Solubility of Ammonia

Properties of Ammonia

Introduction

Ammonia gas is easily generated on a microscale for testing with various acid–base indicators.

Concepts

- pH indicators
- Acid vs. base
- Gas vs. liquid phases
- Properties of gases

Materials

Ammonium hydroxide, 14.8 M, 5 mL
Bromthymol blue indicator solution, 0.04%, 10 mL
Hydrochloric acid solution, 0.1 M, 5 mL
Litmus solution, 0.5%, 10 mL
Methyl red indicator solution, 0.02%, 10 mL
Phenolphthalein indicator solution, 1%, 10 mL
Universal indicator solution, 10 mL
Water, distilled or deionized
Beakers, 100-mL, 7
Hot plate
Paper towels
Pipets, extra-large bulb, 5
Pipets, thin-stem, 7
Scissors
Stirring rods, 5

Safety Precautions

Concentrated ammonium hydroxide is moderately toxic by ingestion, a severe respiratory hazard, and extremely irritating to eyes. Hydrochloric acid solution is toxic by ingestion or inhalation and severely corrosive to skin and eyes. Phenolphthalein solution contains alcohol and is a flammable liquid. Hot objects and escaping steam can cause severe burns. 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.

Preparation

1. Use scissors to cut each stem from the extra-large bulb pipets just below the taper at the top of the stem (see Figure 1). Discard the stem portion of the pipets.

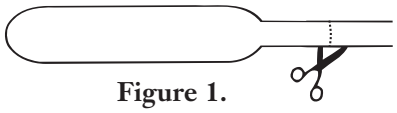

Figure 1.

2. Use a clean thin-stem pipet to add several drops of an acid-base indicator to 75 mL of cold DI water in a beaker. Stir with a clean stirring rod. Add additional indicator to create a deep colored solution.
3. Use a clean thin-stem pipet to add 0.1 M hydrochloric acid solution drop-wise to the solution until the solution is slightly acidic. Stir the solution after each drop of acid is added. Add more indicator as needed.
4. Set up a hot water bath, adjusting the temperature to approximately 90°C.
5. Add about 75 mL of very cold water to the remaining 100-mL beaker. This will be used to cool the concentrated ammonium hydroxide to reduce ammonia vapors from escaping into the room.
6. Place 1–2 mL of concentrated ammonium hydroxide into a thin stem pipet. Use a paper towel to remove any liquid from the outside of the pipet.

Publication No. 91409
061616

7. Place the indicator beakers in a row near the hot water bath. Place the cold water beaker near the hot water bath.

Procedure

1. Insert the thin-stem pipet containing the ammonium hydroxide into one of the cut pipet bulbs.
2. Place the bulb of the thin-stem pipet containing the ammonium hydroxide into the beaker of hot water. Warm the liquid to produce ammonia gas.
3. Fill the cut pipet bulb with ammonia gas. Immediately upon smelling ammonia remove the thin-stem pipet from the hot water bath. Place the thin-stem pipet into the cold water beaker as you finish the following steps.
4. Remove the cut pipet bulb from the top of the thin-stem pipet and quickly place the tip of the jumbo pipet into one of the acid-base indicator solutions.
5. Squeeze the pipet gently to push out one bubble of gas then release the bulb to allow a small amount of the indicator solution to enter the bulb. Listen and feel the bulb as it fills.
6. Repeat steps 1–5 with the remaining cut pipet bulbs and indicator solutions

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. Excess ammonium hydroxide may be neutralized and flushed down the drain with an excess of water according to Flinn Suggested Disposal Method #10. Excess hydrochloric acid solution may be neutralized and flushed down the drain with an excess of water according to Flinn Suggested Disposal Method #24b. Contact a licensed removal company regarding excess phenolphthalein according to Flinn Suggested Disposal Method #18b. The other used solutions should be neutralized before flushing down the drain with an excess of water according to Flinn Suggested Disposal Method #26b.

Tips

- The indicator color change provides a visual reminder of how quickly toxic gases can travel. Since many gases cannot be smelled or seen, this activity reinforces two important safety practices—work in a well ventilated room and carry out any reactions that may produce toxic fumes in a fume hood.
- Reproduce a pH range indicator chart from a reference book such as *Lange's Handbook of Chemistry* and have students determine which additional indicators may be used with this activity.

Discussion

The solubility of ammonia gas in water is extremely high; roughly 50 M of ammonia gas can dissolve in one liter of water at standard conditions. This high solubility of the gas is due to the reaction of the ammonia with the water to form aqueous ammonia molecules, ammonium ions, and hydroxide ions. As a result of the solubility there is a quick reduction in the pressure inside the pipet bulb causing a partial collapse of the pipet bulb, and the rushing of indicator solution into the bulb to equilibrate the pressure differential.

$$NH_3(aq) + H_2O(1) \rightarrow NH_4^+(aq) + OH^-(aq) \qquad \textit{Equation 1}$$

An acid-base indicator can exist in either a protenated or non-protenated form depending upon the pH of the solution. An appropriate indicator will change from its acidic color to its basic color as the ammonia gas dissolves in water and changes the pH of the solution.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Constancy, change, and measurement
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

Reference

Originally developed by Dianne N. Epp, Eash High School, Lincoln, NE, while participating in the Woodrow Wilson Chemistry Program, 1987.

J. G. Speight, Ed., *Lange's Handbook of Chemistry*, 16th ed., McGraw-Hill: New York (2005).

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Solubility of Ammonia* activity, presented by Penney Sconzo, is available in *Properties of Ammonia*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Solubility of Ammonia* are available from Flinn Scientific, Inc.

Catalog No.	Description
L0028	Litmus Solution, 0.5%, 500 mL
B0173	Bromthymol Blue Indicator Solution, 0.04%, 100 mL
P0019	Phenolphthalein Indicator Solution, 1%, 100 mL
M0085	Methyl Red Indicator Solution, 0.02%, 100 mL
U0001	Universal Indicator Solution, 100 mL
A0174	Ammonium Hydroxide, 14.8 M, 100 mL
H0014	Hydrochloric Acid, 0.1 M, 500 mL

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