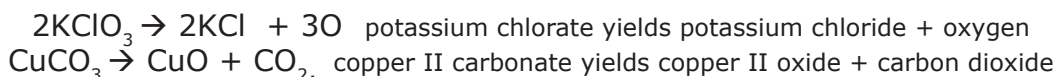


Examples could include sodium and chlorine combining to form sodium chloride or hydrogen reacting with oxygen to form water:  $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$  and  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ .

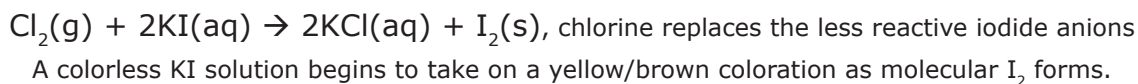
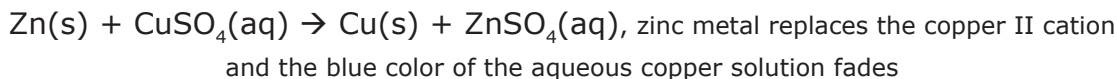
A decomposition reaction is the reverse of a synthesis reaction. A more complex compound breaks down to form two or more simpler substances (elements or compounds). Equations for decomposition reactions have the form



Decomposing water into hydrogen and oxygen is an easy reaction to predict. However, the products of some decomposition reactions prove more difficult to predict and students need to see these decomposition reactions in the laboratory to become more familiar with the reactions. Examples include the decomposition of metallic chlorates and the decomposition of metallic carbonates:



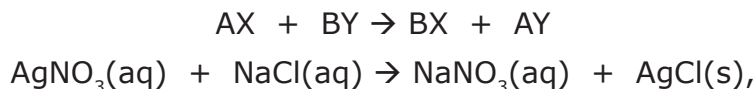
In a single replacement reaction, one element in a compound is replaced by another, more active, element. Equations for single replacement reactions have two general forms. Either a positively charged metal ion is replaced by a more active metal, or a nonmetal with a negative charge is replaced by a more reactive nonmetal. Nonmetal replacements involve the halogens. The result is a new element and a new compound.



Usually, the newly made compound stays dissolved in solution, but sometimes it may form a solid. The lone elements are usually metal atoms or diatomic molecules such as hydrogen or the halogens.

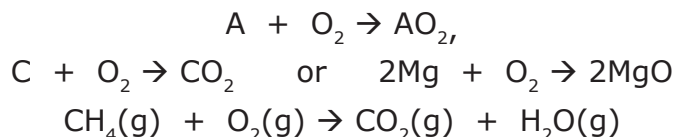
## BACKGROUND INFORMATION (continued)

Most replacement reactions, both single and double, take place in aqueous solutions where ions are free to move about and come into contact with other elements or ions. These free ions act as spectator ions and remain in solution as the reaction occurs. In double replacement reactions, the positive ions of two different compounds replace one another by exchanging places. The positive and negative ions in the compounds can be single atom ions or polyatomic ions. When illustrating double replacement reactions to students, it is best to show an ionic reaction where one of the products will be either a precipitate, a gas or a slightly ionizable product such as water, a weak acid or a weak base. Normally, the other product stays dissolved in solution.



Word equation: Aqueous silver nitrate reacts with aqueous sodium chloride to produce aqueous sodium nitrate and a solid precipitate of silver chloride.

A combustion reaction occurs when a substance is burned in the presence of oxygen to produce oxides and a lot of energy, usually in the form of heat or light. Some synthesis reactions can be considered combustions if they involve oxygen and occur quickly enough for a noticeable release of energy. If the reactant is a hydrocarbon, the product of the organic combustion will be carbon dioxide and water.



Remember, when writing a molecular equation, it is necessary to complete a series of steps.

1. Write good formulas for the reactants and products. Formulas of compounds must be written correctly. The sum of the oxidation numbers must equal zero. In other words, all compounds must be electrically neutral. The positive charges and the negative charges must sum to be zero in a compound. Formulas for the seven diatoms must also show the elements in pairs.
2. Balance the equation. The number of atoms of any given elements must be the same on both sides of the equation. Multiplying the coefficient and the subscript of an element must yield the same number of atoms on both sides of the equation. In most cases, polyatomic ions can be considered the same as an atom for balancing purposes.

## ADDITIONAL RESOURCES

Visit [adamequipment.com/education](http://adamequipment.com/education) regularly for new classroom resources.

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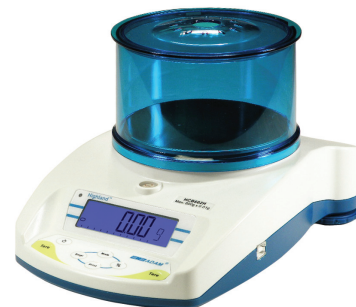
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## ADAM EQUIPMENT BALANCES RECOMMENDED FOR THIS EXPERIMENT

### Highland Portable Precision Balance

**Models recommended for this experiment:  
HCB302 (300g capacity x 0.01g readability)  
or HCB123 (120g capacity x 1mg readability)**

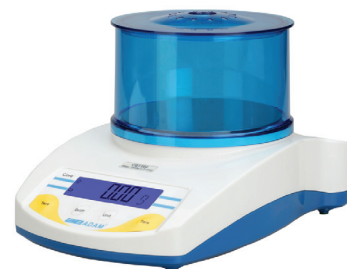
Complete with more features and accessories than any other in its class, Adam Equipment's Highland Portable Precision Balances have what it takes for school and college applications. The reliable Highland provides the latest in weighing technology, 15 weighing units with four weighing modes and it is easy enough for novice students. It features Adam's unique patented ShockProtect™ overload protection to withstand up to 200kg, and HandiCal™ internal calibration with built-in mass. Calibrate whenever you want without external masses or use your own masses. USB and RS-232 interfaces are both included with cables. The rechargeable battery (adapter/charger included), removable draft shield and brilliant backlit display with capacity tracking make Highland the most complete portable precision balance available. Available in seven models from 150g x 0.001g to 3000g x 0.1g. For complete product details, visit [www.adamequipment.com/education](http://www.adamequipment.com/education).



### Core Portable Compact Balance

**Model recommended for this experiment:  
CQT202 (200g capacity x 0.01g readability)**

Compact and durable, no other balance can beat the Core for basic weighing value. The tough, durable ABS housing is designed to withstand classroom environments, while being easy to clean and protected from accidental spills. With built-in ShockProtect™ overload protection, Core balances can handle excessive overloads without a problem. The simple keypad with dual tare keys and a brilliant backlit display make Core balances easy to use. Complete with a removable draft shield, AC adapter, and integral security slot, Core balances are ready to work right out of the box.



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### Submitting Your Own Experiment

If you have an idea for a useful educational resource that you would like to share with other teachers, Adam Equipment is interested in hearing from you. Initial submissions need to include only a simple description of the activity with the activity's purpose, subject, and grade level. Please contact Adam's education division by e-mail at [education@adamequipment.com](mailto:education@adamequipment.com) to determine if your particular activity will fit into our experiment library. Adam Equipment will respond promptly to all inquiries.

# 2

## Student Section

# MASSIVE REACTIONS

## STUDENT HANDOUT

Chemical reactions can be classified into major categories of reactions: synthesis, decomposition, single replacement, double replacement, and combustion. This lab illustrates different types of reactions. You will write a balanced equation for each reaction and predict the identity of the products. After writing a balanced chemical equation for the reaction, respond to additional questions.

### Safety

- Use precaution when lighting and operating a gas burner. When heating a test tube, aim the mouth of the test tube AWAY from yourself and others.
- Burning magnesium produces a very bright, hot flame. Be sure to hold the burning metal away from your body. Intense light may damage your eyes, so do NOT look directly at the flame.
- Never smell a chemical directly. Waft any gas products (teacher illustrated)
- Wear safety goggles and protective clothing when working in the lab.

## MATERIALS

### Laboratory Equipment/Chemicals:

- |                                  |  |
|----------------------------------|--|
| • 250 mL beaker                  | • Test tube rack                           |
| • Bunsen Burner                  | • Copper wire, 22 gauge (Cu)               |
| • Crucible tongs                 | • Magnesium ribbon, 4 cm (Mg)              |
| • Evaporating dish or watchglass | • Copper(II) carbonate ( $\text{CuCO}_3$ ) |
| • Sandpaper, fine                | • Limewater solution                       |
| • Spatula                        | • 0.10 M silver nitrate                    |
| • Test tubes, 15 x 180 mm (7)    | • Sodium bicarbonate                       |
| • Test tube holder               | • Vinegar                                  |

## PROCEDURE

### Part A

1. Gently clean 10.0 cm of copper wire with steel wool or sand paper until wire is shiny. Tare a piece of weighing paper, then mass the piece of copper wire. Record the mass of the wire.
2. Holding a piece of copper with tongs, place the foil into the flame of a Bunsen burner. For 30 seconds, hold the wire a little above the hottest part of the Bunsen burner flame to prevent any of the copper detaching from the wire and drastically reducing the mass. Slowly, move the wire through the flame to heat the wire and allow the reaction to occur.
3. Gently place the piece of wire on the balance. Let the copper cool. Mass the copper wire. Record any observations and respond to questions in part A.
4. Disposal: Return metal pieces to the teacher.

### Part B

1. Half-fill a test tube with 0.1 M silver nitrate solution,  $\text{AgNO}_3$ . Do not get the silver nitrate solution on your hands or clothes. Wash immediately if any part of your body contacts the silver nitrate.
2. Cut a piece of 22-gauge copper wire about 18 cm (five inches) long. Record the mass of the wire, then loosely coil the wire around a pencil so the copper wire can be almost completely submerged in the silver nitrate solution.
3. Observe the submerged wire for five minutes or longer. Hold a piece of white paper behind the test tube to see the changes more clearly.
4. Record any observations and respond to Part B questions.



## STUDENT HANDOUT (continued)

5. Pour the test tube contents into a 250 mL beaker. Using a pair of forceps, carefully remove the copper wire from the test tube and rinse the precipitate off of the wire and into the beaker.
6. Rinse the copper wire with water. Using a small piece of paper towel, lightly dry the wire. Record the mass of the copper wire.
7. Disposal: Follow teacher directions for disposal of the precipitate and solutions.

### Part C

1. A 100.0 cm strip of magnesium ribbon has been previously massed by your teacher and the mass recorded. From this previously massed strip, cut off approximately 4.0 cm of magnesium.
2. Record the exact length of the magnesium. Mass the piece of magnesium.  
\*If the small piece of magnesium is not easily massed on a balance, use dimensional analysis and the mass of the 100.0 cm Mg strip to calculate the mass of the shorter piece (4.0 cm).
3. Record the mass of a small evaporating dish (or a watch glass).
4. Place the evaporating dish near a Bunsen burner. Using a pair of tongs, hold the piece of magnesium in a Bunsen burner flame until it ignites. Your teacher will demonstrate how to view the magnesium with a side glance and how to deposit the product of the burning into the evaporating dish. In order to avoid eye injury, DO NOT look directly at the light produced by the burning magnesium.
5. Hold the burning magnesium away from you and directly over the evaporating dish. Examine the product thoroughly. Record any observations and respond to part C questions.
6. Disposal: Product can be washed down the drain with running water.

### Part D

1. Disposal: Product can be washed down the drain with running water.
2. Record the mass of a test tube to be used in this experiment.
3. Mass about 2 g of copper II carbonate,  $\text{CuCO}_3$ , and place it loosely in the clean, dry test tube. Record the initial mass of the sample. Note the appearance of the sample. Record the mass of the test tube with the sample.
4. Insert a one-hole stopper with a glass bend into the test tube. Place the open end of the glass bend into a second test tube containing limewater. Have the opening of the glass bend beneath the surface of the limewater. An alternative to using the limewater test is to ignite a wooden splint and insert the splint into the test tube where the carbonate is being heated.
5. Using a test tube holder, heat the test tube with  $\text{CaCO}_3$  over a Bunsen burner for about three minutes. Try to heat the sample enough to have the reaction go completely. Note any change in the appearance of the sample in the test tube.
6. Note any changes in the limewater.
7. Do not place the test tube in a plastic test tube rack. Cool. Mass the test tube and its contents.
8. Disposal: Solid product can be discarded in a trash can or waste container. The limewater solution can be washed down the drain with running water.

### Part E

1. Record the mass a clean test tube.
2. Mass about 1 gram of baking soda: sodium bicarbonate,  $\text{NaHCO}_3$ . Record the exact mass and transfer the baking soda into the test tube.
3. Tare the mass of a 25 mL graduated cylinder on a balance. Add approximately 10 mL of vinegar to the cylinder and record the mass of the vinegar.
4. Slowly add about 1.0 mL of vinegar to the test tube with the sodium bicarbonate. Be careful not to let the reaction mixture spill out of the tube when adding the vinegar. Carefully, use a stirring rod to mix the sodium bicarbonate and the vinegar.
5. Continue adding vinegar in small amounts and stirring after each addition. Use all the vinegar. Observations?
6. Pour the products back into the empty 25 mL graduated cylinder and record the mass.
7. Disposal: Down the drain with running water.

## PART A QUESTIONS

1. Write the balanced equation for the reaction of copper in the flame.
2. What type(s) of reaction is this?
3. What observation can you make that indicates a chemical reaction has occurred?
4. What other observations did you make during the experiment?
5. What happens to the mass of the copper wire when you hold it in the flame? Explain why.

Initial mass of copper wire	grams
Mass of copper wire after heating	grams
Change in mass of copper wire	grams

6. Use your laboratory data from Question 5 to calculate the percent increase in the mass of copper wire.
7. Where do the reactants come in contact with each other in this experiment? How does this explain the small change in mass?
8. Given the following data, calculate the percent increase in the mass of the following copper wire.

Initial mass of copper wire	0.291 grams
Mass of copper wire after heating	0.295 grams
Change in mass of copper wire	grams

## PART B QUESTIONS

1. Write the balanced equation for the reaction of copper in a silver nitrate solution.
2. What type(s) of reaction is this?
3. What observations did you make in the lab?
4. How does the mass of the copper wire change? How can this small change be explained?

Initial mass of clean copper wire	grams
Mass of clean copper after reaction	grams
Change in mass of copper wire	grams

5. If 0.20 moles of silver precipitate, how many moles of copper metal reacted? How many grams of copper reacted?
6. If 0.40 moles of silver nitrate were consumed in a similar reaction, how many moles of copper II nitrate were produced?

## PART C QUESTIONS

1. Write the balanced equation for the reaction of magnesium in air (oxygen).
2. What type(s) of reaction is this?
3. What careful observations did you make in the lab?
4. Use the first set of data for sample calculations. Record your data and calculated values in the second table. Show your work for all calculations.

Mass of 100 cm Mg	1.030 grams
Mass of 4.0 cm Mg	0.041 grams
Calculated mass of Mg product, using equation	0.068 grams
Mass of dish	21.84 grams
Mass of Mg product and dish	21.86 grams
Mass of Mg product	0.02 grams
Mass of O <sub>2</sub> : mass product – mass Mg	grams

Mass of 100 cm Mg	grams
Mass of 4.0 cm Mg	grams
Calculated mass of Mg product, using equation	grams
Mass of dish	grams
Mass of Mg product and dish	grams
Mass of Mg product	grams
Mass of O <sub>2</sub> : mass product – mass Mg	grams

5. What are possible sources of error for this experiment? (See Question 3 for hints)
6. What is the percent yield of the product?

## PART D QUESTIONS

1. Write the balanced chemical equation for the reaction when copper II carbonate is heated.
2. Write a word equation for the reaction.
3. What type(s) of reaction is this?
4. What observations did you make in the lab?
5. How does the mass of the copper II carbonate in the test tube change? How can this change be explained?
6. Describe the reaction observed with limewater. Limewater tests for the presence of what substance?

## PART D QUESTIONS (continued)

7. Use the following data table to calculate the theoretical yield and the percent yield of the solid product. What are possible sources of error for the actual mass of the solid product?

Mass of test tube	18.88 grams
Mass of copper II carbonate	1.86 grams
Mass of test tube + $\text{CuCO}_3$	20.74 grams
Mass of test tube + solid product (after heating)	20.26 grams
Actual mass of solid product	1.38 grams
Theoretical mass of solid product	1.20 grams
Theoretical mass of other product	0.66 grams

Lab Data: Calculate the theoretical and percent yield of the solid in your experiment.

Mass of test tube	grams
Mass of copper II carbonate	grams
Mass of test tube + $\text{CuCO}_3$	grams
Mass of test tube + solid product (after heating)	grams
Actual mass of solid product	grams
Theoretical mass of solid product	grams
Theoretical mass of other product	grams

## PART E QUESTIONS

1. Write the balanced chemical equation for the reaction between sodium bicarbonate and vinegar.
2. Write a word equation for the reaction.
3. What type(s) of reaction is this?
4. What observations did you make in the lab?
5. What rule explains why the solid product eventually disappears?

## PART E QUESTIONS (continued)

7. Sample data:

Mass of test tube (optional)	grams
Mass of baking soda	1.00 grams
Mass of grad cylinder (optional)	grams
Mass of vinegar	8.93 grams
Mass sum of vinegar + baking soda	9.93 grams
Mass of product(s) in test tube	9.14 grams
Calculated mass of gas released	0.79 grams

8. Does this reaction follow the law of conservation of matter by having the starting mass of the reactants equal to the final mass of the products? Show calculations.
9. What problem would there be if only 1.0 mL of vinegar was used in the experiment?
10. In all the reactions, which specific chemical(s) could also have the symbol  $\uparrow$  ?
11. Which chemical(s) could have the symbol  $\downarrow$  ?

## GENERAL QUESTIONS

1. What is a reactant in a chemical reaction? How are the reactants identified in a chemical equation?
2. What does the symbol  $\rightarrow$  mean in a chemical equation?
3. List four symbols for physical states of matter in a chemical equation and tell what each symbol means. Also give a specific example from this lab.
4. List four observations you made in the lab that indicates a chemical reaction has taken place.
5. Why must chemical equations be balanced?
6. In all the reactions, which specific chemical(s) also could have the symbol  $\uparrow$  ?
7. Which chemical(s) could have the symbol  $\downarrow$  ?

## PART A QUESTION RESPONSES

1. Write the balanced equation for the reaction of copper in the flame.

ANSWER:  $2\text{Cu}(s) + \text{O}_2(g) \rightarrow 2\text{CuO}(s)$

2. What type(s) of reaction is this?

ANSWER: Synthesis or combustion

3. What observation can you make that indicates a chemical reaction has occurred?

ANSWER: Red hot glow of the copper in the flame, and a new product forms on the surface of the copper

4. What other observations did you make during the experiment?

ANSWER: Red hot glow of the copper metal, and a black solid is deposited on the surface of the copper.

5. What happens to the mass of the copper wire when you hold it in the flame? Explain why.

ANSWER: If none of the copper metal is allowed to drop off, the mass of the copper wire will increase.

Initial mass of copper wire	grams
Mass of copper wire after heating	grams
Change in mass of copper wire	grams

6. Use your laboratory data to calculate the percent increase in the mass of the copper wire.

ANSWER:  $0.004/0.291 \times 100 = 1.5\%$  increase

7. Where do the reactants come in contact with each other in this experiment? How does this explain the small change in mass?

ANSWER: Contact occurs only on the surface of the copper and the surface area is limited. Most of the copper atoms are below the surface area of the copper.

8. Given the following data, calculate the percent increase in the mass of another copper wire.

Initial mass of copper wire	0.291 grams
Mass of copper wire after heating	0.295 grams
Change in mass of copper wire	0.004 grams

## PART B QUESTION RESPONSES

1. Write the balanced equation for the reaction of copper in a silver nitrate solution.

ANSWER:  $\text{Cu}(s) + 2\text{AgNO}_3(aq) \rightarrow 2\text{Ag}(s) + \text{Cu}(\text{NO}_3)_2$

2. What type(s) of reaction is this?

ANSWER: Single replacement

3. What observations did you make in the lab?

ANSWER: A clear solution turns blue, and a shiny solid is deposited on the copper wire

4. How does the mass of the copper wire change? How can this small change be explained?

ANSWER: Mass of the copper wire should decrease.

Initial mass of copper wire	grams
Mass of clean copper after reaction	grams
Change in mass of copper wire	grams

5. If 0.20 moles of silver precipitate, how many moles of copper metal reacted? How many grams of copper reacted?
6. If 0.40 moles of silver nitrate were consumed in a similar reaction, how many moles of copper II nitrate were produced?

## PART C QUESTION RESPONSES

1. Write the balanced equation for the reaction of magnesium in air (oxygen).

ANSWER:  $2\text{Mg}(s) + \text{O}_2(g) \rightarrow 2\text{MgO}$

2. What type(s) of reaction is this?

ANSWER: Combustion or synthesis

3. What careful observations did you make in the lab?

ANSWER: Clean magnesium wire (a reactant) is shiny, the product is a white powder. Also, extremely bright white light and heat are given off.

4. Use the first set of data for sample calculations. Record your data and calculated values in the second table. Show your work for all calculations.

Mass of 100 cm Mg	1.030 grams
Mass of 4.0 cm Mg	0.041 grams
Calculated mass of Mg product, use equation	0.068 grams
Mass of dish	21.84 grams
Mass of Mg product and dish	21.86 grams
Mass of Mg product	0.02 grams
Mass of O <sub>2</sub> : Mg product – 4.0 cm Mg	grams

Mass of 100 cm Mg	grams
Mass of 4.0 cm Mg	grams
Calculated mass of Mg product, use equation	grams
Mass of dish	grams
Mass of Mg product and dish	grams
Mass of Mg product	grams
Mass of O <sub>2</sub> : Mg product – 4.0 cm Mg	grams

5. What are possible sources of error for the experiment? (See question 3 for hints)

ANSWER: Not all the magnesium is burned and converted to magnesium oxide. Some of the MgO produced sticks to the tongs or falls on the countertop.

6. What is the percent yield of the product?

## PART D QUESTION RESPONSES

1. Write the balanced chemical equation for the reaction when copper II carbonate is heated.

ANSWER:  $\text{CuCO}_3(\text{s}) \rightarrow \text{CuO}(\text{s}) + \text{CO}_2(\text{g})$

2. Write a word equation for the reaction.

ANSWER: Solid copper II carbonate decomposes to yield solid copper II oxide and carbon dioxide gas.

3. What type(s) of reaction is this?

ANSWER: decomposition

4. What observations did you make in the lab?

ANSWER: Copper II carbonate has a blue/green color, also copper II oxide is a black powder. The gas produced is bubbled through limewater and a white precipitate is formed,  $\text{CaCO}_3$ .

5. How does the mass of the copper II carbonate in the test tube change? How can this change be explained?

ANSWER: The mass of copper II carbonate decreases as carbon dioxide is evolved.

6. Describe the reaction observed with limewater. Limewater tests for the presence of what substance?

ANSWER: The bubbles form a white precipitate in limewater indicating the presence of carbon dioxide.

Use the following data table to calculate the theoretical yield and the percent yield of the solid product. What are possible sources of error for the actual mass of the solid product?

Mass of test tube	18.88 grams
Mass of copper II carbonate	1.86 grams
Mass of test tube + $\text{CuCO}_3$	20.74 grams
Mass of test tube + solid product	20.26 grams
Actual mass of solid product	1.38 grams
Theoretical mass of solid product	1.20 grams
Theoretical mass of other product	0.66 grams

Lab Data: Calculate the theoretical and percent yield of the solid in your experiment.

Mass of test tube	grams
Mass of copper II carbonate	grams
Mass of test tube + $\text{CuCO}_3$	grams
Mass of test tube + solid product	grams
Actual mass of solid product	grams
Theoretical mass of solid product	grams
Theoretical mass of other product	grams



## PART E QUESTION RESPONSES

1. Write the balanced chemical equation for the reaction between sodium bicarbonate and vinegar.  
ANSWER:  $\text{NaHCO}_3(\text{s}) + \text{HC}_2\text{H}_3\text{O}_2(\text{aq}) \rightarrow \text{NaC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
2. Write a word equation for the reaction.  
ANSWER: Solid sodium bicarbonate (baking soda) reacts with an acetic acid solution (vinegar) to produce sodium acetate and carbonic acid (hydrogen carbonate), which further decomposes to form water and carbon dioxide gas.
3. What type(s) of reaction is this?  
ANSWER: Double replacement
4. What observations did you make in the lab?  
ANSWER: Bubbles are formed as vinegar is added to the baking soda.
5. What rule explains why the solid product eventually disappears?  
ANSWER: First family salts, like sodium acetate, are soluble
6. What substance is the source of the gas bubbles? How many products are formed in the reaction?  
ANSWER:  $\text{H}_2\text{CO}_3$ , carbonic acid, decomposes to form the gas. There are 3 products formed; sodium acetate, water, and carbon dioxide.
7. Sample data:

Mass of test tube (optional)	grams
Mass of baking soda	1.00 grams
Mass of grad cylinder (optional)	grams
Mass of vinegar	8.93 grams
Mass sum of vinegar + baking soda	9.93 grams
Mass of product(s) in test tube	9.14 grams
Calculated mass of gas product released	0.79 grams

8. Does this reaction follow the law of conservation of matter by having the starting mass of the reactants equal to the final mass of the products? Show calculations.  
ANSWER: Yes. 9.93 grams (reactant mass) = (mass of products) 9.14g + 0.79g
9. What problem would there be if only 1.0 mL of vinegar was used in the experiment?  
ANSWER: There wouldn't be enough vinegar to react with all the baking soda; vinegar would be a limiting reactant.
10. In all the reactions, which specific chemical(s) could also have the symbol  $\uparrow$  ?
11. Which chemical(s) could have the symbol  $\downarrow$  ?

## GENERAL QUESTION RESPONSES

1. What is a reactant in a chemical reaction? How are the reactants identified in the chemical equation?

ANSWER: Reactants are the starting materials for a chemical reaction. Reactants are found to the left of the "yields" sign in a chemical equation.

2. What does the symbol  $\rightarrow$  mean in a chemical equation?

ANSWER: "yields" or "produces"

3. List four symbols for physical states of matter in a chemical equation and tell what each symbol means. Also give a specific example from this lab.

ANSWER:

- solid, (s) or  $\downarrow$
- liquid, (l)
- gas, (g) or  $\uparrow$
- an aqueous solution, (aq)

4. List four observations you can make in the lab that would indicate a chemical reaction has taken place.

ANSWER:

- color change
- heat or light produced
- production of a gas
- production of a solid precipitate

5. Why must chemical equations be balanced?

ANSWER: Law of Conservation of Matter: matter can neither be created or destroyed in a chemical reaction, only changed from one form to another. In other words, the number and kind of atoms on the reactant side of a chemical equation must be the same as the number and kind of atoms on the right side of the equation.

6. In all the reactions, which specific chemical(s) also could have the symbol  $\uparrow$  ?

7. Which chemical(s) could have the symbol  $\downarrow$  ?