gas, it is not altogether easy to separate it from the oxygen (O) in commercial amounts. But hydrogen (H) is found in large quantities in all living and dead plant and animal matter and also in natural gas and petroleum, and from these compounds it can be easily obtained; hence, ammonia (NH_3) can be cheaply made in large quantities.

Experiment with Chlorine. Chlorine (Cl) is a transparent gas of a yellowish-green color and Davy, who proved that it is an element, gave it this name from the Greek word *chloros*, which means green. Chlorine (Cl) was discovered by Scheele in 1774, and it was he who first made it. This he did by treating black oxide of manganese (MnO_2) with hydrochloric acid (HCl), or *spirit of salt* as it was called in the early days of chemistry.

Chlorine (Cl) is a gas that is nearly 2½ times as heavy as air, and it has a pungent, suffocating odor, which is very penetrating. In making experiments with it, be very careful not to inhale it, for it has an irritating effect on the throat, and pure chlorine (Cl) will kill. While chlorine (Cl) will not itself burn, it will support the combustion of some substances. Scheele not only discovered this gas, but he found out most of its characteristics, including the all-important one that when it is mixed with water (H_2O) it will bleach out all kinds of vegetable colors.

The process for making chlorine (Cl) is not nearly so simple as that for oxygen (O), but you can make it for experimental purposes without any trouble. There are three ways by which it can be made, and these are to pass a current of electricity through a solution of sodium chloride ($NaCl$), that is, common salt, and water (H_2O), just as you did the water (H_2O) alone, to separate it into its component gases, as described in the previous chapter; to use hydrogen chloride (HCl), or some other cheap compound that contains the gas, and make the hydrogen (H) in it combine with the oxygen (O) of the air, setting free the chlorine (Cl); and, by the easier process which I shall now describe.

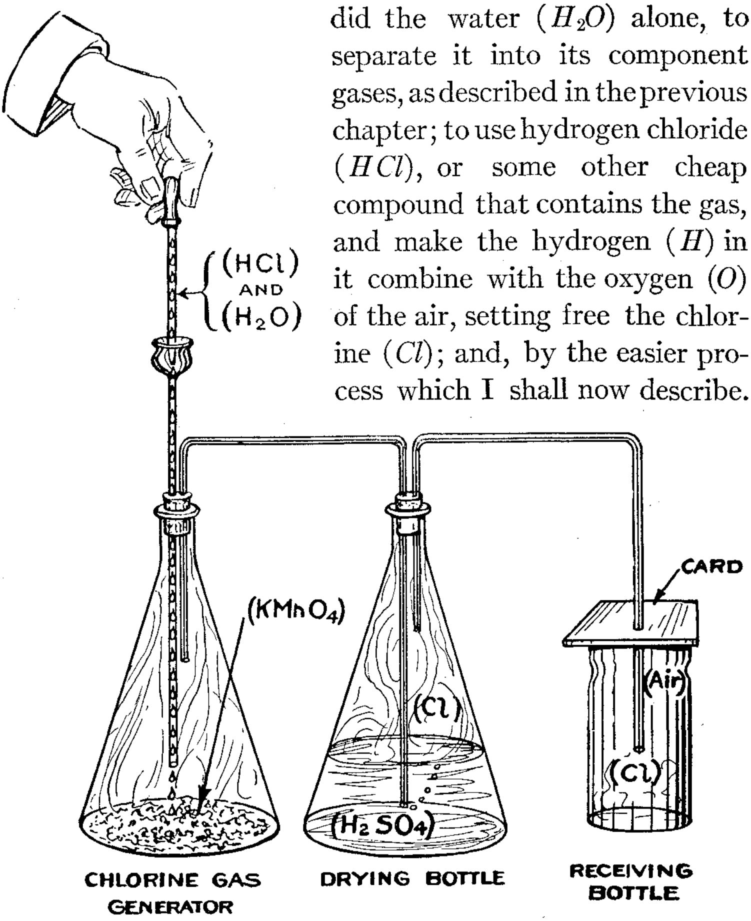

FIG. 94.—Apparatus for Generating Chlorine Gas.

How to Make Chlorine. To make enough chlorine (Cl) to experiment with, all you need is a flask fitted with a funnel and a short delivery tube; connect the latter with the long tube of a wash-bottle while the short tube of the latter leads into a bottle that is to hold the gas, and which stands right side up, as shown in Fig. 94.

Now while chlorine (*Cl*) is heavier than air, it is a good plan to slip a card over the delivery tube of the wash-bottle and lay it over the mouth of the bottle that is to hold the gas, to prevent its dispersion. If you want the gas to be perfectly dry as well as pure, then you will have to use the wash-bottle as a drying bottle, by filling it about one-third full of concentrated sulphuric acid (H_2SO_4).

Having the apparatus set up, put 1 ounce of potassium permanganate ($KMnO_4$) in the flask and then fit the cork in tight. Now fill a pipette, or medicine dropper, with a solution made of 1 part of water (H_2O) and 3 parts of concentrated hydrochloric acid (HCl), which is the only compound that hydrogen (H) and chlorine (Cl) will form with each other, and let it fall drop by drop into the funnel. A better appliance than the pipette is a funnel with a stopcock in it. The acid is used up very fast and the gas is set free in a quantity large enough to make a constant stream of it flow from the delivery tube, while the bottle is filled by the gas falling to the bottom and forcing the air out at the top.

How the Experiment Works. When the potassium permanganate ($KMnO_4$) comes into contact with the hydrochloric acid (HCl) it forms four substances, and these are water (H_2O), potassium chloride (KCl), manganese chloride ($MnCl_2$), and chlorine (Cl). The water (H_2O) and the chlorides are left behind in the flask, and since the chlorine (Cl) is a gas it passes out of the delivery tube.

NOTE.—In making chlorine (Cl) and experimenting with it, you should do so either in a shed or outdoors, for the gas is not only very bad to breathe but it will destroy the finish on furniture, take the color out of draperies, and spoil the polish on metal work.

How to Test for Chlorine. Pour a little of the gas into a test tube of pure water (H_2O), and then dissolve a crystal of silver nitrate ($AgNO_3$) in a teaspoonful of pure water (H_2O); this done, add a few drops of it to the solution in the test tube. If the solution is chlorine (Cl) in water (H_2O)—which makes hypochlorous acid ($HClO$)—a precipitate will be formed like the curd of milk, and this is silver chloride ($AgCl$); spread this salt out on paper and let the sunlight shine on it and it will turn black.

How Chlorine Acts on Flame. Twist a wire around a match, then light it and lower it into a test tube of chlorine (Cl); the latter will ignite and burn with a dull red flame, then dense fumes will be given off and the flame will soon go out.

Spontaneous Combustion. Cut a strip of filter paper about ½ inch wide and 4 inches long and fold it over lengthwise; dip one end of it into some turpentine that has been warmed, and lower it into a test tube of chlorine (Cl). It will instantly ignite and give off a lot of black smoke.

Moisten a strip of filter paper with concentrated liquid ammonia (NH_3) and lower it into the test tube of chlorine (Cl) and it will ignite spontaneously.

How to Make a Smoke Screen. Here is a way to make smoke that is blacker than the blackest smoke of smoky Pittsburgh. Put 1/3 ounce of wood-alcohol (CH_3OH)

into a long test tube, then add 1 ounce of sulphuric acid (H_2SO_4) and heat them over the flame of your alcohol lamp. This done, grease the mouth of the test tube so that an air-tight joint can be made, and pour some chlorine (Cl) gas into the tube, put a piece of glass on top of it, and shake it well. The next step is to take off the glass and light the gas in the tube, upon which a great cloud of dense black smoke will be formed by the carbon (C) which is set free, as shown in Fig. 95. While the gas is burning, you will hear an ominous noise like that of a miniature earthquake as the flame moves down from the mouth to the bottom of the tube.

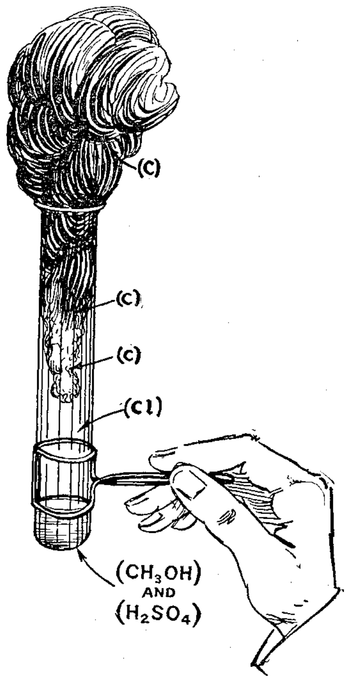

FIG. 95.—How to Make a Smoke Screen.

The Art of Bleaching. Chlorine (Cl) is an active element, and in this respect is very much like oxygen (O); further, it has a larger number of chemical properties than this latter gas has. Now while it is commonly said that chlorine (Cl) *bleaches*, when it is perfectly dry it has no bleaching properties whatever, and before it will bleach it must be brought into contact with water (H_2O). This can be done by adding some chlorine (Cl) to water (H_2O), upon which hypochlorous acid ($HClO$) results, and this has bleaching properties; or the colored piece of goods can be moistened with water (H_2O) first and then dipped into a jar of chlorine (Cl); in either case the colors will fade away until the piece of goods is perfectly white.

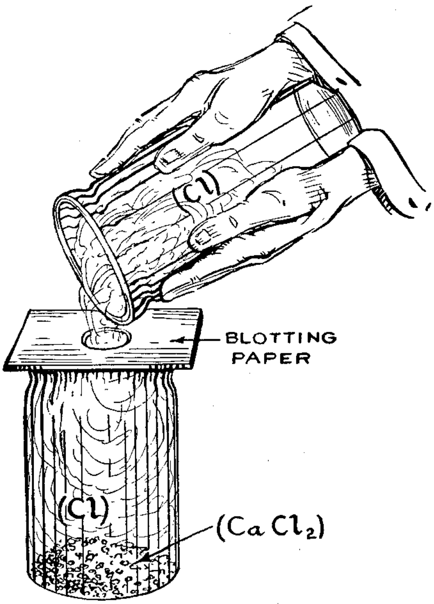

FIG. 96.—Making Some Dry Chlorine Gas.

How to Test the Bleaching Power of Chlorine. Put 2 or 3 ounces of calcium chloride ($CaCl_2$), that you have broken up into small lumps, into a perfectly dry jar, then cut a hole in a sheet of blotting paper and put it on top of the jar. Pour some chlorine (Cl) from the jar or bottle containing it into the other one, as shown in Fig. 96; the purpose of the blotting paper is to prevent any water (H_2O) that may have gathered in the chlorine bottle from getting into the dry jar when you pour it out, and the purpose of the calcium chloride ($CaCl_2$) is to absorb whatever water (H_2O) there may be in the gas itself.

Now take a toothpick or a quill and write your name boldly with some ordinary ink on a strip of paper, dry it

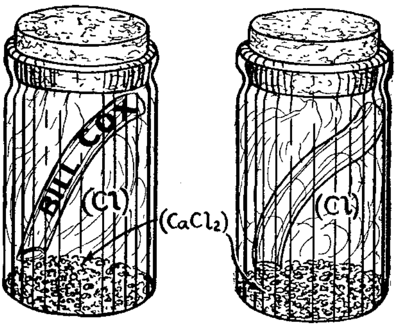

FIG. 97.—The Writing in the Bottle. FIG. 98.—The Writing Bleached Out.

over a stove to expel any moisture that there may be in it, and while it is yet warm put it into the jar of chlorine (Cl) and cork it up, as shown in Fig. 97, and you will find that the gas has practically no effect on it.

Having made this experiment, take out the paper, moisten it with water, (H_2O), again put it in the jar of chlorine (Cl) and cork it up, as in Fig. 98, and in a very short time you will find the ink fading, and, finally, it will disappear altogether.

How the Experiment Works. While chlorine (Cl) when it is perfectly dry has no bleaching power, on coming into contact with water (H_2O) it forms hypochlorous acid ($HClO$), as mentioned before. Now when this solution is exposed to the sunlight it decomposes very fast, and hydrogen chloride (HCl), which is a gas, is formed; this remains behind with the water (H_2O), then the solution becomes hydrochloric acid (HCl) (commonly called *muriatic acid*), and the oxygen (O) is set free.

Oxygen (O) is a strong oxidizing agent and, hence, it combines with the organic matter of which the ink is made, and so takes it out of the paper. Oxygen (O) does not act as a bleaching agent under ordinary conditions, but it takes on this power at the instant it is set free from the water (H_2O) by the chlorine (Cl), hence, it is the oxygen (O) which bleaches, and not the chlorine (Cl) itself.

How to Make Red Roses White. Tie the stem of a red rose to a pin pushed through a cork, and then put the latter into the mouth of a bottle of dry chlorine (Cl), as shown in Fig. 99. In the course of a little while the red color will begin to fade away, and finally it will vanish altogether and the rose will be a perfectly white one. The reason that flowers can be bleached in dry chlorine (Cl) is because a very considerable part of them is formed of water (H_2O). Wheat flour is bleached with chlorine (Cl), and this is the way it is made so white.

How to Make Bleaching Powder. Calcium hypochlorite ($CaOCl_2$), or *chloride of lime*, or *bleaching powder*, as it is more often called, is made by passing chlorine (Cl) through calcium hydroxide ($Ca(OH)_2$), or slaked lime, to give it its common name. Chloride of lime ($CaOCl_2$), is an unstable compound which gives up its oxygen (O) freely and leaves calcium chloride ($CaCl_2$, $6H_2O$) behind. It is the oxygen (O) that is set free which kills germs in decaying and dead plant and animal matter and it is, therefore, largely used as a *disinfectant* as well as a *bleaching agent.*

To make a little bleaching powder, put a tablespoonful of chloride of lime ($CaOCl_2$) in a beaker and half fill the latter with water (H_2O). Stir it with a glass rod until as much as possible of the lime is dissolved, let it settle, and then pour off the clear solution. Now dip a piece of paper colored with ink, or a piece of muslin with fruit stains on it, into it and they will be bleached out, leaving the paper or muslin perfectly white.

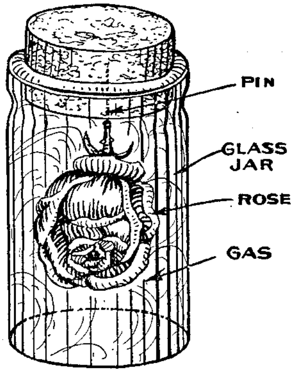

FIG. 99.—To Make a Red Rose White.

How to Make a Bleaching Liquid. Fill a small test tube with water (H_2O), then add a few drops of sulphuric acid (H_2SO_4) and stir with a glass rod; this done, dissolve in the solution as much potassium chlorate ($KClO_3$) as you can put on the point of a knife-blade, and you will find that it has decided bleaching properties.

NOTE.— Do not make this experiment on any larger scale than is given, or you may have an explosion.

How to Make a Bandanna Handkerchief. Fifty years ago a gentleman would be as lost without a *bandanna handkerchief* as he is to-day in Piccadilly without an eye-glass.

But I wonder if you know just what a bandanna handkerchief is. For fear you may not, let me say that it is a very large red silk handkerchief with white spots on it.

When they first became popular, they were made by the very simple expedient of laying red silk handkerchiefs between thin sheets of lead in which there were a number of

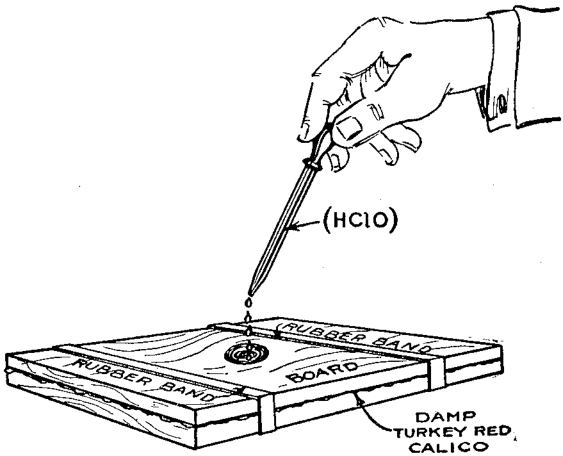

FIG. 100.—How to Make a Bandanna Handkerchief.

holes. When a pile of 40 or 50 handkerchiefs and lead plates were laid in this fashion, a solution of chlorine (*Cl*) and water (H_2O), which is almost the same as hypochlorous acid (*HClO*), was poured in the holes in the top plate, and as it seeped through the successive pieces of red silk it took the color out of them and left spots that were perfectly white.

You can imitate this process by cutting out a hole an inch in diameter in two strips of cigar-box wood, then plac-