The Brown Cloud

Environmental Chemistry

Introduction

Ira Remsen's memoir of his discovery of the properties of nitric acid has become an enduring symbol of the wonders of chemistry. Teachers love to retell the story as they recreate the demonstration that inspired young Remsen "to learn more about that remarkable kind of action."

Concepts

- Chemical reactions
- Oxidation-reduction

Materials

Copper wire, 3 mm length
Nitric acid, HNO_3, 15.8 M, 5-mL
Universal indicator
Water, tap
Pipet, Beral-type, graduated, 2
Plastic bag, Ziploc®
Reaction plate, 6-well
Sandpaper
Scissors

Safety Precautions

Concentrated nitric acid is corrosive and a strong oxidant. It is also toxic by ingestion and inhalation. Avoid contact with acetic acid and readily oxidized substances. Concentrated nitric acid will also attack and destroy metals and most plastics; never store concentrated nitric acid in a plastic bottle. Reaction of nitric acid with metals generates nitrogen dioxide, a toxic, reddish-brown gas with an irritating odor. Perform this demonstration in an enclosed system and ideally with a hood in case any gases leak from the bag. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling and disposal information.

Procedure

1. Obtain a Ziploc plastic bag and add approximately 5-10 mL of water to the bottom corner of the bag.
2. Position a 6-well reaction plate in the bag so that it sits on top of the water.
3. Obtain a 3 mm (exact size is not crucial) piece of copper wire.
4. Use sandpaper to remove the oxidized copper from the wire.
5. Place the copper wire in one of the wells in the 6-well plate.
6. Use a graduated pipet to fill the bulb with concentrated nitric acid.
7. Use scissors to carefully cut off about ¾ of the pipet stem. *Caution:* Make sure the stem is empty of nitric acid before it is cut! Do not remove the entire tip.
8. Place the bulb portion of the pipet on the reaction plate in the plastic bag.
9. Securely close the plastic bag.
10. Once the bag is closed position the remaining pipet tip so it is pointing into the well which contains the copper wire.
11. Squeeze the pipet bulb to release the nitric acid into the well containing the copper wire. Observe the reaction as it takes place.
12. Once the reaction is complete gently swish the bag so that the NO_2 gas is mixed into the water.
13. Fill a second graduated pipet with universal indicator.
14. Insert the pipet into the bag by opening the bag as little as possible.

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15. Empty the universal indicator into the solution in the bag. *Note:* The solution should turn a red color indicating its acidic pH.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory wastes. The waste solution may be disposed of by neutralizing with base and then flushing down the drain with excess water according to Flinn Suggested Disposal Method #24b.

Discussion

Ira Remsen (1846–1927) was an influential American chemist in the late 19th and early 20th centuries. Trained as a physician in New York City, Remsen abandoned the practice of medicine soon after receiving his degree, choosing instead to pursue a passion for chemistry. After receiving a doctorate in organic chemistry in Germany in 1870, Ira Remsen returned to the United States, where he founded the chemistry department at Johns Hopkins University. He later served as president of the university as well. Credited with the co-discovery of the artificial sweetener saccharin, Ira Remsen left behind a rich legacy of research in organic chemistry. Remsen felt that his most important contribution, however, was not to research but to education, "to promote the study of pure science, to develop a scientific habit of mind in students, and to train them to become investigators." Given his devotion to chemistry education, Ira Remsen would be pleased to know that one story in particular from his lifelong interest in chemistry has been passed down from generation to generation.

That Remarkable Kind of Action (The following quotation is attributed to Ira Remsen.)

"While reading a textbook on chemistry, I came upon the statement 'nitric acid acts upon copper.' I was getting tired of reading such absurd stuff and I determined to see what this meant. Copper was more or less familiar to me, for copper cents were then in use. I had seen a bottle marked 'nitric acid' on a table in the doctor's office where I was then 'doing time!' I did not know its peculiarities but I was getting on and likely to learn. The spirit of adventure was upon me. Having nitric acid and copper, I had only to learn what the words 'act upon' meant. Then the statement 'nitric acid acts upon copper' would be something more than mere words.

"All was still. In the interest of knowledge I was even willing to sacrifice one of the few copper cents then in my possession. I put one of them on the table; opened the bottle marked 'nitric acid'; poured some of the liquid on the copper; and prepared to make an observation.

"But what was this wonderful thing which I beheld? The cent was already changed, and it was no small change either. A greenish blue liquid foamed and fumed over the cent and over the table. The air in the neighborhood of the performance became dark red. A great colored cloud arose. This was disagreeable and suffocating—how should I stop this? I tried to get rid of the objectionable mess by picking it up and throwing it out of the window, which I had meanwhile opened. I learned another fact— nitric acid not only acts upon copper but it acts upon fingers. The pain led to another unpremeditated experiment. I drew my fingers across my trousers and another fact was discovered. Nitric acid also acts upon trousers.

"Taking everything into consideration, that was the most impressive experiment, and relatively, probably the most costly experiment I have ever performed. I tell of it even now with interest. It was a revelation to me. It resulted in a desire on my part to learn more about that remarkable kind of action. Plainly the only way to learn about it was to see its results, to experiment, to work in the laboratory."

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
Constancy, change, and measurement
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, chemical reactions,
Content Standard G: History and Nature of Science, science as a human endeavor, nature of scientific knowledge, historical perspective

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of *The Brown Cloud* activity, presented by Peg Convery, is available in *Environmental Chemistry*, part of Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *The Brown Cloud* are available from Flinn Scientific, Inc.

Catalog No.	Description
C0146	Copper, Wire, Bare, 4 oz.
N0043	Nitric Acid, 15.8 M, 100 mL
U0009	Universal Indicator Solution, 35 mL
AP1721	Pipet, Beral-Type, Graduated
AP1725	Reaction Plate, 6-well

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