Red, White, and Blue

The Exciting Nature of Chemistry

Musical Choice: "The Stars and Stripes Forever" (Final 62 seconds) by John Phillip Sousa

Introduction

I have used this as a first day demonstration in my chemistry class. Judging from the comments I have received from parents at our school's Open House Night, my students are impressed with this simple one-minute combination of music and chemistry. The addition of patriotic music helps to draw students into this visually stimulating demonstration.

Concepts

- Acid–base indicators
- Precipitates
- Flame tests, flammability

Materials

Ammonium hydroxide, NH_4OH, 1.0 M, 300 mL
Copper(II) sulfate solution, $CuSO_4$, 1 M, 2 mL
Isopropyl alcohol, 70%, 50 mL
Magnesium sulfate solution, $MgSO_4$, 1 M, 2 mL
Phenol red indicator solution, 15 mL
Water, distilled or deionized
Beakers, 400-mL, 3
Light box
Meter stick, or other long stick
Rubber stopper, size 10
Safety shield
Whoosh bottle demonstration kit
Wood splint

Safety Precautions

Ammonium hydroxide liquid and vapors are extremely irritating, especially to eyes and the respiratory tract. Dispense in a hood and be sure eyewash is accessible. Moderately toxic by ingestion and inhalation. Isopropyl alcohol is a moderate fire risk as it is a flammable liquid. It is also slightly toxic by ingestion and inhalation and should be used in a well-ventilated room. Copper(II) sulfate is slightly toxic by ingestion. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Follow all laboratory safety guidelines and wash hands thoroughly with soap and water before leaving the laboratory. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Whoosh Bottle Demonstration

The "whoosh" bottle demonstration should be performed behind a safety shield and protective eyewear should be worn by the demonstrator and the viewers. With repeated use, plastic water bottles have been reported to break due to the formation of stress cracks. Always inspect the plastic bottle for flaws prior to performing this demonstration to minimize the chances of an accident. Glass water bottles should not be used in this demonstration. **Never** *use methyl alcohol or a pure oxygen environment. Do not perform this demonstration directly underneath smoke/heat detectors or sprinkler systems. Make sure the ceiling is at least 4 feet above the whoosh bottle to prevent scorching and fire. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.*

Preparation

Prepare 10 mL of 1 M magnesium sulfate solution by mixing 2.5 g of magnesium sulfate heptahydrate ($MgSO_4 \cdot 7H_2O$) with 10 mL of distilled or deionized water.

Procedure

Red, White, and Blue

Prior to the students' arrival:

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1. Add 15 mL of phenol red indicator to a 400-mL beaker. (RED)
2. Add 2 mL of the MgSO4 solution to the second 400-mL beaker. (WHITE)
3. Add 2 mL of the CuSO4 solution to the third 400-mL beaker. (BLUE)

Just before the demonstration is to begin:

4. Move the "empty" beakers onto the light box so that the students will eventually see from their left to right the colors red, white, and blue.
5. Darken the classroom and turn on the light box. Students should see "empty" beakers.
6. Pour roughly 300 mL of the NH_4OH solution into the red, white, and blue beakers.

Whoosh Flame Finale

1. Inspect the plastic whoosh bottle for grazing, frosting, cracking, or any small flaws. Replace the bottle if necessary.
2. Coat the inside of the water bottle with 20–30 mL of isopropyl alcohol. Recap the isopropyl alcohol bottle tightly and place it far from the demonstration area. Spinning the water bottle slowly on its side allows the liquid alcohol to volatilize and makes the vapor concentration uniform throughout the bottle.
3. Pour out any excess liquid and wipe the inside and outside of the neck to remove any remaining liquid.
4. Place a large rubber stopper over the top of the water bottle to contain the alcohol vapors.
5. When ready to perform this demonstration, set the jug on the floor and remove the stopper. You may wish to dim the lights.
6. Light a match or wood splint that is taped to a meter stick or other long stick. A butane safety lighter may be used, but is not recommended.
7. Stand back and, at arm's length, bring the burning match or wood splint over or slightly down into the mouth of the bottle. A rapid flame will instantly fill the bottle.

   The instructor must displace the gases from the bottle before repeating this demonstration due to the formation of the products of this reaction. The bottle may be filled with water to displace the gases, but must be completely dry before it is used again. The demonstration will not work again immediately due to the buildup of CO_2 in the bottle. *Safety note:* Do not add more alcohol to a hot jug. This could cause a dangerous flash back and start a fire.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. All the solutions prepared in this lab may be poured down the drain with an excess of water according to Flinn Suggested Disposal Method #26b.

Discussion

Red, White, and Blue

Phenol red is an acid–base indicator that changes from yellow (pH <6.8) to red under basic conditions (pH >8.4).

The white color results from the formation of the insoluble magnesium hydroxide.

$$MgSO_4(aq) + 2NH_4OH(aq) \rightarrow \underset{\text{(white)}}{Mg(OH)_2(s)} + (NH_4)_2SO_4(aq)$$

The deep blue solution is caused by a copper–ammonia complex ion.

$$Cu^{2+}(aq) + 4NH_4OH(aq) \rightarrow \underset{\text{(deep blue)}}{[Cu(NH_3)_4]^{2+}(aq)} + 4H_2O(l)$$

Whoosh Flame Finale

After the reaction has subsided and all the flames are out, wait for a minute or two until the bottle has cooled slightly. Pour out the water droplets from the bottle into a 25-mL graduated cylinder using a small funnel. As much as 12–14 mL of water may

result, showing that water is one of the products of the combustion of alcohol. As an optional add-on activity, you could have students perform calculations to determine the volume of water expected from the starting amount of isopropyl alcohol.

For example, if 20 mL of isopropyl alcohol (density = 0.78 g/mL) are used:

$$20 \text{ mL} \times 0.78 \text{ g/mL} = 15.6 \text{ g} \times 1 \text{ mole}/60 \text{ g} = 0.26 \text{ mol isopropyl alcohol}$$

From the balanced equation,

$$0.26 \text{ mol isopropyl alcohol} \times 4 \text{ mol } H_2O/1 \text{ mol isopropyl alcohol} = 1.04 \text{ mol } H_2O$$

So,

$$1.04 \text{ mol } H_2O \times 18 \text{ g/mol} = 18.7 \text{ g} = 18.7 \text{ mL of } H_2O \text{ expected}$$

Discuss possible reasons why the actual volume of water may have been slightly less, such as evaporation or the droplets of water remaining on the inside of the bottle.

The balanced chemical equation for the complete combustion of isopropyl alcohol:

$$2C_3H_8O + 9O_2 \rightarrow 6CO_2 + 8H_2O$$

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

References

Earles, T. T. *J. Chem. Educ.* **1991**, *68*, 57–58.

Fortman, J. J.; Rush, A. C.; Stamper, J. E. *J. Chem. Educ.* **1999**, *76*, 1092–1094.

Summerlin, L. R., Ealy, J. L. *Chemical Demonstrations: A Sourcebook for Teachers*, American Chemical Society, 1985, p. 148.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Red, White, and Blue* activity, presented by Jeff Bracken, is available in *The Exciting Nature of Chemistry*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Red, White, and Blue* are available from Flinn Scientific, Inc.

Catalog No.	Description
C0246	Copper(II) Sulfate, 1 M, 500 mL
I0021	Isopropyl Alcohol, 70%, 500 mL
M0018	Magnesium Sulfate, 500 g
AP8960	Butane Safety Lighter
AP2234	Rubber Stoppers, Size 10
SE225	Safety Shield
P0100	Phenol Red Indicator Solution
AP5943	Whoosh Bottle Demonstration Kit

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