THE AMMONIA FOUNTAIN REVISITED

The ammonia fountain has been known for many years. The success of this demonstration depends on use of dry ammonia. For those who do not wish to have a cylinder of anhydrous ammonia, obtaining the dry ammonia can be a trying experience. We have investigated several methods of generating ammonia for this demonstration and present here a reasonably simple method.

The basis of this method is to generate ammonia by the reaction of solid ammonium chloride with sodium hydroxide pellets.

\[ \text{NH}_4\text{Cl} + \text{NaOH} \rightarrow \text{NH}_3 + \text{H}_2\text{O} + \text{Na}^+ + \text{Cl}^- \]

The rate of gas evolution is controlled by the rate at which water is added. The heat released by the dissolution of the sodium hydroxide pellets provides the heat to evolve the gaseous ammonia.

Care should be exercised because too rapid a rate of gas evolution could cause an explosion. Also ammonia can be poisonous. Therefore, the ammonia generation should be performed in a fume hood.

A large round-bottomed flask or a Florence flask is used as the fountain and the ammonia collection flask. This flask is fitted with a two-hole rubber stopper with two glass tubes - one long and one short. The long tube extends through the stopper and...
is adjusted so that the end is about 3-4 cm from the bottom of the flask. The short tube just penetrates to the inside of the flask. A short piece of rubber or vinyl tubing is attached to the outside end of each tube so that they can be fitted with pinch clamps.

A smaller flask, such as a 250 mL Erlenmeyer or round bottomed flask, can be used as the ammonia generator flask. This flask is fitted with an addition funnel and an outlet tube. Glass tubes inserted through a two-hole rubber stopper can be used and the funnel connected with rubber tubing to one of the glass tubes. The addition funnel can be replaced by a funnel and pinch clamp or a buret.

The wet ammonia gas is dried by passing the gas first through a drying tube containing a desiccant such as anhydrous CaSO₄ (eg. Drierite brand) or molecular sieve and then passing the gas through a second drying tube containing NaOH pellets to remove any remaining water. If the second drying tube is transparent, any moisture collected by the sodium hydroxide can be seen on the surface of the pellets.

Before collecting any ammonia, all the parts should be dried in an oven (60-105°C.) Assemble the apparatus as indicated in the Figure. A small piece of glass wool should be placed in the outlet of each drying tube to prevent the desiccants from blocking the passage of gases. During assembly, pinch clamps are placed on the rubber tubing on both ends of the drying tubes. These clamps must be removed before starting to generate the ammonia. The fountain-collection flask is inverted because ammonia is heavier than air. Remember that two or three liters of water is heavy. Insert the rubber stopper into the fountain securely and support the fountain properly.

Place sufficient solid NH₄Cl and NaOH pellets into the generator flask to produce enough gaseous ammonia to flush the flask at least three times (ie. 3 times the volume of the fountain flask). Using the Ideal Gas Law, \( V = nRT/P \), a tenth of a mole of ammonium chloride at 27°C and 1 atm will produce approximately 2.5 liters of gaseous ammonia:

\[
(0.10 \text{ mol}) \times (0.082 \text{ L atm mol}^{-1}\text{K}^{-1}) \times (300 \text{ K})/(1 \text{ atm}) = 2.5 \text{ L}
\]

Hence, 5.4 g NH₄Cl and 4.0 g NaOH, should produce about 2.5 L of gas.

To start the generation, remove all pinch clamps and open all stopcocks. Check that no tubes or tubing are blocked. Then close the stopcock to the addition funnel and placed about 10 mL of water in the addition funnel. Now add 1 or 2 mL H₂O to the generation flask. The solids should begin to dissolve. Vapors usually are observed inside the generating flask. Using moist, red litmus paper, test the outlet of the fountain flask for ammonia. If no ammonia is detected after a few minutes, add more water.

After the fountain flask has been flushed, remove the delivery tube from the generation flask. Then clamp both rubber tubes attached to the fountain flask. Clamp both ends of the drying tubes. Set the generation flask at the back of the fume hood or conduct the delivery tube into a beaker of dilute acid such as vinegar.

The ammonia fountain is ready to present to the audience after a tube (glass, clear vinyl, or rubber) has been attached to the longer tube and the end placed in a large container of water. Immediately before starting the demonstration, fill a rubber bulb with water and attach it to the short tube in the fountain.
To start the fountain, remove all clamps from the fountain tubes and squeeze the rubber bulb to start the reaction. Anhydrous ammonia is very soluble in water. Hence as the ammonia dissolves in the water just introduced, a vacuum is created inside the flask. This vacuum draws the water forcefully up into the flask.

If an acid/base indicator is placed in the water in the reservoir, then an appropriate color change occurs in the basic ammonia solution. Phenolphthalein produces a pink fountain. Litmus turns from red in the water reservoir to blue in the fountain. Other indicators can be used along with a small amount of vinegar in the reservoir to produce other colors. Do not use concentrated acids since the heat of neutralization could cause the flask to break.

Art Landis
Tracy Helms
Chemistry Department
Emporia State University