EXPERIMENT 3

THE BURNING QUESTION

A Conservation of Matter Experiment

Contents:

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1

Teacher Guide

THE BURNING QUESTION

A Conservation of Matter Experiment

AGE LEVEL

This experiment is designed for ages 14-18. It can be adapted for ages 10-13.

SUBJECTS

Chemical reactions, chemistry, science as inquiry and data analysis.

PURPOSES

- To demonstrate the Law of Conservation of Matter.
- To dispel common misconceptions about combustion reactions.
- To have students analyze data that has been collected using laboratory equipment (balances).

TIME NEEDED

One laboratory period. Additional time may be required for analysis of data and additional discussions.

ACTIVITY OVERVIEW

Students burn steel wool in both an open and closed environment to understand what happens to matter during a chemical reaction.

This lesson is designed to easily and quickly integrate into existing curriculum. It comes complete with a three-page student hand-out, standards correlations, vocabulary lists, plus extensions and assessment tools with answer keys. This Adam Experiment is appropriate for remedial, review, reinforcement, or extension purposes.

HELPFUL ADVICE TO MAXIMIZE SAFETY AND STUDENT SUCCESS

1. It is best to use medium-coarse steel wool. Fine steel wool might contribute to popping out of the evaporating dish and onto the counter. Do not use steel wool with soap added, such as Brillo pads.

2. For safety purposes, wear safety goggles during this experiment and also remove paper from the area where the steel wool is being heated.

3. Burn steel wool samples in a pre-massed evaporating dish so any pieces of steel wool that break off can still be included in the total mass. Otherwise, student measurements might support the idea that mass decreases in a combustion reaction.

4. Exercise care when heating steel wool. Do not hold the sample piece directly in a Bunsen burner flame. If a burning splint is used to start the burning, quickly remove the splint after igniting the sample. Vigorous heating could produce popping which will reduce the gain in mass to be measured.

5. The difference in mass for this small sample of steel wool will be very small. Every bit counts so using the evaporating dish and taking steps to prevent popping will eliminate some error.

6. To prevent burns, remember to cool the test tubes and the evaporating dish before handling or weighing.

7. Discuss the accuracy of centigram balances. A very slight difference in mass in part two of this experiment might not represent a real change because of the machine's repeatability within ±0.01g.

SCIENCE SKILLS AND ABILITIES

SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry:
  1. Develop descriptions, explanations, predictions, and models using evidence and explanations. (ages 10-13)
  2. Formulate scientific explanations and models using logic and evidence. (ages 14-18)
  3. Using mathematics in scientific inquiry. (ages 10-18)

PHYSICAL SCIENCE

- Understanding chemical reactions. (ages 14-18)

DATA ANALYSIS, PROBABILITY AND DISCRETE MATH

- 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)

KEY VOCABULARY

ANTOINE LAVOISIER: A French pioneer in modern chemistry who, during the 1770's, was one of the first scientists to understand the importance of measurements. Considered by many to be the Father of Modern Chemistry, he is also noted for his discovery of the role that oxygen plays in combustion.

ATOM: The building block of all matter; the smallest particle of an element that has the chemical properties of the element.

BATTERY TERMINAL: The connection point for electrical current on a battery/conductor.

CHEMICAL REACTION: The process in which substances undergo chemical changes, forming new substances with different properties.

CENTIGRAM: A fundamental unit of mass used in the metric system (equal to one hundredth of a gram).

COMBUSTION: A reaction where a substance chemically combines with oxygen while being burned.

CORROSION: The process where metals wear away gradually. The most common form of corrosion is rusting which occurs when iron combines with oxygen and water.

FLAMMABLE: Easily ignited and capable of burning rapidly.

GRAM A fundamental unit of mass used in the metric system (equal to the weight of one cubic centimeter of distilled water at 4°C).

LAW OF CONSERVATION OF MATTER: Matter cannot be created or destroyed. Matter is simply rearranged in a chemical reaction.

MASS: A measurement that reflects the amount of matter (more precisely, the sample's weight divided by acceleration due to gravity).

OXIDIZE: To combine with oxygen in a chemical reaction, as in burning or rusting.

PHLOGISTON THEORY: A former theory of combustion in which all flammable objects contained a substance called phlogiston.

QUANTITATIVE ANALYSIS: A type of chemistry dealing with accurate measurements of the amounts or proportions of the various elements in a substance.

REACTANT: A substance that is part of a chemical reaction, and is present at the start of the reaction.

VAPORIZATION: The conversion of a solid or a liquid into a gas.

VOLATILE: Evaporating or vaporizing very quickly at normal temperatures and pressures.

SAMPLE DATA

EXPERIMENT 1: Open System

Mass of steel wool	1.13g
Mass of evaporating dish	50.75g
Mass of steel wool and dish	51.88g
Mass of burned steel wool and dish	51.99g
Mass of burned steel wool	1.24g

EXPERIMENT 2: Closed System

Mass of test tube	42.78g
Mass of steel wool	0.70g
Original Mass of steel wool and test tube	43.48g
Mass of steel wool and test tube after burning	43.49g
Mass of burned steel wool	0.71g

EXTENSION: Closed System With Increased Oxygen Environment

Test tube	42.77g
Steel wool	0.69g
Test tube + steel wool	43.46g
Test tube + steel wool after burning	43.47g
Steel wool after burning	0.70g

CONTROL TEST: Closed System With Nitrogen Environment

NOTE: This control was teacher-tested to support the experimental data collected. This experiment does not have to be repeated but data is shown for the teacher's benefit.

Test tube	42.13g
Steel wool	0.68g
Test tube + steel wool	42.81g
Test tube + steel wool after burning	42.81g
Steel wool after burning	.67g

ANSWER KEY FOR STUDENT ASSESSMENT SHEET

1. Initially, steel wool is a silver gray color with a little shine to it. After the combustion reaction, the steel wool appears a darker bluish-gray in color and there is less shine. The mass of the steel wool has increased.

2. a. There was a yellow-orange light or glow.

   b. There was a color change. (Note: The increase in mass is calculated from a measurement, and should not be included as an observation.)

3. If the steel wool gets heavier without adding anything that is visible to it, your little brother might think some new matter was created.

4. The mass of the steel wool sample increased when the iron (Fe) combined with oxygen (O_2) in the air.

   $4Fe_{(s)} + 3O_{2\,(g)} \rightarrow 2Fe_2O_{3\,(s)}$

5. The steel wool is heated differently. In the first experiment the heat from the glowing surface, the steel wool and the air are all in direct contact. The steel wool is heated as it burns and it is in direct contact with the air. In the second experiment, the test tube, the air, and the steel wool are being heated, but the heat is not in direct contact with the steel wool. Attaching the balloon prevents air from moving freely in and out of the balloon.

6. Only a color change indicates a chemical reaction might have occurred.

7. There is no light or glow observed. The reaction might be incomplete which would explain less of an increase in mass.

8. An increase in the mass of the steel wool must be balanced by a decrease in the mass of free oxygen molecules in the air. In the first experiment, the increased mass of the steel wool is measured and recorded. No attempt is made to determine if any oxygen is removed from the air. In the second experiment where there is a closed system, the color of the steel wool indicates formation of a new product. Oxygen is removed from the air as it chemically combines with the iron of the steel wool. As the mass of the steel wool increases, the mass of the air in the tube must decrease. In a closed system, the total mass will remain constant as the oxygen simply moves from the air to the steel wool where a new substance forms. The total mass of the closed system remains constant. Pay careful attention to the balloon!

9. When rusting occurs the properties of the metal changes. Corrosion weakens the iron because the iron oxide (rust) flakes off, and the amount of steel wool is reduced.

10. The corrosion of iron can be slowed down or prevented by not permitting the metal to come in contact with oxygen. This can be done by painting, coating with oil, or galvanizing (coating with zinc) the sample of iron.

POSSIBLE EXTENSIONS

Burning steel wool in a closed system filled with extra oxygen.

1. This part is conducted by the teacher but students are to record data during the procedure.

2. TEACHER: Repeat all steps to of Experiment 2 with this modification to Step 4: Flush the test tube with oxygen and slightly inflate the balloon with oxygen to a diameter of approximately 10cm.

3. STUDENTS: Record mass of test tube, steel wool and steel wool with test tube. Make observations after heating and also once test tube has cooled completely. Mass the test tube with the steel wool inside.

4. Compare and contrast the results from the closed system where a sample of steel wool was burned in air (experiment 2) versus the results from this extension where the sample is burned in a closed system with an enriched oxygen environment.

ADDITIONAL RESOURCES

Visit www.adamequipment.com/education regularly for new classroom resources.

ABOUT ADAM EQUIPMENT

Adam Equipment's world headquarters is located in Milton Keynes, United Kingdom, with facilities in the United States, Australia, South Africa and China. The company's balances have been trusted by professionals worldwide for 40 years. Contact Adam Equipment at education@adamequipment.com or online at www.adamequipment.com/education.

ADAM EQUIPMENT BALANCES RECOMMENDED FOR THIS EXPERIMENT

Highland Portable Precision Balance

Models recommended for this experiment:
HCB 302 Portable Balance (300g capacity x 0.01g 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.

Core Portable Compact Balance

Model recommended for this experiment:
CQT 202 (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.

GETTING INVOLVED IN ADAM EQUIPMENT'S EXPERIMENTS

Feedback On This Adam Experiment

If you have feedback on this Adam Experiment that would be valuable to other teachers, we encourage you to share your thoughts. Please email your comments to Adam's education division at education@adamequipment.com.

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 to determine if your particular activity will fit into our experiment library. Adam Equipment will respond promptly to all inquiries.

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2

Student Section

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A Conservation of Matter Experiment

INTRODUCTION

One of the properties of matter is its ability to burn or to support combustion. In the 18th century, the French chemist Antoine Lavoisier determined that when matter burns, the oxygen in the air combines with the matter. Lavoisier conducted experiments so that none of the products of burning could be lost. He carefully measured the mass of all the reactants at the beginning of the experiment then he measured the mass of all the products at the end of the reaction. Lavoisier had the best laboratory money could buy and he was meticulous in taking those measurements. From his work, Lavoisier came up with a theory about combustion that was far better than the popular Phlogiston Theory.

ANTOINE LAVOISIER

The Father of Modern Chemistry

A French pioneer in modern chemistry who, during the 1770s, was one of the first scientists to understand the importance of measurements. He changed chemistry from a qualitative to a quantitative science.

The Law of Conservation of Mass states that the total mass of all the reactants before a chemical reaction must be the same as the total mass of all the products after the chemical reaction has finished. For this to be true, the total number of atoms involved in the reaction must be constant. The total mass does not change because the total number of atoms does not change. Atoms are conserved in a chemical reaction.

Consider the starting mass and the final mass in common chemical reactions such as Alka-Seltzer® dissolving in water, a candle burning, or iron rusting. Observe a piece of wood before and after it has been burned. What products are formed? What similarities and what differences are there between the reactants and the products in this reaction? How does the final mass of the products compare to the starting mass of the reactants?

PURPOSE

What changes are anticipated when a piece of steel wool burns? Would burning a sample of steel wool in an open air environment have a different outcome from burning the sample in a closed container? By conducting these experiments, you'll be able to answer these burning questions and you will come to a better understanding of the Law of Conservation of Matter.

WHAT YOU NEED

- Steel wool pads, #0 grade
- Wooden splint
- Acetone
- Rubber balloon, helium quality
- Aluminum foil
- Glass rod
- Large, rimmed test tube (2.5cm x 19.5cm)
- 250 mL beaker
- Bunsen burner
- New nine-volt battery
- Safety goggles
- Large evaporating dish (metal, porcelain or glass)
- CQT 202 or HCB 302 balance

MAKE A HYPOTHESIS

Predict any changes to the mass of a piece of steel wool when it is burned. Will burning the steel wool in a closed container change your prediction? Write two separate hypotheses for any changes you predict, one hypothesis for burning the steel wool in open air and another hypothesis for burning steel wool in a closed container.

STUDENT PROCEDURES

Teacher preparation of steel wool

1. Remove a small section of a steel wool pad and open the weave to increase the surface area. A 10g to 15g piece should be enough for a class of 20 students, working in pairs.

2. Place the piece of steel wool into a 250mL beaker and add enough acetone to cover the strands of the pad. Cover the beaker with foil to reduce vaporization. Swirl to keep the acetone moving over the strands of steel wool and use a glass stirring rod to make sure all the strands have good contact with the acetone. Soak for five minutes to remove the protective coating on the strands. **Caution: Acetone is volatile and extremely flammable. Handle with care and keep away from heat sources.**

3. Use the glass rod to remove the pad from the acetone and carefully shake any excess acetone into a sink. Immediately flush the sink with water. Place the steel wool on a paper towel and allow it to air-dry. Acetone evaporates quickly, so this should only take a couple of minutes.

Experiment 1: Burning of steel wool in an open system

(Make sure to wear safety goggles during the burning procedure)

1. Remove a small section of steel wool (approximately 1.0 grams) that has been cleaned with acetone. Place the sample on a centigram balance and record the mass in the chart provided.

2. Mass a large evaporating dish. Record. Add the steel wool to the evaporating dish and record the mass of the dish and steel wool.

3. Using a new nine-volt battery, touch the two battery terminals to strands of the steel wool. Make observations. (Be careful the sparks do not hit you, your clothing or other flammable materials.) Use the battery to burn the entire piece of steel wool.

4. If necessary, use a burning splint to completely oxidize the piece of steel wool.

5. Record the new mass of the burned steel wool. Make observations.

Experiment 2: Burning steel wool in a closed system

(Make sure to wear safety goggles during the burning procedure)

1. Mass a large test tube and record the data in the chart provided.

2. Form a small piece of steel wool (approximately 0.50 grams) into the shape of the large test tube. Mass the piece of steel wool.

3. Place the steel wool in the test tube and mass the steel wool and test tube.

4. Remove all air from a balloon and secure the balloon over the opening of the test tube.

5. Heat the test tube over a Bunsen burner flame for five minutes. Be careful not to get the balloon near the flame. Make observations.

6. Cool the test tube completely. Make observations. Now remove the balloon and mass the test tube with the steel wool inside.

STUDENT WORKSHEET

NAME: ____________________ CLASS: ____________________ DATE: ____________________

Hypothesis: Open system: ____________________

Closed system: ____________________

Different or same? Why? ____________________

Data Log Experiment 1 - Burning Steel Wool In An Open System

Mass of steel wool	
Mass of evaporating dish	
Mass of steel wool and dish	
Mass of burned steel wool and dish	
Mass of burned steel wool	

Data Log Experiment 2 - Burning Steel Wool In A Closed System

Mass of test tube	
Mass of steel wool	
Original mass of steel wool and test tube	
Mass of steel wool and test tube after burning	
Mass of burned steel wool	

Conclusions – Experiment 1 (open system)

1. Describe the starting and ending substances for this first experiment. Were they different?
2. What observations indicate that a chemical reaction occurred and a new substance was formed?
   a.
   b.
3. Why would your little brother think matter was created in this experiment?
4. Explain the differences in mass of the steel wool after heating. Write a chemical equation to explain this change in mass.

Conclusions – Experiment 2 (closed system)

5. How is the set-up for the second experiment different from the first experiment?
6. In the second experiment, what observation(s) indicate that a chemical reaction has occurred and a new substance was formed?
7. What observation in Experiment 1 was not seen in Experiment 2? What might this tell you about the second experiment?
8. How are the results of the second experiment different from the first experiment?

Real World Application

9. Why is the corrosion of iron a problem?
10. How can the corrosion or rusting of iron be prevented?