cheaper than you can make them yourself, but still you should make them for the experience that will accrue to you.

About Sulphuric Acid. Sulphuric acid (H_2SO_4), the common name of which is *oil of vitriol*, is a thick, oily liquid that is nearly twice as heavy as water (H_2O). It is the most difficult of all the common acids to make in the laboratory, but with a little patience you can do it. The start has to be made with sulphur dioxide (SO_2), a colorless gas that is more than twice as heavy as air, and 80 volumes of it will dissolve in 1 volume of water (H_2O). This gas is easily made when sulphur (S) burns in the air, causing it to combine with the oxygen (O) of the latter.

Next, the sulphur dioxide (SO_2) must be converted into sulphur trioxide (SO_3), which is a colorless, volatile liquid, and this is done by heating the sulphur dioxide (SO_2) and more oxygen (O) together at a high temperature. Another atom of oxygen (O) then combines with each molecule of it and so converts it into a different substance. The vapor of the sulphur trioxide (SO_3) is then conducted to a vessel which is kept cold, and it will liquefy into concentrated sulphuric acid (H_2SO_4) in the presence of water (H_2O).

The Easiest Way to Make Sulphuric Acid. Take a dozen pieces of cotton thread, each about 3 inches long, dip them into melted sulphur (S), and when they are cold tie them to one end of an iron wire about 6 inches long. Now push the other end of the wire into a cork and then put as much water (H_2O) as will fill a small test tube into a pint bottle. This done, light the sulphur (S) on the end of the wire, push the wire into the bottle, and cork it up, as shown in Fig. 109.

When the vapor of the burning sulphur (S) fills the bottle, dip a thin pine stick into some strong nitric acid (HNO_3) and hold it in it, as shown in Fig. 110. Instantly the nitric acid (HNO_3) will decompose and the nitric oxide (N_2O)

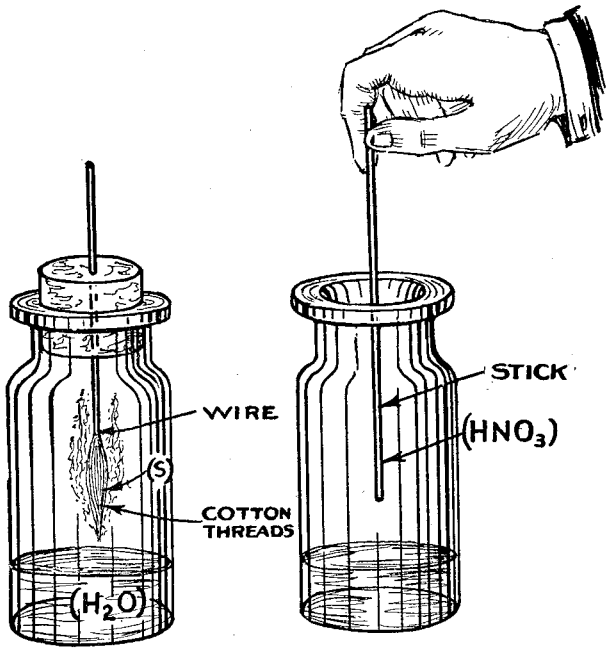

FIG. 109.—Sulphur Burning in a Bottle.

FIG. 110.—Introducing the Nitric Acid.

which is formed will combine with the oxygen (O) and form nitrogen peroxide (NO_2). Let the bottle stand for 10 to 15 minutes and then shake it. The vapors will be absorbed by the water (H_2O). The solution that results is dilute sulphuric acid (H_2SO_4), and you can test it by

dipping a piece of blue litmus paper in it. The paper will then turn red.

A Better Way to Make Sulphuric Acid. Here is another way to make a little dilute sulphuric acid (H_2SO_4), and a better one than that just described. Put 1 ounce of potassium nitrate (KNO_3), or *nitre*, as it is called, and 2 ounces of sulphur (S) into a little cup and set it on a block of wood, or other support, which is about 1 inch high, in a saucer of

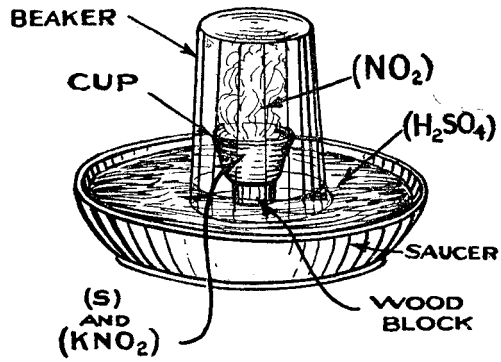

FIG. 111.—A Better Way to Make Dilute Sulphuric Acid.

water (H_2O). Now light the mixture and set a larger beaker over the cup in the water, and it will be air-tight, as shown in Fig. 111. The action produces nitrogen peroxide (NO_2), as in the foregoing experiment, and this is absorbed by the water (H_2O), thus forming dilute sulphuric acid (H_2SO_4). To prove it is an acid, test it with a piece of litmus paper as before.

Another Method for Making Sulphuric Acid. Take 1 ounce of sulphur trioxide (SO_3), which is a compound formed

of white silky crystals that look very much like the fibres of asbestos. This must be kept in a bottle with a glass stopper until you are ready to use it, as it fumes strongly when it comes in contact with the air. Put the sulphur trioxide (SO_3) into 1 pint of water (H_2O), and it will dissolve, in doing which it will make a hissing sound and set up a large amount of heat. The resulting solution formed by the reaction is sulphuric acid (H_2SO_4).

A Laboratory Method for Making Sulphuric Acid. To make sulphuric acid (H_2SO_4) by the process that is generally used in school laboratories, you have to begin with oxygen (O) and sulphur dioxide (SO_2), then change these into sulphur trioxide (SO_3), and, finally, dissolve this in water (H_2O). Sulphuric acid (H_2SO_4) results.

How to Make Sulphur Dioxide. Put 1 ounce of copper turnings (Cu) into a pint flask and pour 2 ounces of concentrated sulphuric acid (H_2SO_4) on them; this done, put a cork that has a delivery tube in it in the flask and heat the latter gently, and sulphur dioxide (SO_2) will be given off. Just as soon as the gas begins to pass over, raise the flask above the flame high enough so that the gas will flow from the delivery tube in a steady stream. Couple the delivery tube with a wash-bottle, and then you are ready to connect it with the apparatus for making sulphur trioxide (SO_3). See Fig. 112.

How to Make Sulphur Trioxide. Sulphur trioxide (SO_3), as its formula shows, has 1 more atom of oxygen in each of its molecules than sulphur dioxide (SO_2) has, and to add this extra atom of oxygen (O) you need the following piece of apparatus. Having your oxygen (O)-generat-

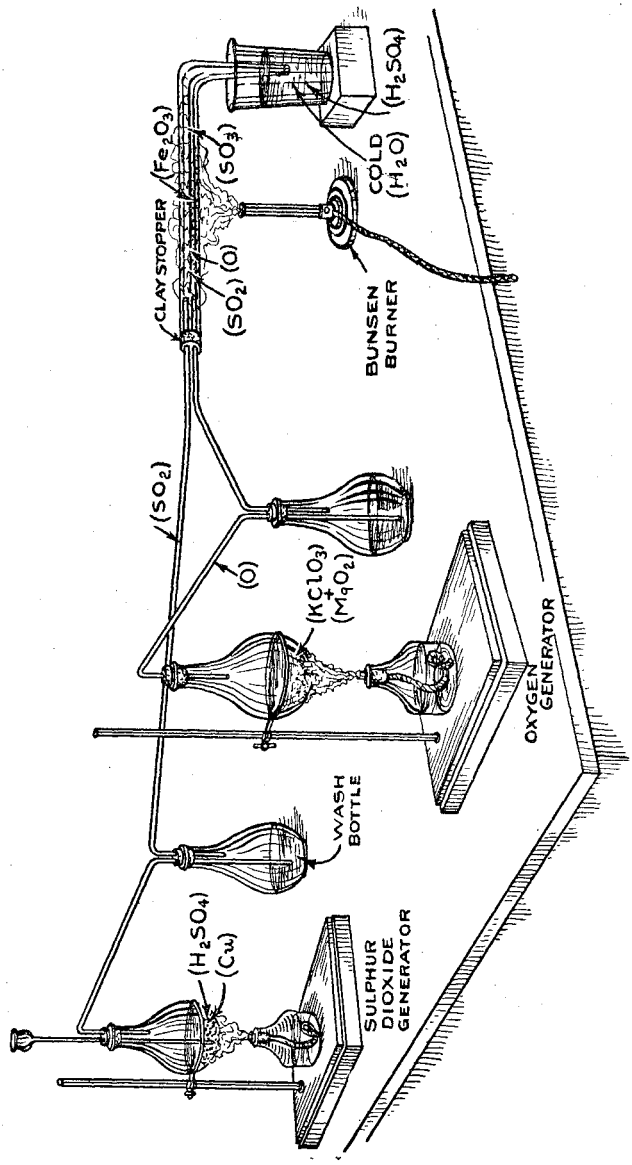

FIG. 112.—Laboratory Method for Making Sulphuric Acid.

ing apparatus, which I described in Chapter III, and the sulphur-dioxide (SO_2) apparatus, just described, set up and ready for action, put 2 ounces of ferric oxide[1] (Fe_2O_3), or iron oxide, as it is usually called and which is common iron rust, into a glass or iron tube ½ inch or ¾ inch in diameter and 8 inches long, one end of which is drawn out to a point to form a nozzle.

Now push the delivery tubes of both the gas generators into the mouth of the glass or iron tube and close it up with a piece of soft clay; now heat the iron oxide (Fe_2O_3) with a Bunsen burner, or, better, a couple of them (an alcohol flame is not hot enough), and then start the generators going and the oxygen (O) and sulphur dioxide (SO_2) will combine and form sulphur trioxide (SO_3), which will pass off through the nozzle of the delivery tube.

How to Make Sulphuric Acid. To make sulphuric acid (H_2SO_4) you need only to set the nozzle end of the tube into a beaker containing a little ice-water (H_2O), and as the sulphur trioxide (SO_3) flows out through the former it condenses into sulphuric acid (H_2SO_4). The complete apparatus for generating the oxygen (O) and sulphur dioxide (SO_2), changing these into sulphur trioxide (SO_3), and finally collecting this as sulphuric acid (H_2SO_4), is shown in Fig. 112.

How the Experiment Works. There are certain sub-

[1] This acts as a *contact agent*, or *catalytic agent*, which is explained in Chapter III under the caption of "A Way to Make More Oxygen." In making sulphur trioxide (SO_3), *platinized asbestos* is a better contact agent than ferric oxide (Fe_2O_3), and it is also much more expensive.

Platinized asbestos is made by soaking the fibers of *asbestos*, or *mineral wool*, as it is commonly called, in chloroplatinic acid ($H_2\ PtCl_3$); this acid is made by dissolving platinum (Pt) in *aqua regia*, and this, in turn, is made by mixing hydrochloric acid (HCl) with nitric acid (HNO_3).

stances, such as oxygen (O) and sulphur dioxide (SO_2), which combine very much better with each other when they are brought into contact with some other substance as, for instance, iron oxide (Fe_2O_3); the latter, curiously enough, does not in any way combine with them and, hence, it remains itself unchanged. Such substances are called *catalyzers* or *catalytic agents*, while the process itself is called *catalysis*. This way of making sulphuric acid (H_2SO_4) is known as the *contact process*.

The reactions that take place in making sulphuric acid (H_2SO_4) by the contact process are these: The copper (Cu) acting on the sulphuric acid (H_2SO_4) gives copper sulphate ($CuSO_4$), or blue vitriol, as it is called, and water (H_2O) which substances remain behind in the flask while the sulphur dioxide (SO_2) gas passes off through the delivery tube. The reaction may be more easily shown by this equation:

$2\,H_2SO_4$	$+$	Cu	$=$	$CuSO_4$	$+\,2\,H_2O$	$+$	SO_2	$\uparrow$
Sulphuric acid		Copper		Copper sulphate	Water		Sulphur dioxide	A gas

The arrow pointing upward shows that one of the resultant products is a gas.

EXPERIMENTS WITH SULPHURIC ACID.

How to Change Sugar into Carbon. Put a couple of pieces of lump sugar ($C_{12}H_{22}O_{11}$) in a beaker and pour a tablespoonful of boiling water (H_2O) on them; now add a few drops of sulphuric acid (H_2SO_4) to the solution and it will begin to boil. The hydrogen (H) and the oxygen

(O) of the sugar ($C_{12}H_{22}O_{11}$) combine and form water (H_2O), while the carbon (C) in it is left behind.

How to Write Indelibly on Cotton Goods. Write your name on a piece of white muslin with dilute sulphuric acid (H_2SO_4) and then quickly wash it out well, and there will be no apparent change in the muslin. This done, heat the muslin so that the water (H_2O) in it is driven off, while the trace of sulphuric acid (H_2SO_4) that still remains in the fibres decomposes them and makes them black, and no amount of washing will ever take the color out.

How to Make Copperas. To make ferrous sulphate ($FeSO_4$) or *copperas*, *green vitriol*, or *iron sulphate*, as it is variously known, put a dozen iron (Fe) shingle nails in a flask and add enough dilute sulphuric acid (H_2SO_4) (1 part of acid to 5 parts of water (H_2O)) to cover them. Now warm the flask a little over the flame of your alcohol lamp, and when all the hydrogen (H) has been set free, pour the clear liquid off into a beaker. This done, add a few drops of dilute sulphuric aicd (H_2SO_4) to it, then heat it until half of it has boiled away and let it cool, and green crystals of copperas ($FeSO_4$) will be formed in it. Finally pour off the liquid and lay the crystals on a sheet of blotting paper to dry.

How to Make Blue Vitriol. Cupric sulphate ($CuSO_4$), or *copper sulphate*, or *blue vitriol*, as it is more often called, comes in the form of large blue crystals. Like the crystals of copperas ($FeSO_4$) above described, blue vitriol ($CuSO_4$) contains a large amount of water of crystallization (see Chapter IV), and when the crystals lose this they lose their color, and become what is called *white vitriol*. But just as

soon as water (H_2O) touches them again, they take on a blue color. To make copper sulphate ($CuSO_4$) crystals, let some dilute sulphuric acid (H_2SO_4) trickle over copper (Cu) borings, or, better, granulated copper (Cu), in the presence of air.

How to Make Epsom Salts. The chemical name for *Epsom salts* is *magnesium sulphate* ($MgSO_4$), and to make a little of it dissolve 1 ounce of magnesium carbonate ($MgCO_3$) — that is *magnesite* — in dilute sulphuric acid (H_2SO_4), filter it through filter paper placed in a funnel, and catch it in a small porcelain dish. Now heat this gently over the flame of your lamp or burner until the crystals separate from it, and then dry them on blotting paper. You will then have a dose of the famous Epsom salts that have long been used as a laxative.

About Nitric Acid. When sodium nitrate ($NaNO_3$) or *Chili saltpeter*, as it is commonly called, or potassium nitrate (KNO_3), which is *Bengal saltpeter*, is acted upon by any kind of an acid nitric acid (HNO_3) is formed. Since sodium nitrate ($NaNO_3$) is the cheapest nitrate and sulphuric acid (H_2SO_4) is the cheapest acid, they are always used for making nitric acid (HNO_3).

Pure nitric acid (HNO_3) is a colorless liquid that fumes when it is set in the open air. *Commercial* nitric acid (HNO_3) contains 68 per cent of the acid and the rest is water (H_2O), and when you buy *commercial* nitric acid (HNO_3), this is the strength you get. If you really want concentrated nitric acid (HNO_3), then you must buy *pure* acid.

How to Make Nitric Acid. It is as easy to make nitric

acid (HNO_3) as it is hard to make sulphuric acid (H_2SO_4). In fact, if you have sulphuric acid (H_2SO_4) to start with, it is easy to make almost any other kind of acid. To make some nitric acid (HNO_3), put 1 ounce of sodium nitrate ($NaNO_3$), which is a salt of the metal sodium (Na), and

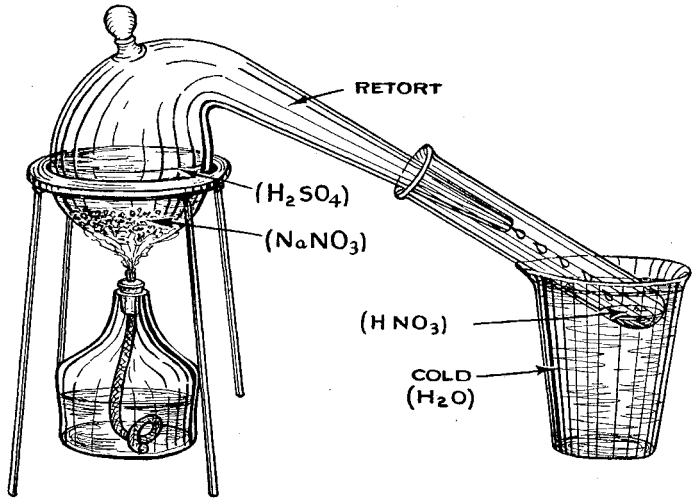

FIG. 113.—How to Make Nitric Acid.

½ ounce of concentrated sulphuric acid (H_2SO_4) into a retort and set your lamp or burner under it; this done, put the mouth of the delivery tube into a test tube and set this in a beaker of cold water, all of which is shown in Fig. 113. Now light the lamp or burner, and the mixture in the retort will give off nitric acid (HNO_3) as a vapor, and this is condensed in the test tube.