Active Metals in the Periodic Table

Periodic Trends and the Properties of the Elements

Introduction

Like good experiments, good demonstrations often lead to other demonstrations. What follows is a series of related demonstrations. This illustrates the scientific method to students in a practical way. Irwin Talesnick is a master of this technique, and much of what is listed below was an outgrowth of his demonstration workshop.

Concepts

- Density
- Combustion

Background

Magnesium occurs in the Earth's crust as insoluble carbonates and sulfates. It generally is considered to be sixth among the elements in order of abundance by weight. The element was first isolated in 1807 by Sir Humphrey Davey. (Between 1807 and 1808, Davey also isolated sodium, potassium, calcium, barium, beryllium and strontium.) Because of its low density and high strength, magnesium is alloyed with other metals for use in structures such as aircraft, bicycle frames, wheels, and even superstructures on warships. It is also sold in sporting goods stores as a fire starter. It is important in biochemical processes in animals for nerve impulse transmission, muscle contraction, and carbohydrate metabolism. Magnesium is an active metal and reacts readily with most non-metals.

Reactions of Magnesium in Air

Concepts

- Synthesis reactions
- Combustion

Background

Magnesium is very chemically active; it joins together with most non-metals and almost every acid. When ignited, magnesium will react with oxygen, O_2, and nitrogen, N_2, to form the products magnesium oxide, MgO(s), and magnesium nitride, Mg_3N_2. See Equations 1 and 2. Its reaction with nitrogen can be demonstrated by adding water to the combustion residue. The odor of ammonia results from the reaction of the magnesium nitride with water. See Equation 3.

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s) \qquad \textit{Equation 1}$$

$$3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s) \qquad \textit{Equation 2}$$

$$Mg_3N_2(s) + 6H_2O(l) \rightarrow 2NH_3(g) + 3Mg(OH)_2(s) \qquad \textit{Equation 3}$$

Materials

Magnesium ribbon, Mg, 25 cm
Bunsen burner
Balance, centigram
Crucible and crucible lid, 15- or 30-mL
Crucible tongs
Ring stand, ring, and clay triangle
Scissors
Wash bottle
Wire gauze with ceramic center

Publication No. 91222
061616

Safety Precautions

Magnesium is a flammable metal. Magnesium burns with an intense flame. Do not look directly at burning magnesium. The light contains ultraviolet light that may hurt your eyes. Do not inhale the smoke produced when magnesium is burned. Handle the crucible and its lid only with tongs. Do not touch the crucible with fingers or hands. There is a significant burn hazard associated with handling a crucible—remember that a hot crucible looks exactly like a cold one. Always keep your face at arm's length from the crucible. Wear chemical splash goggles and chemical-resistant gloves and apron. Wash hands thoroughly with soap and water before leaving the laboratory. Use a Class D fire extinguisher like Flinn Met-L-X®. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information

Procedure

1. Burn a piece of magnesium ribbon in air. CAUTION—The combustion of magnesium produces UV light which can cause eye damage. Do not look directly at the burning piece of magnesium.
2. Before class heat about 0.5 gram of magnesium in a crucible until all of it has reacted. See the following procedure.
    1. Set up a Bunsen burner on a ring stand beneath a ring clamp holding a clay pipestem triangle. Do NOT light the Bunsen burner.
    2. Adjust the height of the ring clamp so that the bottom of a crucible sitting in the clay triangle is about 1 cm above the burner. This will ensure that the crucible will be in the hottest part of the flame when the Bunsen burner is lit (step 7).
    3. Measure a 25-cm length of magnesium ribbon and cut the magnesium to this length.
    4. Wearing gloves coil the metal ribbon around a pencil to obtain a loose ball of metal.
    5. Place the coiled magnesium ribbon in the bottom of the crucible and cover the crucible with its lid.
    6. Place the covered crucible with its lid on the clay triangle. Light the Bunsen burner and brush the bottom of the crucible with the flame for 2–3 minutes to slowly heat the crucible and its contents.
    7. Place the burner on the ring stand and heat the crucible in the hottest part of the flame.
    8. After 3 minutes, use crucible tongs to carefully lift the lid a small amount. This will allow air to enter the crucible. *Caution:* Do not open the lid too far, because doing so will allow the metal to ignite. There will be some smoke produced. Do not inhale the smoke! Do not lean over the crucible. Keep the crucible at arm's length at all times.
    9. Replace the lid and continue to heat the crucible. After 3 minutes, again lift the crucible lid to allow more air to enter the crucible. Replace the lid immediately if the metal starts to burn or the amount of smoke increases greatly.
    10. Continue heating the crucible for a total of 15 minutes. Approximately every three minutes, lift the crucible lid to allow air to enter.
    11. After 15 minutes, turn off the gas source and remove the burner.
    12. Using tongs, remove the crucible lid and place it on a wire gauze on the bench top. With the tongs, remove the crucible from the clay triangle and place it on the wire gauze as well.
    13. Allow the crucible and its contents to cool completely on the wire gauze for at least 10 minutes.
3. Add water to the cool product in the crucible. The odor of ammonia will be detected.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Any solid waste may be disposed of according to Flinn Suggested Disposal Method #26a.The crucible waste may be filtered with the solid waste disposed of to Flinn Suggested Disposal Method #26a and the liquid neutralized and disposed of according to Flinn Suggested Disposal Method #10.

Tip

- Should the crucible lid be on the crucible the whole time? Should the crucible be heated gently for a short time with the lid off prior to covering the crucible and placing it in the hottest part of the flame? Should the crucible lid be kept off the whole time, placed at an angle over the crucible in the clay triangle? These and many other variations for letting in enough air for the combustion of magnesium have been published in the literature. We have tested the safety of these modifications and recommend in this demonstration what we feel is the simplest and safest procedure to follow.

Reaction of Magnesium with Water

Concepts

- Redox reactions

Background

Magnesium reacts with water according to the following reaction.

$$Mg(s) + 2H_2O(l) \rightarrow H_2(g) + Mg(OH)_2(s) \qquad \textit{Equation 4}$$

What would happen if you poured water on a magnesium fire? Many city fire departments put a limit on the amount of active metals that may be stored within the city limits. A fire in the Chicago area at a plant that recovered magnesium from car parts was rocked by explosions when the local fire department trained their water hoses on the fire. The fire was allowed to burn itself out.

Materials

Magnesium ribbon, Mg, 25 cm
Bunsen burner
Phenolphthalein solution, 0.5%, 1 mL
Scissors
Test tube, 16 × 100 mm
Test tube holder
Wash bottle

Safety Precautions

Magnesium is a flammable metal. Wear chemical splash goggles and chemical-resistant gloves and apron. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information

Procedure

1. Cut a few pieces of magnesium and place them in a test tube about half full of water.
2. Heat the water magnesium mixture to boiling.
3. Stop heating the mixture and observe that the magnesium continues to bubble after the water has stopped boiling.
4. Collect some of the gas released and test for hydrogen. Add a few drops of phenolphthalein and observe the pink color.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The test tube waste may be filtered with the solid waste disposed of according to Flinn Suggested Disposal Method #26a and the liquid neutralized and disposed of according to Flinn Suggested Disposal Method #10.

Reaction of Magnesium with Carbon Dioxide

Concepts

- Redox reactions

Background

Active metals readily burn in air to produce oxides of the metals. In the absence of elemental oxygen active metals will often remove oxygen from other compounds. For example, hot magnesium will remove oxygen from carbon dioxide. The reaction is

$$2Mg(s) + CO2(g) \rightarrow 2MgO(s) + C(s) \qquad \textit{Equation 5}$$

How would you put out a magnesium fire? Not with CO_2. During the Falkland Islands war, a British ship sank when one Exocet missile hit it. The ship was made of a magnesium aluminum alloy which caught fire and the fire fighting system on the ship was CO_2.

Materials

Magnesium ribbon, Mg, 25 cm
Baking soda, 50 g
Butane safety lighter
Crucible tongs
Dry ice pieces (optional)
Erlenmeyer flask, 1-Liter
Vinegar, 25 mL

Safety Precautions

Magnesium is a flammable metal. Magnesium burns with an intense flame. Do not look directly at burning magnesium. The light contains ultraviolet light that may hurt your eyes. Do not inhale the smoke produced when magnesium is burned. Wear chemical splash goggles and chemical-resistant gloves and apron. Wash hands thoroughly with soap and water before leaving the laboratory. Use a Class D fire extinguisher like Flinn Met-L-X®. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information

Procedure

1. Fill a one liter flask with carbon dioxide. You can generate the CO_2 using vinegar and baking soda or use a few pieces of dry ice.
2. Hold a 3 cm piece of magnesium ribbon in forceps and ignite it in a Bunsen burner flame. *Caution:* Protect your eyes.
3. Thrust the burning magnesium into the flask. The magnesium will crackle and pop as it reacts with the CO_2. Black carbon will be deposited on the sides of the flask.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The flask waste may be disposed of according to Flinn Suggested Disposal Method #26a.

Reaction of Magnesium with Sand

Background

If water and carbon dioxide are not acceptable, what can be used to put out a magnesium metal fire? The third choice that comes to most students' minds is sand—smother the fire. Mendeleev would be rolling over in his grave snickering. This suggestion leads to an excellent lesson in chemical PERIODICITY.

Sand is primarily SiO_2 and while the bonding in sand is nothing like carbon dioxide (network solid vs van der Waals), the bonds that have to be broken to release oxygen are covalent. The reaction that occurs in the test tube is

$$SiO_2(s) + 2Mg(s) \rightarrow Si(s) + 2MgO(s) \qquad \textit{Equation 6}$$

Materials

Magnesium powder, Mg, 1 g	Sand, SiO_2, 1 g
Bunsen burner	Spatula
Ring stand and clamp	Test tube, heavy-walled, borosilicate, 16 × 125 mm

Safety Precautions

Magnesium is a flammable metal. Magnesium burns with an intense flame. Do not look directly at burning magnesium. The light contains ultraviolet light that may hurt your eyes. Do not inhale the smoke produced when magnesium is burned. Use a heavy-walled borosilicate test tube with no chipped or cracked edges. Remove all combustible materials from the area. Wear chemical splash goggles and chemical-resistant gloves and apron. Wash hands thoroughly with soap and water before leaving the laboratory. Use a Class D fire extinguisher like Flinn Met-L-X®. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Measure and mix the magnesium and sand in a clean dry container. The actual amounts of magnesium and sand are not that important.
2. Pour the mixture into the heavy-walled test tube.
3. Clamp the test tube to a ring stand. Have the test tube pointing up at a 10 to 20 degree angle.
4. Shake the contents of the test tube so that it is spread out in the test tube. You don't want it all piled up in the bottom of the test tube. The mixture should be spread about half way to the top to the test tube.
5. Heat the test tube. Move the burner around so that all the mixture is heated. The reaction has a high activation energy so you will have to heat it intensely.
6. When a red glow starts to spread through the test tube stop heating and allow the test tube to cool.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The test tube waste may be disposed of according to Flinn Suggested Disposal Method #26a.

Tips

- White magnesium oxide and silver gray silicon can be seen in the test tube. Note since glass is often written with the formula SiO_2 there is also a reaction between the walls of the test tube and the Mg. The reaction is so exothermic that the heavy walled test tube shows signs of melting.
- One interesting side comment is related to the gray-black discoloration that forms in crucibles that are used for the

formula of magnesium oxide experiment that is common to many lab manuals. The discoloration is silicon produced when the magnesium reacts with the compounds in the glazes on the crucibles. Crucibles that show this discoloration are better for the experiment because the Mg will not be reacting with the crucible.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation

Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter, understanding of motions and forces

Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, motions and forces

Acknowledgment

Special thanks to John Smith, West High School, Middleton, IL.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Active Metals in the Periodic Table* activity, presented by Bob Lewis, is available in *Periodic Trends and the Properties of the Elements*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Active Metals in the Periodic Table* are available from Flinn Scientific, Inc.

Catalog No.	Description
M0145	Magnesium Powder
M0139	Magnesium Ribbon
S0003	Sand Line, White
AP1254	Porcelain Crucible, 30-mL
AP8248	Porcelain Crucible Cover

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.