How the Experiment Works. After you have made the nitric acid (HNO_3) you will find a substance, or *residue*, as it is called, left over in the retort. Now when the sodium nitrate ($NaNO_3$) and the sulphuric acid (H_2SO_4) are heated together they combine and form sodium sulphate ($NaHSO_4$), which is the residue, and nitric acid (HNO_3), which passes over as a vapor and is condensed into a liquid in the test tube. The reaction can be more easily shown by the equation:

$NaNO_3$	+	H_2SO_4	=	$NaHSO_4$	+	HNO_3
Sodium nitrate		Sulphuric acid		Sodium sulphate		Nitric acid

Experiments with Nitric Acid. After water (H_2O), nitric acid (HNO_3) will dissolve the most substances, even the heavy metals on which water (H_2O) has little or no effect. Not only this, but nearly all the compounds that are formed by the action of nitric acid (HNO_3) on the metals and other substances will dissolve in water.

An Experiment in Spontaneous Combustion. Put a little fuming nitric acid (HNO_3) in a test tube, then wad up some woolen yarn and push it half-way down in the tube. In a little while the yarn will catch fire, and after it has burned up a white substance will be left in the tube. When you make this experiment hold the test tube with your clip in a beaker, so that in case it should break the acid will not do any damage.

The Action of Nitric Acid on Metals. When nitric acid (HNO_3) acts on metals it dissolves them and forms salts that are called nitrates; thus when nitric acid (HNO_3) acts

on copper (Cu), copper nitrate ($Cu(NO_3)_2$) is formed; when it acts on silver (Ag), silver nitrate ($AgNO_3$) is formed, and so on, and all these salts will dissolve in water (H_2O).

Cut a silver (Ag) ten-cent piece into bits, put them into a large test tube and add just enough concentrated nitric acid (HNO_3) to cover them. Now hold the test tube over the flame of your alcohol lamp and heat it gently. Colored gases then will be formed, the silver (Ag) will dissolve, and in its place white crystals will be found which are formed of silver (Ag), nitrogen (N), and oxygen (O), and this is silver nitrate ($AgNO_3$).

How the Experiment Works. When nitric acid (HNO_3) acts on the silver (Ag), it gives up part of its hydrogen (H) and oxygen (O) and leaves silver nitrate ($AgNO_3$) and water (H_2O) remaining in the tube. If now you will evaporate the solution, the water (H_2O) will pass off as a vapor and crystals of silver nitrate ($AgNO_3$) alone will remain in the tube.

About Hydrochloric Acid. Since hydrochloric acid ($HCl + H_2O$), or *muriatic acid*, as it is commonly called, or *spirit of salt*, which is its old-time name, is very widely used in the arts, it is a good thing to know something about it. In its pure state it is a colorless gas called hydrogen chloride (HCl), and when this is exposed to the air it fumes, especially in moist air; it has a sour taste which is common to all acids, a strong, pungent odor, and it is very corrosive; further, it has a very great affinity for water (H_2O), and 1 volume of the latter will absorb 500 volumes of the gas.

What we call hydrochloric acid ($HCl + H_2O$) is then hydrogen chloride (HCl) that is dissolved in water (H_2O),

and the formula for it is usually given as (HCl) since this is the form of it that is generally known, and the H_2O to show that it is a solution is not considered necessary. When the hydrogen chloride (HCl) and the water (H_2O) are both pure, the hydrochloric acid (HCl) formed of them is colorless, but the acid that is sold for commercial purposes has a yellowish color due to the impurities in it. As hydrochloric acid (HCl) is made of sodium chloride ($NaCl$), that is, common salt, and sulphuric acid (H_2SO_4) it is very cheap, and as it is a most useful acid it is made in large quantities.

HOW TO MAKE HYDROCHLORIC ACID.

To Make Hydrogen Chloride. Put 1 ounce of sodium chloride ($NaCl$) into a flask and then mix ½ ounce of water (H_2O) with 1½ ounces of sulphuric acid (H_2SO_4) in a beaker. Now fit a cork that has a funnel and a delivery tube in it into the flask and let the end of the tube dip into a test tube, as shown in Fig. 114.

This done, pour the solution of sulphuric acid (H_2SO_4) slowly into the flask and heat it gently over the flame of your lamp or burner, and the solution will boil at a great rate. This action causes sodium sulphate (Na_2SO_4) to be formed, while the bubbles that rise up through the solution and break on reaching the surface are the hydrogen chloride gas (HCl), and this passes out of the delivery tube.

To Make Hydrochloric Acid. To change the hydrogen chloride (HCl) into hydrochloric acid (HCl), it is only necessary to fill the test tube with water (H_2O) and let the free end of the delivery tube dip into it while the gas is being generated.

How the Experiment Works. If you have used the right proportions of sulphuric acid (H_2SO_4) and water (H_2O) in making the hydrogen chloride (HCl) and have heated them very gently, all that will be left in the flask will be

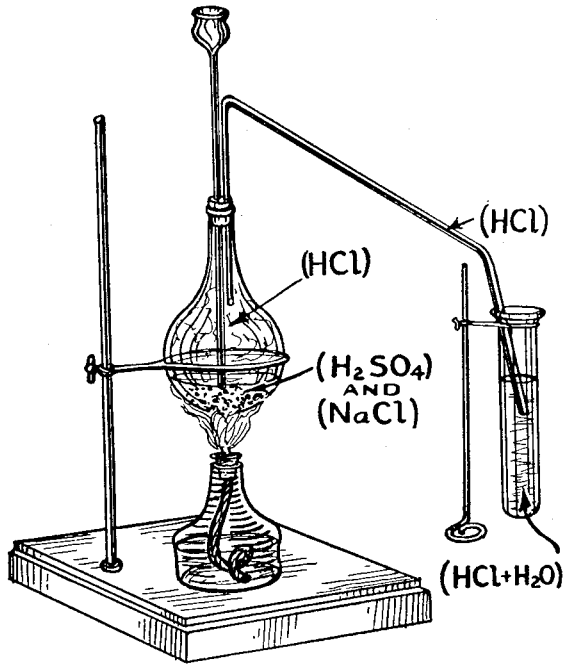

FIG. 114.—How to Make Hydrochloric Acid.

sodium sulphate (Na_2SO_4), which is a white solid substance. That is to say, the reaction of the sodium chloride ($NaCl$) and the sulphuric acid (H_2SO_4) makes sodium sulphate (Na_2SO_4) and hydrogen chloride (HCl), and when this

is dissolved in water (H_2O) the solution becomes hydrochloric acid (HCl). The following equation shows it in a more simple way.

$2\,NaCl$	+	H_2SO_4	=	Na_2SO_4	+	$2\,HCl$	↑
Sodium chloride		Sulphuric acid		Sodium sulphate		Hydrochloric acid	A gas

EXPERIMENTS WITH HYDROCHLORIC ACID.

How to Make a Hydrogen Chloride Fountain. Fill a dry flask with hydrogen chloride (HCl) and fit into the neck of it a cork having a glass tube in it, one end of which is drawn out into a nozzle, and also a pipette filled with water (H_2O), the jet of which is closed with a bit of soft wax. Now dip the outside end of the long tube into a beaker of water (H_2O) and you are ready to make the experiment.

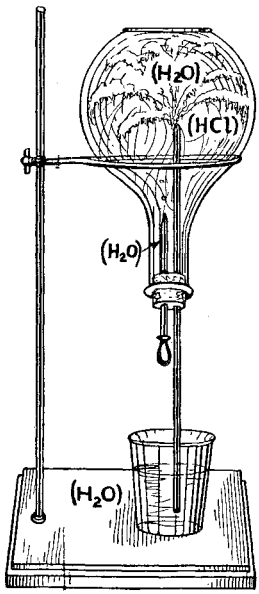

FIG. 115.—A Hydrogen Chloride Fountain.

Blow the wax out of the end of the pipette by pinching the bulb, and it will send a little stream of water (H_2O) into the flask; the water will absorb so much of the gas that a partial vacuum is formed in the flask. The pressure of the outside air on the water (H_2O) in the beaker will then force it up the tube and into the flask, where it will break into a spray, as shown in Fig. 115.

The Great Smoke Experiment. Fill a wide-mouth bottle

with hydrogen chloride (HCl) by inserting the free end of the delivery tube of the generator in it, and then grease a sheet of glass and lay it on top of the bottle. Now fill another bottle with dry ammonia gas (NH_3), as explained in Chapter VI, and close it with a sheet of greased glass also and then set one bottle on the other with their mouths together, as shown in Fig. 116.

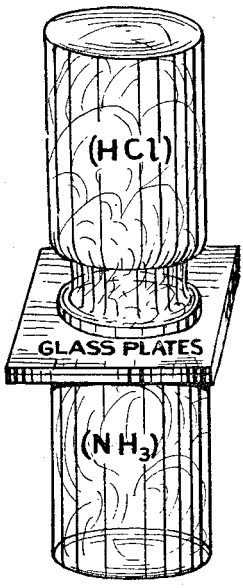

FIG. 116.—The Great Smoke Experiment.

To the onlookers, both bottles will appear to be perfectly empty, but when you pull out the sheets of glass the gases will rush together and form a dense vapor that looks exactly like smoke, and this substance is ammonium chloride (NH_4Cl), or *sal ammoniac*, as it is ordinarily called. A good magical experiment can be performed with a little hydrochloric acid (HCl) and concentrated liquid ammonia (NH_3), and the effect and cause you will find explained in Chapter XIII.

How the Experiment Works. In this experiment the ammonia gas (NH_3) and the hydrogen chloride (HCl) simply combine and make ammonium chloride (NH_4Cl), which is in the form of a fine white powder.

How the Make a Good Soldering Fluid. To make some soldering fluid, cut up a piece of sheet zinc (Zn) into bits, put them into an earthenware bowl, and then pour on

enough hydrochloric acid (HCl) to cover them. When the zinc (Zn) is dissolved, the solution makes a good soldering fluid.

How the Experiment Works. When zinc (Zn) is dissolved in more hydrochloric acid (HCl) than is needed, zinc chloride ($ZnCl_2$) is formed, and this remains in the solution. To obtain the zinc chloride ($ZnCl_2$), the solution must be evaporated, and the salt will remain behind. Now by dissolving this in water (H_2O) you can also make a good soldering fluid.

How to Make Imitation Emeralds. Put a few iron (Fe) nails into an earthenware bowl and pour on enough hydrochloric acid (HCl) to cover them. When the nails are dissolved and the solution is yet hot, filter it into a narrow-neck bottle, and solid green crystals that, with a little imagination, look like emeralds, will separate from it, and these are formed of ferrous chloride ($FeCl_2$).

How the Experiment Works. The reaction in this experiment is as follows: The iron (Fe) and the hydrochloric acid (HCl) form ferrous chloride ($FeCl_2$) and hydrogen (H), which is set free. When written as an equation you can see the reaction at a glance:

Fe	+	$2\ HCl$	=	$FeCl_2$	+	H_2	↑
Iron		Hydrochloric acid		Ferrous chloride		Hydrogen	A gas

How to Make Aqua Regia. The term *aqua regia* comes from two Latin words which mean "water" and "royal", or "royal water". It was so called by the early chemists because it is the only known compound that will dissolve gold (Au) and platinum (Pt), which were and are the *noble metals*.

Aqua regia is therefore a solvent that possesses remarkable properties, and to make it, all you need to do is to mix one part of concentrated nitric acid (HNO_3) and three parts of hydrochloric acid (HCl) in an earthenware bowl.

About Fluorine and Hydrofluoric Acid. Fluorine (F) is a greenish-yellow gas and at room temperature it is the most active element known, for there are very few substances that it will not attack and combine with. The exceptions are oxygen (O), nitrogen (N), chlorine (Cl), platinum (Pt), and those elements of the helium (He) family.

Moreover, it combines usually with all the other elements of its own accord when it is brought into contact with them, and without the application of heat to help the reaction along. The most interesting experiments with fluorine are due to its property of attacking glass (Na_2O, CaO, SiO_2) and other silicate compounds, and the conversion of water (H_2O) into ozone (O_3).

Fluorine (F) is found chiefly in calcium fluoride (CaF_2), which is ordinarily called *fluor-spar*, and also in combination with sodium (Na) and aluminum (Al) in a mineral called cryolite (Na_3AlF_6). Hydrofluoric acid (HF), is formed when sulphuric acid (H_2SO_4) is made to react with fluor-spar (CaF_2).

How to Etch Glass. To etch on glass (Na_2O, CaO, SiO_2), you have to make some hydrofluoric acid (HF), and an easy way to do this is to take a sheet of lead (Pb) 5 inches wide and 8 inches long and bend up its edges 1 inch all around to form a tray, as shown in Fig. 117. Now put 2 ounces of powdered calcium fluoride (CaF_2), that is, fluor-

spar, into the lead tray and add enough sulphuric acid (H_2SO_4) to make thin paste of it.

This done, melt some paraffin wax, pour it on the sheet of glass which you want to engrave, run it all over the surface and drain it off at one corner, and a thin film of the

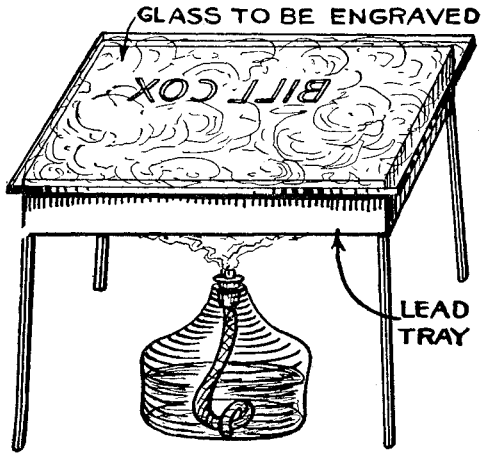

FIG. 117.—How to Etch Glass with Hydrofluoric Acid.

wax will remain on it. This done, take a darning needle and scratch a name or a picture on the film of wax with the head of it so that the lines go clear through and expose the glass (Na_2O, CaO, SiO_2). Now set the glass (Na_2O, CaO, SiO_2) with the waxed surface down on the tray, light your alcohol lamp and gently heat the paste. The fumes that are given off are hydrogen fluoride (HF), and this attacks the glass (Na_2O, CaO, SiO_2) and eats it away. After you have exposed it to the fumes for half an hour or

so, wash off the wax with turpentine and you will see the name or picture etched into the glass (Na_2O,CaO, SiO_2).

An Easier Way to Etch on Glass. An easier way to etch on glass (Na_2O, CaO, SiO_2) is to buy some hydrofluoric acid ($HF + H_2O$), which is simply hydrogen fluoride (HF) gas dissolved in water (H_2O). This is sold in rubber bottles, as the acid does not attack rubber (C_5H_8) to any great extent. Coat the glass (Na_2O,CaO, SiO_2) with paraffin wax and scratch a name or draw a picture on and through the film with a needle as before, and then build up a little wax ridge all around the plate, lay it on a table, and with your pipette cover the scratched-in lines with the acid. Let it remain on the plate over night, then wash the wax off with turpentine, and the surface of the exposed parts of the glass (Na_2O,CaO, SiO_2) will be found to be etched away.

How to Change Water into Ozone. If you will turn back to the last part of Chapter II, you will see that ozone (O_3) is produced when electric sparks are made to take place in air. To change the oxygen (O) of water (H_2O) into ozone (O_3), fill a tube with fluorine (F), and as this gas is heavier than the air in the tube, the latter can be held right side up. Now let a single drop of water (H_2O) fall into the tube of fluorine (F) with your pipette, and the oxygen (O) of the water (H_2O) will be turned to ozone (O_3).