ing a piece of calico dyed with Turkey red,[1] which you have moistened, between them, and slipping a strong rubber band over each end, as shown in Fig. 100. This done, drop some hypochlorous acid($HClO$), which is a bleaching liquid, into the hole of the top board and let it filter through the cloth. Finally, take the calico from the boards and wash

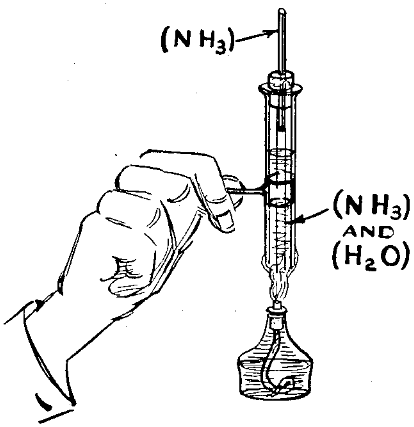

FIG. 101.—Making a Little Ammonia Gas.

it, and you will find a perfectly white spot on it where the liquid came in contact with the colored fibres.

Experiment with Ammonia. While the ammonia (NH_4OH) we know so well and use so much of is a liquid formed of ammonia (NH_3), which is a gas, dissolved in water (H_2O), real ammonia (NH_3) is a transparent colorless gas that has a very penetrating, choking odor, and

[1] Turkey red is a dye produced when alizarin ($C_{14}H_8O_4$) is used with a *mordant* of aluminum sulphate ($Al_2(SO_4)_3.H_2O$).

when inhaled it produces suffocation. Ammonia (NH_3) is only about half as heavy as air, and while it will not burn in the latter, it will burn in oxygen (O).

One of the characteristics of ammonia (NH_3) is that a large amount of it will dissolve in a very small amount of water (H_2O), which is to say that 600 volumes of ammonia (NH_3) can be dissolved in 1 volume of water (H_2O). Now,

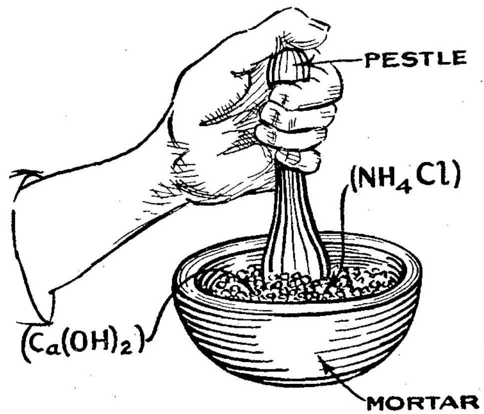

FIG. 102.—Rubbing Up Sal Ammoniac and Slaked Lime in a Mortar.

in the experiments to follow, be sure to keep ammonia (NH_3) gas separate and distinct in your mind from ammonium hydroxide (NH_4OH), which is ammonia (NH_3) gas dissolved in water (H_2O), and is generally called *ammonia*, or more properly, *aqua ammonia*.

How to Make a Little Ammonia. Half fill a test tube with *concentrated liquid ammonia*, which is made by dissolving as much ammonia (NH_3) in water (H_2O) as possible, then put a cork into the mouth of it, which is fitted with a delivery tube, as shown in Fig. 101, heat the solution of ammonia (NH_3) over the flame of your alcohol lamp, and ammonia (NH_3) gas will be given off, and this you can detect by cautiously smelling at the opening of the delivery tube.

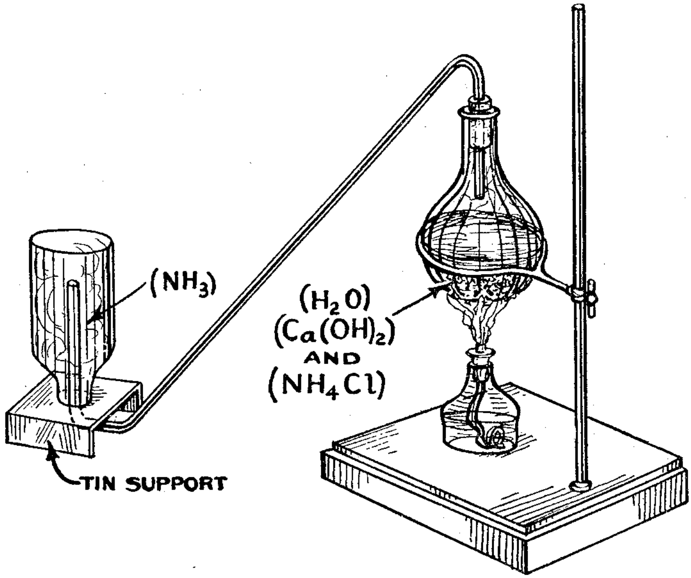

FIG. 103.—Making Ammonia Gas for Experimental Purposes.

How to Make Ammonia on a Larger Scale. Put 1 ounce of ammonium chloride (NH_4Cl), that is, *sal ammoniac*, into a mortar and powder it, as shown in Fig. 102; now powder 1 ounce of calcium hydroxide ($Ca(OH)_2$), which is slaked lime, in a mortar and then mix them well together. This done, put them into a glass flask, add a little warm water (H_2O), and put in a cork that has a delivery tube in it; finally heat it gently over the flame of your alcohol lamp for 10 minutes, as shown in Fig. 103, and ammonia (NH_3) gas will be given off, and, as it is only about half as heavy as air, you can collect it in a large test tube or a bottle by inverting it over the free end of the delivery tube, which should reach nearly to the top of the container.

How the Experiment Works. When the ammonium chloride (NH_4Cl) and calcium hydroxide ($Ca(OH)_2$) are heated together they combine and form calcium chloride ($CaCl_2$), water (H_2O), and ammonia (NH_3) gas, which is given off, or to write it as an equation:

$$2\,NH_4Cl + Ca(OH)_2 = CaCl_2 + 2\,H_2O + 2\,NH_3 \uparrow$$

2 NH₄Cl	Ca(OH)₂	CaCl₂	2 H₂O	2 NH₃
Ammonium chloride	Calcium hydroxide	Calcium chloride	Water	Ammonia

To Show How Ammonia Dissolves in Water. Take a strong test tube and fill it with ammonia (NH_3) gas, stand it in a small dish of mercury (Hg) (an individual butter-dish will do) so that the gas will be sealed in the tube air-tight, as shown in Fig. 104. Now set the dish and the tube in a larger glass dish and nearly fill the latter with water (H_2O); these preliminaries attended to, lift the test tube so that its mouth will be just above the surface of the mercury (Hg), but not out of the water (H_2O), and the latter will rush up into the tube and nearly fill it, as shown in Fig. 105.

How the Experiment Works. This curious action is due to the fact that the instant the mouth of the test tube is lifted above the mercury (Hg), the water (H_2O) enters it and absorbs about all of the ammonia (NH_3) gas that fills the tube; this action leaves a vacuum in the tube and the pressure of the outside air on the water (H_2O) in the dish forces the latter up into it.

How to Make an Ammonia-Operated Fountain. For this experiment, which is one in physics as well as in chemistry, use a round flask, and through the cork of it fit a

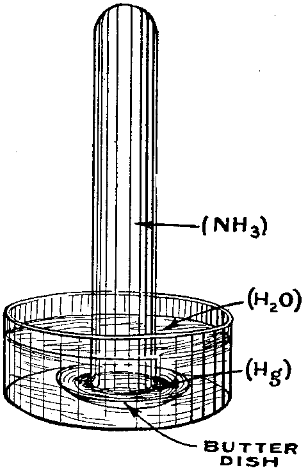

FIG. 104.—The Test Tube Sealed by Mercury.

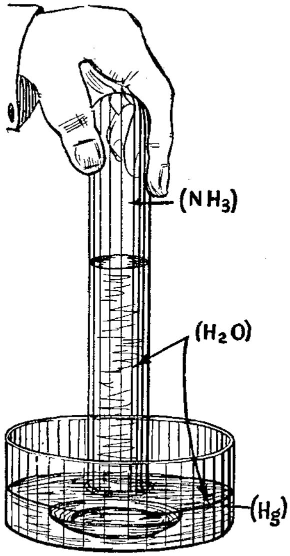

FIG. 105.—The Test Tube Lifted from the Mercury.

short piece of tube with one end drawn to a nozzle. Now fill the flask with ammonia (NH_3) gas and put the cork into it tight, with the nozzle end of the pipette up into the neck; color some water (H_2O) with a little aniline dye, either red or blue, and then dip the lower and larger end of the pipette into it, as is shown in Fig. 106.

Instantly the ammonia (NH_3) gas in the flask will be absorbed by the water (H_2O) and produce a vacuum in the flask. This causes the pressure of the air on the water (H_2O) outside to force it up through the nozzle, after which it will fall in a spray.

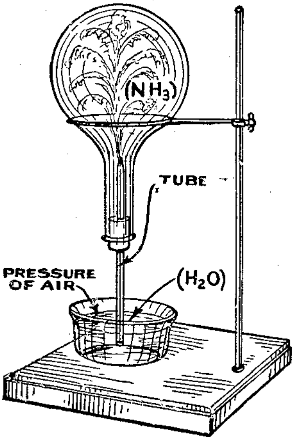

FIG. 106.—An Ammonia-Operated Fountain.

How to Make Concentrated Liquid Ammonia. Liquid ammonia (NH_3) is ammonia (NH_3) gas *liquefied*, which condition is brought about in the same way that air is liquefied, and this is by heat extraction and pressure, but what we ordinarily call liquid ammonia (NH_3) is, as I explained before, simply ammonia (NH_3) gas dissolved in water (H_2O), and *concentrated liquid ammonia* is water (H_2O) in which the largest possible amount of ammonia (NH_3) gas is dissolved.

You can make a small quantity of concentrated liquid ammonia (NH_4OH) by putting a little distilled water (H_2O) into a U-tube and setting this in a beaker of ice-water (H_2O), as shown in Fig. 107. One end of the U-tube is connected with the delivery pipe of your ammonia (NH_3) generating apparatus that is shown in Fig. 103, and the other end of it is closed with a cork in which you have inserted the tube of a pipette. As water (H_2O) increases from 100 volumes in its normal condition to 175 volumes when it is saturated with ammonia (NH_3) gas, the U-tube must not be more than one-third full of water (H_2O) to start with.

How the Experiment Works. When the ammonia (NH_3) is passed *very slowly* into the U-tube the water (H_2O) will rise in the arm of it that contains the pipette,

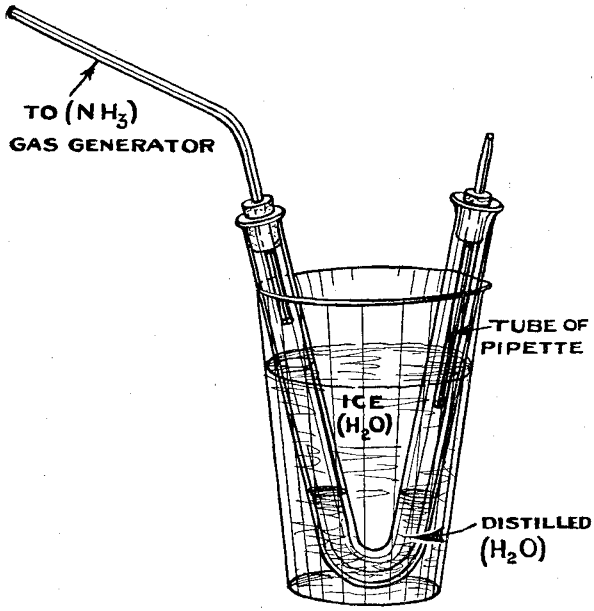

FIG. 107.—Apparatus for Making Concentrated Liquid Ammonia.

and the pressure of the gas will make the water (H_2O) absorb the largest possible amount, and a saturated solution will result. You will know when the water (H_2O) has absorbed all the ammonia (NH_3) gas it can by the expansion of it, causing it almost to touch the cork that has the pipette in it. The resulting solution will be concentrated liquid ammonia (NH_4OH), and it will be very strong indeed.

An Experiment with Concentrated Liquid Ammonia. Put some concentrated liquid ammonia (NH_4OH) into a test tube and set this in a beaker of melting ice (H_2O), and it will be cooled to a temperature of 32 degrees Fahrenheit, which is the freezing point. When it is thoroughly chilled, pour it into a beaker and set this in a warm room; now when it reaches a temperature of 62 degrees Fahrenheit it will begin to boil and give off ammonia (NH_3) gas; as soon as it ceases boiling and giving off gas, grip the beaker with the palm of your hand, as shown in Fig. 108, and the heat of the hand will make the liquid ammonia (NH_4OH) boil again and give off still more gas.

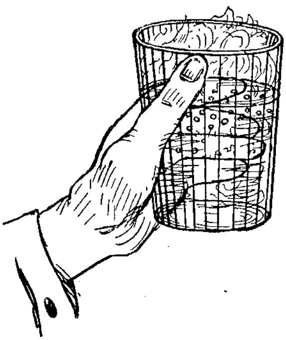

FIG. 108.—Boiling Ammonia with the Heat of Your Hand.

Some Uses of Aqua Ammonia. Ammonia (NH_4OH) is used in small amounts in the household as a remedy for headache (aspirin or phenacetine is better), for polishing some metals, for cleaning clothes, and for softening water. It is used in larger amounts commercially for refrigeration, in which the gas is liquefied by pressure and cooled by running it through a coiled pipe in cold water.

The liquid ammonia (NH_4OH) then drips through a nozzle in the end of the pipe, causing evaporation. This takes the heat out of a salt solution, or brine, in which there are suspended cans that are filled with pure water; in this way the temperature of the brine is reduced below the freezing point and the water (H_2O) in the cans freezes into cakes of ice (H_2O). Finally, ammonia is used for making compounds of various kinds, including fertilizers.

CHAPTER VII.

ACIDS, THE GREAT SOLVENTS

WHILE water (H_2O) is the greatest of all solvents, still there are many substances which it will not dissolve, and acids of different kinds must be used instead. All acids are alike in at least four respects, and these are that they have a sour taste, change blue litmus paper red, contain hydrogen (H), and, finally, metals dissolve in them, causing the acids to give up their hydrogen (H).

Acids are usually formed of gases which are dissolved in water (H_2O), and acid solutions of this kind will dissolve metals. Weak acids which are called dilute acids, contain as high as 80 per cent of water (H_2O); stronger acids, called commercial acids, have about 7 per cent of water (H_2O) in them, while concentrated acids have the smallest possible amount of water (H_2O) in them. It is very seldom that the water (H_2O) which forms a part of an acid has any effect on the substances to be acted upon and, hence, it is not taken into consideration in the reactions.

The most useful acid is sulphuric acid (H_2SO_4), then comes hydrochloric acid (HCl), and this is followed by nitric acid (HNO_3); and then there are more than 50 other kinds which have a less extensive use. Now, like all other chemicals, you can buy the acids you need a great deal