comes in round sheets and you can fit it into the funnel by folding a sheet of it over once, then again, and, finally, again, causing it to be creased, as shown in Fig. 62.

This done, spread the paper out flat and then make a cone of it, set it into the funnel and rub it along the creases to make it fit closely, as in Fig. 62; next, wet the paper all over with clean water to make it cling to the surface, and

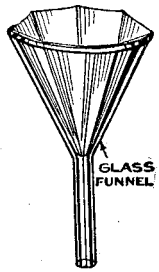

FIG. 62.—The Filter Paper in the Funnel.

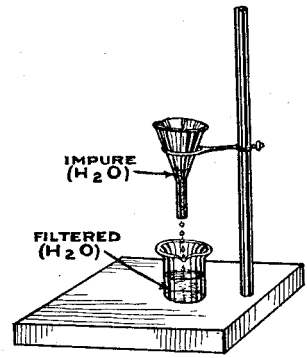

FIG. 63.—The Funnel in Use.

set the funnel in the ring of a support, as in Fig. 63. Finally place a beaker, or a test tube under the funnel and pour the solution you want to filter into the latter.

How to Boil Water. You can boil the water (H_2O) in an ordinary teakettle, or if you only need a small amount of it you can use a beaker. Boiling does not remove all the foreign matter in the water (H_2O) by any means, but if it has what is called *temporary hardness*, which will be explained presently, then the mineral compounds causing

it will be deposited on the sides and bottom of the vessel and in this way are removed. It is these compounds that form *fur* in the kettle and *scale* in a boiler. But if the water (H_2O) has *permanent hardness*, boiling will not remove the compounds that cause it.

How to Distil Water. The easiest way to get distilled water (H_2O) for your experiments is to buy it at the drug

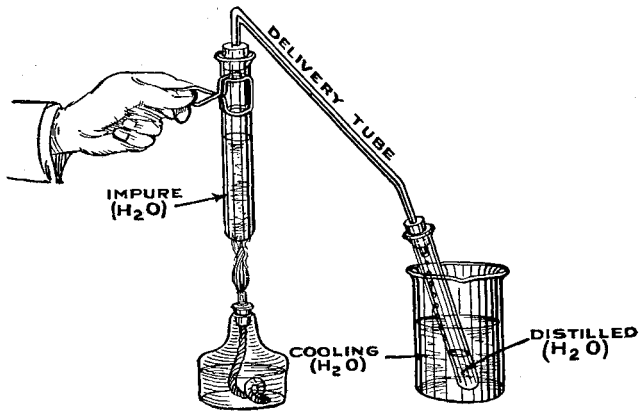

FIG. 64.—How to Distil a Little Water.

store, but I shall give you three modifications of the same apparatus, so that you can distil it for yourself. To distil a very small quantity of water (H_2O), so that you can see clearly the exact nature of the process, all you need is two test tubes, a delivery pipe, an alcohol lamp, and a beaker, or a tumbler.

Pour enough water (H_2O) of any kind into one of the tubes to half fill it, then push the short end of the delivery tube through a cork and fit this into the neck of the test

tube; put the other test tube into a beaker or tumbler of cold water (H_2O) and put the other end of the delivery tube into this second test tube. Light the alchohol lamp and hold the test tube with the water (H_2O) in it over the flame with your test-tube holder, as shown in Fig. 64, and let the water (H_2O) boil.

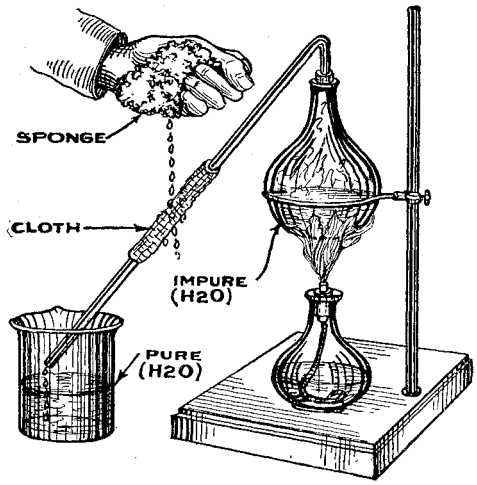

FIG. 65.—A Better Apparatus for Distilling Water.

How the Experiment Works. As soon as the water (H_2O) begins to boil, it will generate steam, and as this passes through the delivery tube it will be chilled and condensed into water (H_2O) when it reaches the cold test tube that is in the beaker.

NOTE.— To see that only pure water (H_2O) passes over and that the impurities are left behind, you can dissolve enough cupric sulphate ($CuSO_4$), or *copper sulphate*, *blue-stone*, or *blue vitriol*, as it is variously called, in the water

(H_2O) you are going to distil to give it a good green color, and you will see that this is left behind.

To distil enough water (H_2O) to make an experiment with, half fill a small glass flask with some water (H_2O) and set it in the ring of your stand. Now place your lamp, or burner, directly under the flask, and put a beaker, or a tumbler, under the end of the delivery tube, as shown in

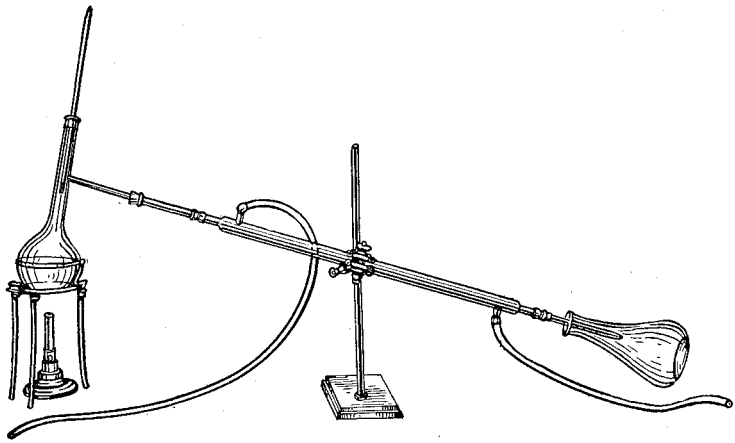

FIG. 66.—An Apparatus for Distilling Water on a Large Scale.

Fig. 65. This done, light the lamp and when the water (H_2O) begins to boil and to generate steam, the latter will pass through the tube; when it does so, let some cold water (H_2O) fall on the tube by means of a sponge, and the steam (H_2O) will then condense into water (H_2O). The better to aid the process of *condensation*, wrap a cloth round the tube and let the water fall on it. Very soon pure water (H_2O) will flow out of the tube and into the beaker.

An apparatus for distilling water in large quantities is shown in Fig. 66. It consists of a retort, with a delivery tube which passes through a larger tube sealed to the former at both ends, so that as much of the surface of the delivery tube as possible will be exposed to the cooling water (H_2O). A stream of cold water (H_2O) is made to flow into the cooling tube at the bottom and to flow out of it at the top, as warm water (H_2O) always rises when circulating.

Tests for the Purity of Distilled Water. The first proofs of the purity of water (H_2O) are that it has no color, no odor, and no taste, and that it is perfectly clear and transparent. Farther, it must not change the colors of indicators, such as litmus paper and phenolphthalein ($C_{20}H_{14}O_4$), and, finally, when slowly evaporated it must not leave any solid matter behind. How to make a test for each of these will be explained farther along.

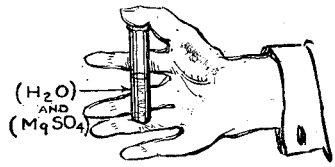

FIG. 67.—How to Raise the Temperature of Water.

How to Raise the Temperature of Water. Pour enough distilled water (H_2O) into a test tube to half fill it, then hold it by the mouth and place the closed end against your cheek, which will give you a rough idea of the temperature of the water (H_2O). Now put ½ teaspoonful of magnesium sulphate ($MgSO_4$), or *Epsom salts*, as it is commonly called, in the tube, hold your finger, or thumb, over the mouth of it, as shown in Fig. 67, and shake it until the salts have completely dissolved. Again hold the tube to your cheek and you will find that it is considerably warmer than it was before.

How the Experiment Works. Many compounds besides magnesium sulphate ($MgSO_4$) have what is called a *positive heat of solution*, and when they come in contact with water (H_2O) they give up their latent heat to it.

How to Lower the Temperature of Water. Pour enough distilled water (H_2O) into a test tube to make it half full and hold it to your cheek to get an idea of its temperature as before. This time put ½ teaspoonful of ammonium chloride (NH_4Cl), or *sal ammoniac*, as it is more often called, in the tube and shake it until the compound is completely dissolved. Again hold the tube to your cheek and you will find that it is considerably colder than it was before.

How the Experiment Works. Many compounds besides ammonium chloride (NH_4Cl) have what is known as a *negative heat of solution* when they are brought into contact with water (H_2O), and, hence, they absorb the heat of the latter.

How to Make Ice. The principle of extracting the heat of a compound by adding a substance that has a negative heat of solution is used in a practical way in making ice-cream. In this case, however, sodium chloride ($NaCl$), which is common salt, is mixed with cracked ice and this is packed around the can containing the cream to be frozen. As the ice melts and the salt dissolves, they extract the heat of the water (H_2O) thus formed, and a temperature still lower than that of the melting ice alone will be produced.

To make a little ice (H_2O), all you have to do is to pour enough water (H_2O), distilled or otherwise, into a test tube to half fill it, then put it into a beaker, or a tumbler, and fill this up with a mixture of finely cracked ice (H_2O) and

soldium chloride ($NaCl$), as shown in Fig. 68. Grip the test tube by the mouth and turn it rapidly around in the beaker, and in a couple of minutes the freezing mixture will change the liquid water (H_2O) into ice (H_2O).

What Water of Crystallization Is. There are some kinds of crystals which seem to be perfectly dry, as, for instance, *Glauber's salts*, which is the *decahydrate*[1] of sodium sulphate ($Na_2SO_4.10H_2O$), that are formed of more than half of their weight of water (H_2O), and this is called *water of crystallization*. If the crystals are heated and the water (H_2O) is driven out of them, they will decompose and crumble to pieces.

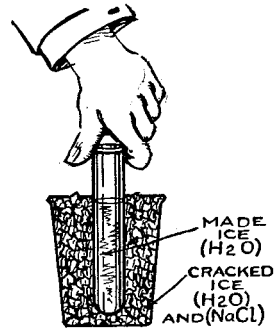

FIG. 68.—How to Make Ice.

Some crystalline compounds must be heated to the temperature of boiling water (212°F) before they will give up their water of crystallization, and others will do so when they are simply exposed to the open air. When crystals give up their water of crystallization the process is called *efflorescence*. There are, however, some crystals which when the water of crystallization is driven out of them will absorb it again when the compound of which they are formed is exposed to moist air, and new crystals are produced; this process is just the reverse of efflorescence and is called *deliquescence*.

How to See the Water of Crystallization. Put half a

[1] A *hydrate* is a substance that combines with water, or the elements of water, and a decahydrate is a hydrate one molecule of which combines with 10 molecules of water.

teaspoonful of copper sulphate ($CuSO_4.5\,H_2O$) into a clean, dry test tube and heat it over the flame of your lamp or burner. Almost instantly it will boil and give up its water of crystallization in the form of steam (H_2O), and some of this will condense into little drops of water (H_2O) on the surface of the tube. You will also see that as the water is driven out of the crystals they change from blue until they become colorless. Nearly all crystals lose their colors when the water of crystallization is driven out of them.

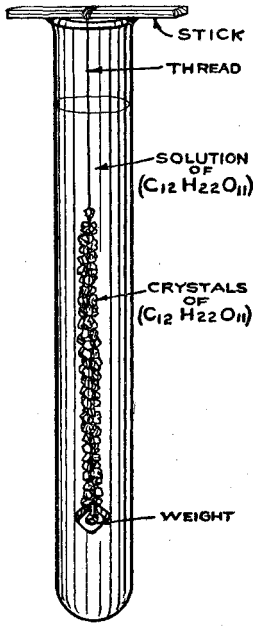

FIG. 69.—How to Make Rock-Candy.

How to Make Rock-Candy Crystals. This is a very interesting experiment, and to make it take a large test tube and then tie one end of a stout thread, which is about as long as the tube, to a nut, or other little weight and the other end of it to a bit of wood. This done, half fill the tube with boiling water (H_2O) and stir in as much granulated sugar ($C_{12}H_{22}O_{11}$) as it will dissolve; now let the thread down in the solution and set the tube in a rack where it can slowly cool off, and large crystals of *rock-candy* ($C_{12}H_{22}O_{11}$) will be formed on the thread, as shown in Fig. 69. In the same way you can produce beautiful crystals of other substances that have water of crystallization in them.

How the Experiment Works. When the crystals of rock-candy ($C_{12}H_{22}O_{11}$) are forming they leave behind them the water of crystallization that is in the minute crystals of sugar ($C_{12}H_{22}O_{11}$). It is the water of crystallization that makes the crystals of ordinary sugar ($C_{12}H_{22}O_{11}$) as soft as they are, and since there is very little water (H_2O) in the crystals formed on the string, they are quite hard, hence the name rock-candy ($C_{12}H_{22}O_{11}$).

How to Make a Secret Writing Ink. Put a little water (H_2O) into a test tube and add as much cobalt chloride ($CoCl_2$) as it will dissolve, after which it is called a *saturated solution.* To help along the operation, put your thumb over the mouth of the test tube, as shown in Fig. 67, and shake it vigorously. Now take a quill pen, or sharpen the end of a match, and write upon a sheet of pink paper with it. Then let it dry, and the writing will be invisible.

To read what you have written, your friend has only to heat the paper a little, and the writing will come out in a bright blue color; but as soon as the paper cools off, the writing will vanish as completely as if it had never been, at least as far as the human eye is concerned.

How the Experiment Works. Cobalt Chloride ($CoCl_2$) comes in the form of blue crystals, and these have very little, if any, water (H_2O) in them. When it is dissolved in water (H_2O) and is used as an ink, the cobalt chloride ($CoCl_2$) absorbs the moisture from the air and forms crystals that, of course, contain water of crystallization, and the mixture of cobalt chloride and water (H_2O) in them has the formula of ($CoCl_2+6H_2O$), since the cobalt chloride ($CoCl_2$) has combined with 6 molecules of water (H_2O).

How to Make a Weather Forecaster. The same principles can be used for indicating whether the weather is going to be *fair* or *rainy*, and this is done by the percentage of moisture there is in the air. Put enough water (H_2O) into a test tube to fill it half full, and then dissolve all the cobalt chloride ($CoCl_2$) that it will take up, that is, you make a saturated solution of it.

Cut a strip ½ inch wide and 4 inches long from a sheet of clean white blotting paper and immerse it in the cobalt chloride ($CoCl_2$) solution; now hang it up to dry and it will forecast what the weather is to be by its changing colors. When *rain* is to be expected, the air will be *damp* and the moisture will turn the crystals of cobalt chloride ($CoCl_2$) in and on the paper *pink*, and, when the weather is to be *fair*, the air is much *drier* and the crystals lose enough of their water of crystallization to turn them *blue*.

How to Make Imitation Ground Glass. A sheet of clean glass painted over with the following solution and then allowed to dry makes a very good imitation of *ground glass*. To make the solution, nearly fill a large test tube with water (H_2O) and then put in 3 teaspoonfuls of ammonium chloride (NH_4Cl), which is sal ammoniac; shake the tube until the salt is thoroughly dissolved, then stir in a couple of drops of glue, boil it over the flame of your alcohol lamp, and paint the surface of the glass with it while it is hot. As soon as the solution begins to cool, the water (H_2O) will start to evaporate and minute crystals will form all over the surface of the glass, and it will look as if it were ground.

Kinds of Water. By kinds of water (H_2O), are meant various specimens of it that contain different substances,