THE CHEMCRAFT BOOK

FOR

CHEMCRAFT
THE CHEMICAL OUTFIT

No. 2

(FIFTH EDITION)

Directions

Explanation of Chemical Science and Industries

Chemical Magic

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Chemical Magic

The Porter Chemical Co.
Hagerstown, Md.

TABLE OF CONTENTS

PART I

CHEMISTRY AND ITS APPLICATION TO THE INDUSTRIES

Chemical Elements

Indicators

Air-Oxygen

Hydrogen

Water

The Halogen Family

Carbon—Combustion—Carbonates

Nitrogen

Sulphur

Silicon—Silicates

Boron—Borates

The Fire-Works Industry

The Ink Industry

The Paint Industry

The Soap Industry

The Dyeing Industry

Organic Chemistry

The Chemistry of Foods

Testing Soil

PART II

CHEMICAL MAGIC

Magic Inks and Papers

Magic Changes

Magic Colors

Chemical Sorcery

Chemical Colors

Miscellaneous

INTRODUCTION

Before beginning the experiments described in this book let us consider for a moment the broader aspects of the science of chemistry. The whole great universe about us from its uppermost heights to its lowest depths is built up of chemicals and chemical compounds. Earth, sky and water are all passing constantly through chemical changes. Deep down in the ground, coal is being formed from the remains of prehistoric forests. Precious metals and ores are being smeltered under the heat and pressure of millions of tons of earth and rock. On the surface of the earth, air and water are continually producing chemical changes in everything they touch.

All nature is but a series of wonderful chemical reactions; plants, forests, birds, animals and people are all complex chemical engines.

Chemistry is more closely interwoven with the industries of the world than any other science, and the country which leads in chemical industries will ultimately be the richest and most powerful. It will have the fewest waste materials, it will have the best manufactured articles, its foods will be the most nourishing and the cheapest, it will possess the secrets of the most powerful explosives, the hardest steels and the mightiest engines.

Surely a population educated in the science of chemistry is the greatest asset your country can have.

To-day, no matter what profession a man follows, he is greatly handicapped without a knowledge of chemistry. The manufacturer, the farmer, the tradesman, the professional man, the scientist, all have constant need of chemical knowledge. In the home the housewife who knows nothing of the chemistry of the food which she prepares or of the materials which she daily uses is seriously handicapped.

Chemistry is also a spectacular science and many chemical phenomena are most startling and mystifying to the layman. The science of chemistry plays an important part in enabling sleight-of-hand performers and magicians to perform their tricks.

In CHEMCRAFT, the various phases of chemistry have been combined into a series of fascinating experiments which will furnish amusement for the young people during many profitable hours, and as the experimenter gains in skill and knowledge he can by means of the numbers 3 and 4 CHEMCRAFT sets extend still further his acquaintance with this most fascinating science.

Chemistry is sometimes looked upon as a dangerous profession, but this is not the case. Contrary to an old popular idea, a chemical experiment does not necessarily result in an explosion.

Chemicals, as a class, are not intended for use as food and should not be eaten, but very few of them are violent poisons. CHEMCRAFT, in particular, does not contain any dangerous poisons or otherwise harmful substances.

The quantities of chemicals furnished with the outfit are sufficient to allow each experiment to be performed a number of times. An additional supply of any chemical or extra apparatus can be obtained by sending direct to the manufacturer. See the price list at the end of this book.

THE PORTER CHEMICAL CO.,
Hagerstown, Md.

GENERAL DIRECTIONS

Before performing the experiments given in this book the following paragraphs should be carefully read.

MEASURING CHEMICALS

One measure of a chemical means the quantity which can be held on the end of a small measure. One-half measure calls for one-half of the amount, two measures for twice the amount, etc. The spoon is not intended for measuring chemicals except where especially mentioned.

STIRRING ROD

A solid can be dissolved in a liquid much more quickly if the mixture is stirred or shaken. Always clean the rod after taking out of one liquid and before putting it into another.

TEST TUBES

Test tubes are made of hard, thin glass specially annealed to stand heating. Liquids may be boiled, and solids heated to a high temperature in these tubes, but care should be taken never to wet a dry hot test tube as this is almost sure to break it. If you have been heating a solid let your test tube cool before washing it, or adding liquid.

GAS DELIVERY TUBE

The Gas Delivery Tube is used for the purpose of conducting a gas which is being generated in a test tube, into any desired vessel. Its use is specified wherever necessary.

TEST TUBE HOLDER

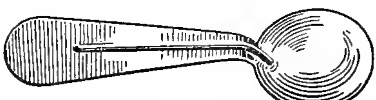
When heating mixtures in a test tube it sometimes becomes too hot to hold with the fingers, in which case a test tube holder is necessary. To make one of these holders cut a piece of fairly heavy paper six inches square, and fold it over three times, making a strip six inches long and three-quarters of an inch wide. Put this around the test tube and fasten securely with a paper clip.

HEATING

A candle is included in each outfit and will give all the heat necessary in most of the experiments, if it is set in a place which is free from draught so it will burn with a steady flame. In a very few cases the use of some other common method of heating has been suggested so as to obtain a little higher temperature. When heating a test tube by a candle, hold it just over the top of the flame to avoid the deposit of soot.

Never point the mouth of a test tube at yourself, or at anyone nearby, when heating a liquid. It may boil over suddenly, thereby causing burns or spotting the clothing. Always remove a test tube or other vessel from the flame before bringing it near the face to smell the evolved gas.

REMAINING EQUIPMENT



A spoon for measuring liquids and heating compounds and a length of glass tube are included, their use being mentioned in the experiments in which they are needed.

A number of experiments call for the use of glasses; these should be ordinary jelly glasses or heavy tumblers.

All bottles should be kept tightly corked, as many of the chemicals gradually lose their strength, if exposed to the air.

When performing experiments, be sure to spread a thick layer of newspaper or other protecting materials over the table so that the hot liquids, candle grease, etc., cannot injure the surface.

Always read an experiment entirely through before starting to perform it. By following this rule, many mistakes will be avoided.

PART 1

CHEMISTRY AND ITS APPLICATION TO THE INDUSTRIES

CHEMICAL ELEMENTS

Chemistry is the science which tells us what things are made of. Everything that we handle has in some way to do with chemistry. The ground we walk on, the clothes we wear, and the food we eat, are all chemicals or mixtures of chemicals.

Chemistry teaches us that all matter is made of elements. There are only about 85 elements, but they may be combined in all sorts of ways so that the number of chemical compounds possible is enormous.

Experiment 1—Combination of Elements.

Zinc is an element; there is nothing in it but zinc. Sulphur is another element; there is nothing in it but sulphur.

Take 1 measure of Powdered Zinc (No. 11) and an equal amount of Sulphur (No. 1). Mix on a sheet of paper. The mixture is not a compound, and the sulphur can be again separated from the zinc.

Now put half a measure of the mixture of zinc and sulphur in the spoon, and heat over a candle or alcohol lamp for 3 or 4 minutes, keeping your face at a little distance. After the mass becomes hot, the sulphur will take fire and burn. The mixture meanwhile swells to a bulky, porous mass. Suddenly there is a small flash, and the sulphur and zinc unite chemically, forming zinc sulphide.

Examine the zinc sulphide closely. You will find no traces of the original zinc or sulphur. If treated with acid this substance gives off a gas having the smell of rotten eggs, hydrogen sulphide.

Put the zinc sulphide in a test tube, add 1 measure of Sodium Bisulphate (No. 7), a few drops of water, and warm over a flame for a moment. Smell the gas given off at the mouth of the tube.

Some chemical compounds are broken up on heating.

Experiment 2—Breaking Up a Chemical Compound.

Place 2 measures of Sodium Thiosulphate (No. 16) in a test tube; using a test tube holder so as not to burn your fingers, heat over a flame. Notice that the solid first becomes moist and steam is given off. This is because sodium thiosulphate contains water of crystallization which is driven off when the substance is heated. Continue heating for a few minutes longer and you will find that sulphur is given off and is deposited on the upper part of the test tube. Remove the tube from the flame and smell the gas which is given off at the mouth of the tube. You will recognize the odor of hydrogen sulphide, the same gas which was given off in Experiment 1.

We see from this experiment that by heating sodium thiosulphate it is broken up into several different substances. First—water which was driven off as steam. Second—sulphur which was deposited around the upper part of the test tube. Third—hydrogen sulphide gas which you could smell at the mouth at the test tube. Fourth—a reddish mass left in the bottom of the tube which consists of sodium sulphate and sodium sulphide.

Most common substances are compounds of two or more elements, and the art of the chemist lies in his ability to add or subtract elements, and change them around in various ways. Such a change in the elements in substances is called a reaction. Reactions may be of various kinds. Experiment 1 illustrates a reaction of combination. Experiment 2 is an example of a reaction of decomposition. One of the most common kinds of reaction is the exchange, in which the elements in two or more substances change places with each other.

Experiment 3—An Exchange of Elements.

Fill a test tube half full of water and add ½ measure of Ferric (Iron) Ammonium Sulphate (No. 21) close the mouth of the test tube with your thumb and shake to dissolve the solid. Now add ½ measure of Calcium Oxide (No. 20) and shake again. A brown precipitate will be formed.

The iron (ferric) in the ferric ammonium sulphate changed places with the calcium in the calcium oxide, forming calcium sulphate and ferric oxide, which is insoluble in water and appeared as a brown precipitate.

INDICATORS

There are many classes of chemical compounds, but the most common are Acids, Alkalies and Salts. Acids are substances which have a peculiar "acid" taste, are capable of dissolving many other substances, and can unite with alkalies to form neutral substances called salts. Alkalies have an "alkaline" taste and unite with acids. Common table salt is a good example of a salt. Its chemical name is Sodium Chloride.

There are certain substances which are known as indicators and which have the property of turning one color in the presence of acids and another color in the presence of alkalies. They can thus be used to show whether any liquid is acid or alkaline.

Experiment 4—Phenolphthalein.

Put 1 or 2 drops of Phenolphthalein Solution (No. 22) into half a glass of water. Drop in 1 measure of Sodium Carbonate (No. 4) which is an alkali and stir. Next drop in 1 measure, or possibly 1½ measures of Tartaric Acid (No. 14) or a few drops of vinegar (which contains acetic acid) and stir again.

Phenolphthalein is an indicator which is red in the presence of alkalies, and colorless in the presence of acids. Some water supplies are alkaline and hence give the red color as soon as the phenolphthalein is added.

Experiment 5—Litmus.

Put a piece of Blue Litmus Paper (No. 18) into a glass half full of water. Add ½ measure of Tartaric Acid (No. 14) (or a few drops of vinegar) and stir. Next add 1 measure of Sodium Carbonate (No. 4) and stir again. Note the color changes.

Litmus is a dye-stuff obtained from a kind of lichen. It is red in the presence of acids and blue in the presence of alkalies.

Litmus paper is prepared by staining white unsized paper with a strong solution of litmus in hot water.

Experiment 6—Household Indicators.

An indicator may be prepared by soaking red cabbage leaves in water, and pouring off the clear purple liquid. This liquid will be colored red by acids and green by alkalies. The petals of dahlias and violets also contain a coloring matter, which is one color in the presence of acids and another in the presence of alkalies.

AIR-OXYGEN

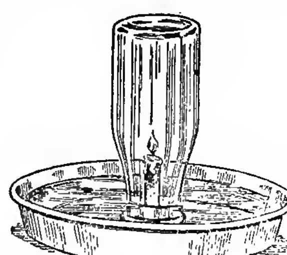
Air is a mixture of two elements, oxygen and nitrogen, both of which are gases. Of all the elements, oxygen is the most abundant, and most widely diffused. One-fifth of air is free oxygen, and eight-ninths of water is combined oxygen. Common materials like sandstone, limestone, brick and mortar contain about fifty per cent oxygen. It has been estimated that fully two-thirds of our world is oxygen.

It is the oxygen of the air which we breathe into our lungs from whence it is carried by the blood throughout our tissues to combine with waste materials. Carbon dioxide is formed by the reaction, is carried back to the lungs by the blood and finally reaches the air in our breath. If the air should be deprived of oxygen we could not live, but on the other hand, if we were forced to breathe pure oxygen the reaction would consume our tissues too rapidly, we would soon expend our energy and die. Pure oxygen is often used as a stimulant for sick people who are in an extremely weak condition.

Oxygen is necessary for ordinary combustion. Fire will not burn unless fresh air is constantly supplied, so that it can have oxygen. Air will not keep fire burning after the oxygen in it has been used up, and stoves are provided with chimneys so that there will be a draft or current of air passing through the fuel. Fire can be smothered by keeping fresh air away from it, as by throwing a blanket over it.

Experiment 7—Suffocating a Fire.

Set a candle in the middle of an ordinary milk or baking pan, first allowing a few drops of molten grease to fall on the pan to stick the candle tightly. Next pour about 2 inches of water into the pan.



Now light the candle and set over it an inverted milk bottle or fruit jar. The bottle or jar must be high enough so that the bottom will not come too close to the candle flame.

Note that almost at once the candle flame grows dim, and that after a few minutes it dies out, the oxygen of the air inside the bottle having been used up.

Note further that after the flame has gone out, the water begins to rise inside the bottle, and finally stands at a considerably higher level in the bottle than in the pan.

This is due to the removal of the oxygen from the air inside the bottle, thus leaving a partial vacuum which is filled by the water. In the flame, the oxygen unites with the candle forming carbon dioxide (See Experiment 31), a gas which dissolves in water, and steam which condenses to water (See Experiment 34).

Experiment 8—Fire Proofing.

(a)—Cloth.

Cloth, wood or other inflammable substances may be fireproofed by treating them with chemicals which when heated give off vapors that smother the flame.

Dissolve 12 measures of Ammonium Chloride (No. 9) in a test tube 1-3 full of water. Put a piece of cotton cloth 2 or 3 inches square in the bottom of a glass and pour the liquid in the test tube over it. Stir the cloth around until it is wet through, then let it dry and try to light it with a match. You will find that it will burn while held in the flame, but just as soon as the match flame is removed it will go out.

Because fabrics treated in this manner cannot be set on fire by sparks or overturned candles this process of fire-proofing is quite generally used in connection with the curtains and scenery for theatres. All the woodwork on battleships is also treated in this manner, so that it will not take fire from the explosion of shells. Other chemicals than ammonium chloride are frequently used, one of the best being sodium tungstate, which, however, is rather expensive.

(b)—Wood.

Hold a match by the head and dip the other end into No. 19 which contains Water Glass (Sodium Silicate Solution). Let the coating which is obtained dry for about 15 minutes, then light the match. There will be no danger of burning your fingers, for the flame will go out as soon as it reaches the water glass.

A reaction which adds oxygen to a substance is called oxidation. Some compounds contain oxygen in such a form that it is easliy given up to other compounds. Such compounds are called oxidizing agents. A reaction of oxidation usually gives out much heat and sometimes fire.

Experiment 9—Fire Ink.

Place 6 measures of Potassium Nitrate (No. 8) in a test tube and add ½ inch of water. Heat over the candle for a moment to dissolve all of the solid.

Now use the liquid as ink, writing with a clean pen (or still better using a small brush) on unglazed paper. Make your strokes heavy and connect all lines.

Allow the marks to dry thoroughly and then apply a lighted match or better a glowing spark, to some portion of the writing. Blow out any flame which results. If properly started a spark will travel along the lines where the liquid has been applied without burning the rest of the paper. Thus the writing is brought out in burning lines.

Drawings made with this ink are invisible until brought out by the moving spark of fire. The effect is most mysterious. The best results are obtained by using soft paper which absorbs the liquid fairly well and by making the lines rather heavy.

Potassium nitrate is an oxidizing agent and oxidizes the paper when the reaction has been started by the application of heat.

Experiment 10—Making a Fuse.

Prepare a solution of Potassium Nitrate according to the directions in Experiment 8. Obtain a piece of ordinary white string two or three feet long, place it in the solution in a test tube, and let it soak for three or four minutes. Remove the string, hang it up and when thoroughly dry, light one end. It will burn just like a fuse, and by regulating the length of the string it can be made to burn for any desired length of time.

Save a few pieces of fuse for use in following experiments.

A reaction which takes oxygen away from a substance is called reduction, and substances which have a strong attraction for oxygen so that they can take it away from other substances are called reducing agents.

Experiment 11—The Reduction of Logwood.

Place 1 measure of Logwood (No. 29) in a test tube ¾ full of water and warm the solution for a few moments until it becomes a deep red color. Now pour the red solution into another test tube and add 4 measures of Sodium Bisulphite (No. 5).

Upon shaking this solution you will find that it is bleached and turned nearly colorless. The sodium bisulphite has removed oxygen from the logwood, thus converting it into a nearly colorless substance.

Experiment 12—Bleaching with Sulphur Dioxide.

Place about 5 measures of Sodium Bisulphite (No. 5) and an equal amount of Tartaric Acid (No. 14), or some vinegar, in a glass. Pour in a few drops of water, smell cautiously and note the odor of sulphur dioxide.

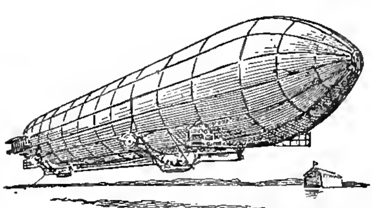
Hang in the glass some colored (red or blue) flowers and cover the top with a saucer. In about 30 minutes the colored flowers will be turned white.

Most yellow flowers do not bleach well and the experiment works best on red, pink or blue flowers. If the flowers are dipped in water to moisten them before being hung in the glass it helps the action.

Some colored fabrics can also be bleached in this manner, but not all dyes are bleached by this particular compound.

Sodium bisulphite when treated with acids gives off sulphur dioxide, a gas which is a powerful reducing agent, and hence an excellent bleaching agent for many colored compounds.

HYDROGEN



Hydrogen is a colorless, odorless gas. It is more than fourteen times as light as air and about eleven thousand times as light as water. Because of its lightness it is frequently used in ballons and airships to make them rise in the air. Small amounts of hydrogen occur in the atmosphere in the free state, but in combination it occurs almost everywhere, being found in water, in petroleum and in all animal and vegetable substances.

Experiment 13—Preparation of Hydrogen.

Put 4 measures of Sodium Bisulphate (No. 7) and 5 measures of Ammonium Chloride (No. 9) in a test tube and fill ¼ full of water. Heat the solution over a candle flame for a few minutes, allowing it to boil until the solids are completely dissolved and the liquid appears perfectly clear.

Now add 1 measure of Powdered Zinc (No. 11) to the solution in the test tube. Notice the violent action which occurs due to the evolution of a gas. This gas is hydrogen.

Hydrogen gas is inflammable. When burned it unites with the oxygen of the air, forming water, which passes away as vapor, steam.

When sodium bisulphate and ammonium chloride are boiled together, a solution of hydrochloric acid is formed. Acids react with many metals, liberating hydrogen and forming salts. Thus in the case of the zinc, we had formed zinc chloride, a salt, which remained dissolved in the water, and hydrogen which came off as a gas.

WATER

The great quantity of water which occurs in nature makes it one of the most familiar chemical substances. Like oxygen, water is essential to the existence of life. It is present in the air, in the ground, and in animal and vegetable tissues. Water is a compound of two elements, oxygen and hydrogen, both of which are gases.

A great many substances may be dissolved in water. A body is dissolved or "in solution" when it is so finely divided, and its particles are so completely scattered through a liquid that they can neither be seen nor separated from the liquid by filtering. The substance may in most cases be recovered in its original state by evaporating off the liquid.

Experiment 14—Solution.

Dissolve a spoonful of common table salt (not included in outfit) in half a glass of water.

Now pour this solution into a small pan or similar cooking utensil and heat on the stove until the water is all driven off. Taste what you find remaining in the pan and satisfy yourself that it is the same salt with which you started.

Unless the pan is heated very gently when the salt is nearly dry you will find there will be some violent popping due to the expansion of steam in the crystals of salt. This does no harm except to throw about some of the salt.

Experiment 15—Diffusion.

Fill a clean glass nearly full of water and let it stand for a minute or two to become quiet. Now add a small particle of Mixed Dyes (No. 30) and watch closely what occurs.

As the dye dissolves the color seems to flow out of the mass in a stream until it finally reaches the bottom of the glass. After a few moments the color will begin to diffuse through the liquid until finally after several hours the entire solution will be a uniform color.

Most chemicals react much more readily if they are dissolved in water, as this permits the particles to come into closer contact.

Experiment 16—The Effect of Solution on Chemical Reaction.

Mix together on a sheet of paper 1 measure of Sodium Bicarbonate (No. 25) and 1 measure of Tartaric Acid (No. 14). The dry mixture shows no sign of any chemical reaction.

Now put this mixture in a test tube and add a drop or two of water. Immediately a violent reaction occurs, liberating much gas.

Many salts absorb heat when they dissolve. Thus it is possible to lower the temperature of water by dissolving certain salts.

Experiment 17—The Effect of Solution on Temperature.

Fill a test tube half full of water and note the temperature by feeling the outside of the glass. Now add 5 measures of Potassium Nitrate (No. 8) to the water in the test tube again and notice the change in temperature.

Water normally freezes at zero degrees Centigrade (32 degrees Fahrenheit), but under certain conditions it may be cooled considerably below this temperature without freezing.

Experiment 18—Undercooled Water.

Obtain a tumbler full of crushed ice and mix in 2 or 3 spoonfuls of ordinary table salt. Now place a clean test tube about ¼ full of pure water in this mixture. Do not allow any of the salt or ice to get into the test tube.

If kept perfectly quiet the water in the test tube may be cooled to minus 4 to 5 degrees Centigrade (25 degrees Fahrenheit) or even to minus 10 degrees Centigrade (15 degrees Fahrenheit) without solidifying. If this undercooled water is stirred, or if a tiny crystal of ice is added, it immediately freezes and the temperature rises to zero degrees Centigrade (32 degrees Fahrenheit).

Most substances are very much more soluble in hot water than in cold water. This fact is made use of by the chemist in many ways.

Experiment 19—The Effect of Temperature on Solubility.

Put 6 measures of Nickel Ammonium Sulphate (No. 13) in a test tube ¼ full of water. Close the end of the test tube with your thumb and shake for a few minutes. Notice that the nickel ammonium sulphate will not completely dissolve in this amount of cold water. Now heat the test tube for a few minutes and the solid will entirely dissolve.

Set the test tube aside and allow the solution to cool slowly. After one or two hours crystals of nickel ammonium sulphate will form in the solution and gradually grow larger.

It is an invariable rule that the more slowly crystals are formed the larger they will be.

Experiment 20—The Formation of Crystals.

Put 6 measures of Boric Acid (No. 2) in a test tube and fill ¼ full of water. Boil for a minute to dissolve the boric acid, then set aside and let the solution cool slowly. After 15 or 20 minutes a heavy deposit of white frost-like crystals will be formed in the test tube.

Repeat the experiment, but cool the solution rapidly, as soon as the boric acid has all dissolved, by setting the test tube in a glass half full of cold water. The crystals obtained this time will be much smaller than in the first case where the solution was cooled slowly.

Water is contained in many solid dry substances in a state of chemical combination. For example, some crystals contain what is called "water of crystallization."

Experiment 21—Water of Crystallization.

Drop 1 measure of Nickle Ammonium Sulphate (No. 13) into a clean dry test tube and heat the bottom of the tube with a flame, using the test tube holder so as not to burn your fingers. Do not hold the tube in the flame, as this will cause soot to deposit. Rather hold it about ½ inch above the top of the flame.

Note that the green powder becomes wet and water is driven off in the form of steam. Heat until all the water is driven off. The substance remaining will be a dark yellow color, which gradually turns yellow tinged with green.

Aluminum Sulphate (No. 12), Ferric Ammonium Sulphate (No. 21), Ferrous Ammonium Sulphate (No. 17), and ordinary washing soda also contain water of crystallization. Heat small quantities of some of these substances and notice the change which occurs when the water of crystallization is driven off.

Ordinary washing soda is a good example of a substance containing water of crystallization. If you are familiar with this material you know that it sometimes comes in clear, nearly transparent crystals, while other times it is covered with white powder and is very dusty. This is because washing soda loses part of its water of crystallization when it is exposed to the air, and the white, dusty powder has probably been stored so long that much of the water has been lost. It is just as well to remember, however, that a pound of washing soda which has lost part of its water contains much more soda than a pound of the big, good looking crystals which still have water in them.

Experiment 22—Dissolving Solids in Their Water of Crystallization.

Put 1 measure of Ammonium Chloride (No. 9) and 1 measure of Sodium Thiosulphate (No. 16) in the palm of your hand and rub them together with your fingers. In a few minutes the solids will become moist, and will gradually dissolve in their water of crystallization. Be sure to wash your hands immediately after working this experiment.

Experiment 23—Testing for Traces of Moisture.

A convenient method of testing for small traces of moisture is as follows:

Prepare a solution of 2 measures of Ferric Ammonium Sulphate (No. 21) in a test tube half full of water. Saturate some strips of smooth white paper with this solution and dry the strips. When you are ready to use them place half a measure of Sodium Ferrocyanide (No. 6) on one of the dry strips and spread it over the surface by means of a soft brush or wad of cotton.

The slightest trace of moisture produces dark blue spots on these strips. Hold a strip over the mouth of the test tube in Experiment 21.

Experiment 24—Sympathetic Ink.

Dissolve 1½ measures of Cobalt Chloride (No. 27) in a test tube ½ full of water. Writing done with this solution shows blue when the paper is heated and disappears again on cooling.

Write with a clean pen on white paper. To bring out the writing warm the paper. If heated too hot so that the paper is scorched the ink will not disappear on cooling because of the formation of cobalt oxide.

Cobalt Chloride is blue, but in the presence of moisture it takes up water of crystallization and becomes pale pink in color. Even the small amount of water in the air is sufficient to cause the blue color to become more or less pale and pinkish.

On heating the writing the water is driven away and the cobalt chloride in the ink shows blue. On cooling, it absorbs moisture from the air and turns pale pink, so that it is not easily seen. Sometimes when the air is quite hot and dry, as in heated houses in the winter time, the blue requires a very long time to fade away.

This same substance is often used as a sort of chemical barometer. A sheet of white paper is moistened with a concentrated solution and allowed to dry. It is then hung up some place where the outside air will circulate freely around it, but where the rain will not reach it.

When it looks bluish it is an indication of dryness and usually of continued fair weather. When it is pink in color it indicates wet or moist weather.

Experiment 25—The Dehydration of Cobalt Chloride.

To illustrate more clearly the change which takes place in Experiment 24, try the following:

Place 1 measure of Cobalt Chloride (No. 27) in the spoon, notice that the color is pink. Now heat the spoon very gently until the cobalt chloride just changes to a blue color. The water of crystallization has been driven off, or in other words, it has been dehydrated.

Now add 1 to 2 drops of water to the blue cobalt chloride in the spoon, mix it around and notice that the mass becomes pink again. The cobalt chloride has taken up water of crystallization or has been rehydrated. This change can be repeated as often as you like.

Experiment 26—Permanent Sympathetic Ink.

Dissolve 4 measures of Sodium Bisulphate (No. 7) in a test tube half full of water.

Using a clean pen, write with this solution on white paper. The writing cannot be seen until the paper is heated, when it appears in dark brown lines. This writing is permanent and will not disappear.

It is possible to prepare supersaturated solutions of some substances, that is, solutions which contain more of the substances than is normal for the temperature of the solution. Such solutions are very unstable and will crystalize suddenly if given a proper start.

Experiment 27—A Supersaturated Solution.

Fill a test tube 1-3 full of Sodium Thiosulphate (No. 16). Add exactly 2 drops of water and warm gently. The sodium thiosulphate will melt in its own water of crystallization, and the warming should be continued until the crystals are completely dissolved and the solution is almost boiling. Now close the end of the test tube with a plug of cotton and allow it to stand without moving or shaking until cool.

You now have a supersaturated solution. To start crystallization drop in a crystal of Sodium Thiosulphate the size of a pin head and watch carefully for a few minutes to see the crystals grow.

THE HALOGEN FAMILY

There are four elements whose chemical properties resemble each other very closely, and which the chemist has named the Halogen family. The elements belonging to this family are: Fluorine, Chlorine, Bromine and Iodine. Fluorine is a colorless gas, Chlorine is a greenish gas, Bromine is a reddish brown liquid or gas and Iodine is a gray solid which when heated changes into a purple gas.

Chlorine is a heavy unbreathable gas with a suffocating odor and astringent taste. It is the most interesting as well as the most useful of the Halogens. It is used as a bleaching and disinfecting agent, and in the extracting of gold from its ores. Chlorine gas also played an important part early in the recent war. The gas was generated on a very large scale and liberated when conditions were favorable for blowing it into the trenches of the enemy. The only protection from an attack of this sort is obtained by wearing respirators which prevent the breathing of the gas into the lungs. Later, other, even more deadly gases were used.

Experiment 28—Preparation and Properties of Chlorine.

(a)—Preparation.

Put 3 measures of Sodium Bisulphate (No. 7), 3 measures of Potassium Nitrate (No. 8) and 3 measures of Sodium Chloride (common table salt) in a test tube and heat the mixture over a flame for a few minutes. Cautiously smell the gas which is evolved.

(b)—Tests for Chlorine.

Obtain a small lump of starch about the size of a pea (or 1 measure of powdered starch) and mix thoroughly with a few drops of water in a glass. Pour the mixture into a test tube half full of hot water, add 3 or 4 drops of Sodium Iodide Solution (No. 23) and boil for a minute. Now dip a strip of white paper into this solution and hold it over the mouth of the test tube in which you are generating chlorine gas. Heat the test tube to drive off the gas freely, and notice the blue coloration which appears on the paper. The color will disappear if the paper is exposed to the chloride gas very long. This is a very delicate test for chlorine.

(c)—Bleaching with Chlorine.

Obtain a few pieces of different colored paper and cloth; wet them with water and put them in a glass. Cut a piece of heavy paper large enough to cover the top of the glass and make a small hole in the center.

Now fit the test tube in which chlorine is being generated with the perforated cork and delivery tube. Heat the test tube and pass chlorine gas through the hole in the paper into the glass containing the pieces of wet cloth and paper. In a short time the colors will be bleached.

Chlorine is one of the most powerful bleaching agents known.

Experiment 29—Hydrogen Chloride.

Place in a test tube 1 measure of Sodium Bisulphate (No. 7) and 2 measures of Ammonium Chloride (No. 9). Heat the mixture over a candle flame for a few minutes. When a quantity of fumes is given off moisten a piece of Blue Litmus Paper (No. 18) and hold it at the mouth of the tube for a moment. Notice that it is turned red, showing the presence of an acid. Take the test tube away from the flame and cautiously smell the gas which is coming off. It is hydrogen chloride.

This gas when dissolved in water forms hydrochloric or muriatic acid.

If you have some household ammonia dip your glass rod into it and then hold the rod at the mouth of the test tube. The white fumes are ammonium chloride and are an example of smoke without fire.

Hydrochloric acid is a compound of hydrogen and chlorine. It is manufactured commercially by heating sodium chloride (common table salt) with sulphuric acid.

Experiment 30—Another Method of Preparing Hydrogen Chloride and Chlorine.

Heat together in a test tube 1 measure of Sodium Bisulphate (No. 7) and 2 measures of Ammonium Chloride (No. 9) as in experiment 29. When fumes of hydrochloric acid are given off stop heating for a moment and add 2 measures of Patassium Nitrate (No. 8). Continue heating for a minute or so longer and smell cautiously. Notice that hydrogen chloride is no longer coming off, but instead, chlorine gas is being evolved.

CARBON—COMBUSTION—CARBONATES

Carbon is an element which is found in all living matter and in all substances which are made from living or growing things. Your food, your clothing and you, yourself, are largely made of carbon compounds. Carbon and many of its compounds unite readily with oxygen and give off heat in doing so, in other words they burn. It is because wood and coal consist mainly of carbon that they are so valuable as fuels.

When carbon burns it unites with oxygen to form the compound carbon dioxide, which is gas.

Experiment 31—A Test for Carbon Dioxide in Products of Combustion.

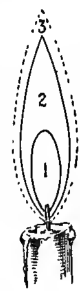
Place 5 measures of Calcium Oxide (No. 20) in half a glass of water and stir for several minutes. Let stand until the powder has settled to the bottom and then pour off the clear liquid into another glass. This liquid is lime water.

Now repeat Experiment 7, but after the candle has gone out remove the jar or bottle from the water and quickly pour in a little of the clear lime water. Put your hand over the mouth and shake violently for a moment.

If you will look closely you will see that the lime water is now turbid with white particles. Carbon dioxide unites with lime water to form calcium carbonate which is white and is not soluble in water. Hence the formation of this white turbidity is a test for carbon dioxide and shows that this gas is formed by the burning of the carbon of the candle.

Experiment 32—The Structure of Flame—A Gas Factory.

If you will look closely at a candle flame you will see that it consists of three parts.



First, a dark zone just around the wick.

Second, a bright yellow zone which gives the light.

Third, a transparent zone of heat around the outside.

The first or inner zone consists of unburned gas given off from the wick of the candle. The melted grease is drawn up by capillary action into the wick and is there converted into gas by the heat of the flame. With care a portion of this gas can be drawn off through a tube.

Hold one end of the glass tube in the flame and directly over the wick. Hold the tube slanting upwards so that the other end is out at the side and a little above the flame. If held correctly smoke will come from the end of the tube and can be lighted with a match.

That it is relatively cool inside of the flame can be shown by thrusting a match stick into this zone for a few seconds. The portion of the stick which was held in the dark zone will not be burned so soon as that portion passing through the sides of the flame.

Experiment 33—The Structure of Flame—Manufacturing Lampblack.

The second or bright yellow zone of the flame contains particles of carbon heated to a white heat so that they glow brightly. The carbon is formed by the action of the heat on the gas of the inner zone.

The presence of this carbon can be shown by holding a cold spoon or piece of glass tubing in the flame for about a minute. You will notice that when you take it out it is covered with a black deposit of lampblack or soot which is one form of carbon. The cold spoon chills the flame and prevents the carbon from being completely burned.

Lampblack is made on a large scale in just this way except that natural gas is burned instead of candles and the cooling is done by means of iron pipes with water circulating through them.

The third or outside zone of the flame consists of the gases formed by the complete burning of the carbon particles. If you will hold the cold spoon in this outer zone you will find that it gets very hot but that no soot or only a very small amount will be deposited. This zone is above the luminous part.

Wood, oil and many other fuels contain hydrogen combined with carbon and when burned this hydrogen unites with oxygen from the air to form water, hydrogen oxide

Experiment 34—Making Water from Fire.

Take a cold, dry glass and invert it over a lighted candle, holding the mouth just above the flame. After a few seconds remove the glass and examine the inside. You will find that a film of moisture has been deposited on the inside of the cold glass.

Water is liberated from the flame in the form of steam, and in order to make it visible it must be condensed on some cold object.

Breathing is a form of combustion. The oxygen of the air that we take into our lungs combines with the carbon and hydrogen of the food we have eaten, and the heat that is generated by this combustion serves to keep our bodies warm. Just as in the case of the burning candle, carbon dioxide is formed by this reaction and is therefore present in the breath we expel.

Experiment 35—Test for Carbon Dioxide in the Breath —"Bugs in the Breath."

Prepare half a glass of clear lime water according to the directions given in Experiment 31.

Using the piece of glass tubing blow through the lime water. You will find that as your breath bubbles through the liquid it causes it to turn white and turbid, thus showing the presence of carbon dioxide.

The white precipitate is calcium carbonate, which is soluble in most acids. Stir in a little vinegar, or 3 measures of Tartaric Acid (No. 14) and see the turbidity disappear.

I remember one time seeing a "Medicine Man" who made use of this reaction in selling a so-called consumption cure to ignorant people. After getting a crowd about him he would pick out some poor fellow and say:

"Friend, you have consumption. You don't know it but I see it in your face. Now I'll prove it to you. Your breath is just chuck full of germs. You come here and I'll show them to you. Here, blow through this and we will catch them in the glass."

He has his victim blow through some lime water until it turns white. Then he goes on:

"See here, folks, the liquid's white with consumption germs.

Now I'll show you how Smither's Specific kills the dread disease."

Then pouring some diluted acid into the glass, the turbidity disappears and he says: "There, clear as crystal! Smither's Specific just naturally eats those germs right up. Now, friend, you don't want to die in the prime of your young manhood. Buy a bottle and cure yourself. One dollar please. Thank you—who's next?"

The experiment carried out along these lines makes a very good trick on credulous people, and is very perplexing to anyone not familiar with its chemistry.

When wood, coal and similar substances are heated, and no air or oxygen is permitted to get to them they do not burn, but the hydrogen, nitrogen, and portion of the carbon which they contain are driven off in the form of gas and tar, while most of the carbon is left behind as charcoal or coke. This process of heating without access of air is the means of obtaining many valuable chemicals and forms the basis of enormous industries.

When coal is heated in this way, coal gas, tar and crude ammonia are obtained. The gas is used for lighting and heating; the crude ammonia is purified and used in various ways, while from the tar are obtained all aniline dyes, many drugs used in medicine, disinfectant compounds such as creosol and carbolic acid, the materials from which many of the modern high explosives are made, and a multitude of other valuable products.

When wood is distilled in this way, gas, tar and a liquid containing acetic acid (wood vinegar), wood alcohol and other valuable products are obtained.

Experiment 36—The Distillation of Wood.

Break the heads off of 5 or 6 matches and put the sticks in the bottom of a test tube. Now heat, using your test tube holder, over an alcohol lamp or gas flame (a candle flame is not hot enough to give the best results in this experiment).

When smoke begins to come off from the wood hold a piece of moistened Blue Litmus Paper (No. 18) in the mouth of the tube. Note that it is turned red, showing that there is acid in the gas. Now fit the test tube with your gas delivery tube, continue heating and light the gas as it comes from the end of the tube. You will find that the gas is inflammable and after the distillation has continued for a few minutes it will burn as it comes out of the tube.

Continue heating until gas no longer comes off, then let the test tube cool and empty out the charcoal which remains, using your stirring rod to loosen it from the sides if necessary. Charcoal is practically pure carbon.

Many chemicals contain carbon in such a form that it is easily liberated as carbon dioxide. Such compounds are known as carbonates. When carbonates are brought in contact with acids and carbon dioxide is given off as gas.

Experiment 37—The Manufacture of Carbon Dioxide—Chemical Boiling.

Place 2 measures of Sodium Bicarbonate (No. 25) in a test tube and fill 1-3 full of water, shaking well to dissolve all the solid. In another test tube containing an equal volume of water put 1½ measures of Tartaric Acid (No. 14) and shake well. Now pour the contents of the second tube into the first.

The liquid will boil violently due to the evolution of carbon dioxide gas.

Smell the gas. It is the same as that used in soda water to make it foam and give it the sparkling taste.

Ordinary baking soda is sodium bicarbonate. When heated it gives off part of the carbon dioxide gas which it contains, so when used in biscuit, cake, etc., the gas coming off "raises" the dough and makes it porous and light.

Experiment 38—Some Properties of Carbon Dioxide.

Carbon Dioxide gas is heavier than air and may be poured almost like water. It will not support combustion.

Obtain a small quantity of baking soda and half a glass of vinegar. Place a candle in a tumbler or other similar vessel, so that when lighted the top of the flame will be just below the top of the tumbler or vessel. Now put a teaspoonful of baking soda in a glass and add a small quantity of vinegar. There will be a violent boiling or effervescence and carbon dioxide gas will be given off. While this action is going on, hold the glass over the vessel in which the candle is burning and pour the carbon dioxide gas over the candle. Tilt the glass as though you were pouring water from it, but do not allow any of the liquid to come out. In a short time the candle will be extinguished although it may be necessary to add a little more vinegar to the glass in which the carbon dioxide is being generated.

The relatively great weight of carbon dioxide as compared with air is responsible for its accumulation in abandoned mines, old wells, etc., and such places should always be tested by lowering a lighted candle into them before people descend, as otherwise suffocation may result.

Some hand fire-extinguishers and most chemical fire-engines make use of carbon dioxide. They contain sodium bicarbonate (baking soda) and sulphuric acid held in separate containers and are so arranged that when the extinguisher is turned upside down the chemicals are mixed and carbon dioxide is generated. Because of the weight of this gas it may be directed by a nozzle on to the fire and thus made to extinguish the flame.

The small, hand fire-extinguishers which are so largely used on automobiles and in homes contain a liquid called Carbon Tetra-Chloride. This liquid when heated is converted into a heavy gas, which will not burn. When Carbon Tetra-Chloride from these small fire-extinguishers is squirted on to a fire, the liquid is turned into this heavy gas which smothers the flame in the same manner as Carbon Dioxide.

Experiment 39—Acid Properties of Carbon Dioxide.

Prepare a solution of 1 measure of Sodium Carbonate (No. 4) in half a glass of water. Add 1 drop of Phenolphthalein Solution (No. 22), which will turn the water red, proving it to be alkaline. Now fill a test tube about ¾ full with the solution in the tumbler.

In another test tube put 4 measures of Sodium Bicarbonate (No. 25) and 4 measures of Sodium Bisulphate (No. 7). Fill the tube 1-3 full of water and quickly fit with the gas delivery tube and stopper. Now place the end of the gas delivery tube in the solution in the first test tube which is colored pink, and let the carbon dioxide gas bubble through this solution. After several minutes you will find that the pink color has disappeared and the solution is now colorless, due to the fact that carbon dioxide when dissolved in water forms carbonic acid and this changes phenolphthalein solution from red to colorless. It may be necessary to renew the sodium bicarbonate and sodium acid sulphate in the carbon dioxide generator before the phenolphthalein solution is made completely colorless.

Experiment 40—Testing Household Materials for Carbonates.

Test the materials suggested below for carbonates by placing 4 measures of the specified material in a test tube and adding 3 measures of Sodium Bisulphate (No. 7) and a little water. Warm the mixture gently, if necessary, to start the reaction, and when a gas is given off, test for carbon dioxide by means of lime water made as described in Experiment 31.

The test may be performed in either of two ways. It is conveniently carried out by dipping the glass tube into clear lime water. Place your finger over the upper end to prevent the liquid from running out and then hold the liquid in the tube a short distance above the mixture in the test tube. If the lime water becomes cloudy or white it shows the presence of carbon dioxide gas.

The other method of testing may be carried out as follows:

Fit the test tube in which the gas is being generated with the gas delivery tube and stopper. Fill another clean test tube about ¼ full of clear lime water and place the end of the gas delivery tube in the lime water so that the gas will bubble through it. If the solution of lime water becomes cloudy or white it shows that the gas is carbon dioxide.

Test in the manner described above, any of the following substances:

Baking Soda (sodium bicarbonate), Washing Soda (sodium carbonate). Baking Powder (a mixture of sodium bicarbonate with calcium acid tartrate, calcium acid phosphate or alum), oyster shells (which consist chiefly of calcium carbonate), chalk, tooth powder, plaster (which also contain calcium carbonate).

The same test may be applied to the gas given off by foaming beverages, such as soda water, ginger ale, etc.

Since carbon dioxide is formed when fuels burn, and is given off in our breathing, we might expect to find a small quantity present in the air about us. That the air does contain carbon dioxide is readily shown by the following experiment.

Experiment 41—Limestone Ice.

Make up half a glass of lime-water according to the directions given in Experiment 31. Pour this into a saucer, and let it stand over night. Do not put a cover over the saucer. In the morning you will find that a thin white crust has formed over the surface of the liquid.

This crust consists of calcium carbonate and is the same thing chemically as limestone rock. It is formed by the action of the carbon dioxide in the air on the lime-water.

NITROGEN

The element nitrogen is an inert gas. It occurs in the air mixed with oxygen. The compounds of nitrogen are among the most interesting and valuable known to the chemist. With hydrogen and oxygen, nitrogen forms nitric acid, from which is made most of our high explosives. Nitrogen is essential to the growth of plants and its compounds are used largely in fertilizers. Animal life also contains a large portion of nitrogen.

Nitrogen combines with hydrogen to form the compound ammonia. Crude ammonium salts are obtained from the distillation of coal and from these pure ammonia is made by treatment with lime or other alkali.

Experiment 42—The Manufacture of Ammonia.

Place 2 measures of Ammonium Chloride (No. 9) and 2 measures of Calcium Oxide (No. 20) in a test tube. Notice that neither of these chemicals has any smell before they are mixed together. Gently heat the mixture over a candle flame and after a moment smell cautiously; also test with moistened Red Litmus Paper (No. 18). This simple experiment illustrates the way in which ammonia is made on a large scale.

Ammonia gas is very soluble in water and the liquid or household ammonia which is commonly used, is a solution of this gas in water.

Experiment 43—Another Method of Preparing Ammonia.

Place 2 measures of Ammonium Chloride (No. 9) in a test tube as before, but this time add 2 measures of Sodium Carbonate (No. 4). Heat the mixture gently and notice the smell of ammonia in the mouth of the test tube.

Experiment 44—Making Ammonia in Your Hand.

Put 1 measure of Calcium Oxide (No. 20) and 1 measure of

Ammonium Chloride (No. 9) in the palm of your hand and mix the substances together with your finger. Smell the mixture occasionally and notice that ammonia gas is being given off.

Ammonium Salts are readily volatile, and some of them pass into the form of vapor without first melting.

Experiment 45—Volatilization of Ammonium Compounds.

Put 1 measure of Ammonium Chloride (No. 9) into a clean dry test tube. Heat gradually over the candle flame, being careful not to get the bottom of the test tube sooty. Notice how the ammonium chloride volatilizes and how the vapor condenses on the upper part of the test tube.

Experiment 46—Nitrogen Compounds.

Take 2 measures of Potassium Nitrate (No. 8), 1 measure of Sulphur (No. 1) and 1 measure of powdered Charcoal (made by crushing up burned match sticks). Mix these substances thoroughly on a sheet of paper, but do not grind or rub hard.

Now pour the mixed powders into a little pile on a pan and drop a lighted match on it, keeping your hands and face at a distance. It will go off with a puff. If you have saved some pieces of fuse from Experiment 9, the mixture may be lighted by imbedding one end of the fuse in it and lighting the free end.

Gunpowder is a mixture of potassium nitrate, sulphur and charcoal finely ground, mixed together and formed into grains. It was originally invented by the Chinese. Since the discovery of modern high explosives such as nitro-glycerine, gun cotton, picric acid, etc., gunpowder is used very little except for blasting and fireworks.

SULPHUR

Sulphur is a very useful element. From it is made sulphuric acid, one of the most powerful acids, and a necessity in many large industries. In fact, sulphuric acid enters in some way or other into the manufacture of about 90 per cent of the things which we use in our daily life, such as food, clothing, etc.

Sulphur is obtained from the craters of volcanoes in Italy, Mexico and Japan, and there are also important mines in Louisiana where the sulphur is melted in the ground by superheated steam and pumped out of wells.

Experiment 47—The Properties of Sulphur.

Put 2 measures of Sulphur (No. 1) into a dry test tube and heat gently over a flame.

Notice that it first melts to a dark liquid and is then converted into vapor. The vapor condenses again in the cool upper part of the test tube.

Now put 2 measures of sulphur in a spoon and heat this over the flame. While the sulphur is burning smell it cautiously.

In the test tube the sulphur did not burn because not enough air could get to it, but when heated in the spoon it unites with the oxygen of the air, forming the gas, sulphur dioxide. In Experiment 12 you made this same gas by another method.

Sulphur has no smell; try it. What is usually spoken of as the odor of sulphur or brimstone is the smell of sulphur dioxide.

Experiment 48—Elastic Sulphur.

Put 5 measures of Sulphur (No. 1) in the spoon and heat over the alcohol lamp flame until the sulphur has melted and is fluid. Now quickly pour the melted sulphur into a glass of water. After a few moments remove the mass of sulphur from the water and examine it. You will find it is an elastic substance resembling rubber more than anything else.

Sulphur exists in several different physical forms of which the "elastic" or "gamma" sulphur is one. After a long time this elastic sulphur will change back into the ordinary form.

Experiment 49—Preparation and Properties of Hydrogen Sulphide.

(a)—Preparation.

Cut a piece of paraffine about as big as the end of your little finger from your candle and place this, together with 5 measures of Sulphur (No. 1), in a test tube. Heat over the candle flame, and after several minutes smell the gas which is given off. This is the same gas that was prepared in Experiment 1, when sodium bisulphate was added to zinc sulphide.

(b)—Properties.

Fit the perforated cork and delivery tube to the test tube in which hydrogen sulphide is being generated. Heat the test tube and when the gas is being given off rapidly, apply a flame to the open end of the delivery tube. The gas will burn with a blue flame. When hydrogen sulphide burns in the air the sulphur and hydrogen unite with oxygen, forming sulphur dioxide and water. If, however, insufficient air is present only the hydrogen burns, and sulphur is set free. Hold a cold piece of glass in the blue flame for an instant; notice the deposit of sulphur which is formed.

Put 2 measures of Sodium Bisulphite (No. 5) and an equal amount of Tartaric Acid (No. 14) in another test tube, add a few drops of water. Warm slightly and cautiously smell the gas which is given off. It is sulphur dioxide. Now heat the test tube in which hydrogen sulphide is being generated and using your delivery tube, pass some of the gas into the test tube where sulphur dioxide is being given off. A deposit of sulphur will be formed around the walls of the tube. When hydrogen sulphide and sulphur dioxide are mixed together they react, forming sulphur and water. This is the way in which the great deposits of sulphur are formed in the neighborhood of volcanoes.

Moisten a bright penny with water and hold it against the open end of the delivery tube through which hydrogen sulphide is passing. In a short time a black spot will appear on the copper due to the formation of copper sulphide. The same result can be obtained with a silver coin, the stain in this case being silver sulphide. The presence of small traces of sulphur compounds in the air is the cause of the tarnishing of household silver.

Experiment 50—Test for Hydrogen Sulphide.

Moisten a piece of Sulphide Test Paper (No. 31) and hold it in the mouth of a test tube in which hydrogen sulphide is being generated (See Experiment 49, part a). The test paper will turn black, due to the formation of lead sulphide. This is a very delicate test for hydrogen sulphide.

Test your illuminating gas supply for hydrogen sulphide by letting the gas from a jet flow against moistened sulphide test paper. Illuminating gas is supposed to be purified and have all hydrogen sulphide removed from it, but in some cases this is not completely accomplished.

When cabbage is being cooked the steam arising from the pot contains hydrogen sulphide, which can be detected with sulphide test papers. The odor of boiling cabbage is due to hydrogen sulphide and other sulphur compounds.

The dark color in Experiment 50 is due to the action of the hydrogen sulphide on the lead salt with which the paper is impregnated. Lead sulphide, a black compound, is formed.

The presence of small traces of hydrogen sulphide in the air sometimes causes white paint to turn dark. White paint generally contains either lead carbonate or zinc oxide, and in case the paint contains the lead salt it is very apt to turn black due to the small traces of hydrogen sulphide in the air, which may result from sewer gas, coal gas or from cooking vegetables, such as cabbages. Zinc paint cannot be changed black by hydrogen sulphide gas. For this reason zinc paint is always used in chemical laboratories where hydrogen sulphide fumes are common.

Some oxidizing agents convert lead sulphide into lead sulphate, which is a white compound.

Experiment 51—The Oxidation of Lead Sulphide to Lead Sulphate.

Wet the test paper which was turned dark by hydrogen sulphide in Experiment 50 with Hydrogen Peroxide (Dioxygen) (not included in outfit). It will turn white again.

This is the method used to restore old oil paintings which have become darkened by the action of hydrogen sulphide in the air. Many famous paintings have been restored by this method.

Experiment 52—Silver Sulphide.

Sulphur unites directly with most metals to form sulphides. Experiment 1 illustrates the formation of zinc sulphide.

Place ½ measure of Sulphur (No. 1) on a bright silver coin and wrap in several thicknesses of paper. After a few days you will find a black spot of silver sulphide on the coin where the sulphur was in contact with it.

Rubber contains sulphur used in its vulcanization. Wrap a rubber band around a silver coin and you will find it will turn black after a few days due to the formation of silver sulphide.

A silver coin is turned black in a few hours by a paste of mustard and water, as mustard contains sulphur. Eggs also contain sulphur and this is the reason why silver spoons turn black when used for eating eggs.

Experiment 53—The Manufacture of Lime Sulphur Solution.

Put 1 measure of Calcium Oxide (No. 20) and 1 measure of Sulphur (No. 1) in a test tube and fill 1-3 full of water. Boil the mixture for 6 or 7 minutes. A clear yellow liquid will be formed.

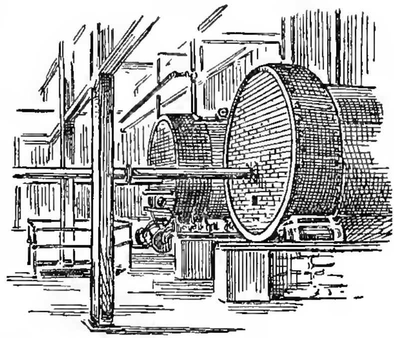
This liquid is commonly known as "Lime-Sulphur Solution." It has the property of destroying fungi, and is largely used as a spray for fruit trees.

Pour a drop of the hot solution on a bright silver coin and let it stand for about 15 minutes; a black spot of silver sulphide will be formed. Pour a small quantity of the lime-sulphur solution into a clean test tube and add ½ measure of Tartaric Acid (No. 14), hydrogen sulphide will be given off and the yellow liquid will become colorless.

SILICON—SILICATES

The element silicon, in combination with oxygen as silica (quartz, sand, flint), and with the metals and oxygen as metallic silicates (clay, feldspar, mica, etc.), form a large part of the earth's surface.

The most important artificial silicates are glass and portland cement. Glass is generally a mixture of sodium



and calcium silicates. Water glass (or soluble glass) is sodium silicate, which is soluble in water. Portland cement is made by strongly heating a mixture of calcium carbonate (limestone) and a siliceous clay. The calcium unites chemically with the silica and alumina of the clay, producing a substance which when very finely ground and mixed with water, sets to a solid stone.

Clay is a combination of silica with oxide of aluminum and water. It is the combined water which gives it the property of plasticity, and makes it possible to mould it into pottery and bricks. On burning, the combined water is driven off and the clay is made permanently hard.

Experiment 54—Silicon Dioxide.

Put ½ inch of Water Glass (No. 19) in a test tube and add water until the tube is ¼ full. Shake to mix the liquids.

In another test tube put 4 measures of Sodium Bisulphate (No. 7) and fill the tube 1-3 full of water. Shake until the solid is completely dissolved.

Pour the liquid in the first tube into the second. A transparent jelly-like precipitate gradually forms and after a few minutes all the liquid in the tube will have become solid. This is silicic acid.

Break up this precipitate by means of a stirring rod or piece of wire and empty it into a spoon. Heat the spoon strongly in an alcohol lamp or gas flame for 4 or 5 minutes, or until the precipitate is entirely dried and has been reduced to a white solid. This substance is silicon dioxide and is the same thing chemically as pure sand.

Experiment 55—Sodium Silicate (Water Glass).

Paint a thin film of Water Glass (No. 19) on a sheet of paper and let it dry for 15 or 20 minutes. Note the smooth transparent glass-like film which results.

Paste together two sheets of paper or two blocks of wood, using water glass as the adhesive. You will find that it makes an exceptionally strong paste and it is frequently used for this purpose.

Silicates of sodium and potassium are the only silicates which are readily soluble in water.

Most metallic silicates are insoluble in water. They are formed as beautiful precipitates when a soluble silicate is added to a solution of the metallic salt.

Experiment 56—Strontium Silicate.

Dissolve 2 measures of Strontium Nitrate (No. 10) in half a test tube of water and add two or three drops of Water Glass (No. 19).

A bulky white precipitate will form and upon shaking the test tube the precipitate will fill the whole tube.

Experiment 57—Zinc Silicate.

Place ½ measure of Powdered Zinc (No. 11) and 2 measures of Sodium Bisulphate (No. 7) in a test tube. Fill the tube half full of water and heat the solution for a few moments to completely dissolve the zinc. Now hold the tube in a glass of cold water for a moment or two until it becomes cool.

Add to the solution of zinc sulphate thus formed two or three drops of Water Glass (No. 19). A thick precipitate of zinc silicate will be formed.

Experiment 58—Aluminum Silicate.

Place 2 measures of Aluminum Sulphate (No. 12) in a test tube and fill the tube half full of water, shake to completely dissolve the solid. Now add two or three drops of Water Glass (No. 19) and note the thick white precipitate of aluminum silicate which is immediately formed.

Experiment 59—Nickel Silicate.

Place 2 measures of Nickel Ammonium Suplhate (No. 13) in a test tube and fill the tube half full of water. Heat the solution for a few moments to completely dissolve the solid, and immerse the tube in cold water to cool it again.

Add two or three drops of Water Glass (No. 19) to the solution of nickel ammonium sulphate and you will obtain a beautiful green precipitate of nickel silicate.

Experiment 60—Ferric and Ferrous Silicates (Iron Silicates).

(a) Ferrous Silicate.

Dissolve 2 measures of Ferrous Ammonium Sulphate (No. 17) in a test tube half full of water. To this solution add two or three drops of Water Glass (No. 19) and a thick greenish precipitate of ferrous silicate will be formed.

(b) Ferric Silicate.

Dissolve 2 measures of Ferric Ammonium Sulphate (No. 21) in a test tube half full of water and add two or three drops of Water Glass (No. 19). A very pretty reddish brown precipitate of ferric silicate will be formed. Compare this ferric silicate with the ferrous silicate obtained in part (a).

Experiment 61—Cobalt Silicate.

Dissolve 1 measure of Cobalt Chloride (No. 27) in half a test tube of water and add two or three drops of Water Glass (No. 19).

In this case a beautiful blue precipitate of cobalt silicate is formed. This is one of the prettiest of the entire series of silicates.

Experiment 62—Manganese Silicate.

Place 2 measures of Manganese Sulphate (No. 24) in a test tube half full of water and heat the liquid for a few moments to completely dissolve the solid.

Now add to this solution two or three drops of Water Glass (No. 19). A pale pink precipitate of manganese silicate will be formed.

BORON—BORATES

Boron is found principally in the form of borax (Sodium Pyroborate).

Large quantities of borax are obtained from certain lakes in foreign countries and also in the western part of the United States.

Boric Acid may be made by adding acid to a solution of borax. Large quantities of boric acid were formerly used as a preservative for milk, canned meats and vegetables. It is also used as an antiseptic and most talcum powders contain a certain amount of boric acid.

Experiment 63—A Test for Boric Acid.

Dissolve 2 measures of Boric Acid (No. 2) in a test tube 1-3 full of alcohol. Pour a small quantity of the alcohol into the spoon and light it. The alcohol will burn with a bright green flame. This is a characteristic test for Boric Acid.

Experiment 64—Borax Glass.

Mix together on a sheet of paper 1 measure of Sodium Carbonate (No. 4) and 1 measure of Boric Acid (No. 2).

Obtain a small piece (about ½ inch wide by 2 or 3 inches long) of thin glass. It is very important to have thin glass, as thick glass will break when heated and will also conduct a large amount of heat away from the mixture. A piece of broken test tube is ideal for this experiment.

Place ½ measure of the mixture of sodium carbonate and boric acid on the piece of glass and heat the glass in an alcohol lamp or gas flame until the mixture melts and forms a clear glass-like film. This is borax glass, and it can hardly be distinguished from the glass on which it is made.

Many metallic salts have the property of dissolving in melted borax forming various colors, depending on the metal present.

Experiment 65—Cobalt Borax Glass.

Repeat Experiment 64, but just before you heat the mixture of sodium carbonate and boric acid, add to it a small particle of Cobalt Chloride (No. 27). You will find after melting this mixture that the glass film obtained is blue in color. The intenseness of the blue color will depend upon the amount of cobalt which is used. If very much cobalt is used the film will appear to be black, so intense is the coloring power, but if only a very slight trace of the cobalt salt is used the film will be a beautiful azure blue.

Experiment 66—Iron Borax Glass.

Iron salts color borax glass yellow. Repeat Experiment 64, adding to the mixture of sodium carbonate and boric acid a very small amount of Ferric Ammonium Sulphate (No. 21).

Repeat using Ferrous Ammonium Sulphate (No. 17) in place of the ferric ammonium sulphate.

Experiment 67—Manganese Borax Glass.

Manganese colors borax violet or lilac. Try the experiment, using just a trace of Manganese Sulphate (No. 24).

Experiment 68—Nickel Borax Glass.

Repeat the borax glass experiment, using a trace of Nickel Ammonium Sulphate (No. 13). In this case the borax glass will assume a brown color on being cooled due to the nickel.

THE FIREWORKS INDUSTRY

Fireworks depend largely on the use in various ways of colored fire, and the manufacture of colored fire is based on the property possessed by certain metals and their compounds of coloring flame. Copper, zinc and barium color flame green, strontium and lithium color it red, sodium gives a yellow color, and potassium violet.

Experiment 69—The Manufacture of Colored Fire.

(a)—Red Fire.

Mix thoroughly on a sheet of paper 1 measure of Strontium Nitrate (No. 10), 2 measures of Potassium Nitrate (No. 8), ½ measure of Sulphur (No. 1) and 2 measures of powdered Charcoal (No. 3). Pour this mixture on a pan, making it into a little pile. Light the pile with a match, or use a short piece of fuse. Keep your face at a little distance. The mass will take fire and burn, giving off a red light due to the presence of stroutium.

(b)—Yellow Fire.

Repeat, using instead of strontium nitrate ½ measure of Sodium Carbonate (No. 4) or ½ measure of ordinary table salt (which is sodium chloride). In this case the light will be yellow owing to the presence of sodium.

THE INK INDUSTRY

The manufacture of writing ink dates back to earliest history, and the first inks consisted chiefly of fine soot mixed with a solution of some kind of gum. Today there are many kinds of inks for every conceivable purpose and many formulae are in existence for the manufacture of each kind.

Experiment 70—The Manufacture of Writing Ink.

Fill a test tube 1-3 full of water and add ½ measure of Tannic Acid (No. 15). Put an equal amount of water in another test tube and add ½ measure of Ferric (Iron) Ammonium Sulphate (No. 21). Shake both test tubes to dissolve the solids and then pour the contents of the first tube into the second.

A deep black color will appear, due to very finely divided tannate of iron which was formed when the liquids were mixed.

The manufacture of most of our ordinary writing inks is based on this reaction, though many of them contain in addition a certain amount of some aniline dye. Gum is also generally added to thicken the ink slightly and prevent the suspended iron tannate from settling out.

These iron gall inks, as they are called, have the advantage of being permanent, that is, they withstand the action of air and light for many years, and they are very cheap to manufacture. They are, however, very easily erased by the use of certain chemicals and steel pens are more or less corroded by them.

Experiment 71—The Manufacture of Blue Ink.

Dissolve 2 measures of Sodium Ferrocyanide (No. 6) in a test tube ¼ full of water. In another test tube ¼ full of water dissolve 1 measure of Ferric Ammonium Sulphate (No. 21). Pour the second solution into the first. A deep blue liquid will result, due to the formation of Prussian Blue. This is much used as a blue ink. Try writing with it. Prussian Blue is also widely used as a substitute for indigo in laundry blueing.

Experiment 72—The Manufacture of Violet Ink.

Put 2 measures of Logwood (No. 29) in a test tube and fill ¼ full of water. Boil for 3 or 4 minutes to extract the color and then add ½ measure of Aluminum Sulphate (No. 12) to the hot solution. When the aluminum sulphate has dissolved write with the solution, using a clean pen.

Experiment 73—The Manufacture of Red Ink.

Put 2 measures of Logwood (No. 29) in a test tube and fill the tube ¼ full of water. Boil for 3 or 4 minutes to extract the color. Then add ½ measure of Aluminum Sulphate (No. 12) and ½ measure of Sodium Bisulphate (No. 7). When these solids have completely dissolved try writing with the ink, using a clean pen.

THE PAINT INDUSTRY

Ordinary paints consist of colors or pigments ground up with a "drying oil." By drying oil is meant one which when spread out in a thin layer dries to a solid sheet or film, due to oxidation. Linseed oil is generally used. The pigments used are usually compounds of lead, iron, chromium and zinc.

Experiment 74—The Manufacture of Iron Pigments.

In a test tube 1-3 full of water dissolve 1 measure of Ferric Ammonium Sulphate (No. 21). In another test tube 1-3 full of water dissolve 4 measures of Sodium Carbonate (No. 4). Pour the first solution into the second. The red brown precipitate which is formed is ferric carbonate and hydroxide. This is very similar to the iron compounds used as pigments.

Experiment 75—The Manufacture of Lakes.

Put 1 measure of Logwood (No. 29) in a test tube, fill half full of water and boil for three minutes to extract the color. Add 1 measure of Aluminum Sulphate (No. 12) to the colored solution. In another test tube make a solution of 1 measure of Sodium Carbonate (No. 4) in ¼ test tube of water. Add this to the solution of logwood and aluminum sulphate. A deep purple precipitate will form and gradually settle to the bottom of the tube. This belongs to the class of pigments known as lakes. They are very extensively used in painting.

After the pigments have settled from the solutions in which they were precipitated the clear liquid may be poured off and the pigments dried on a sheet of paper if it is desired to save them.

Experiment 76—Manufacture of Zinc White.

Zinc oxide is largely used as a white pigment under the name of "zinc white." This pigment may be prepared by heating one measure of Powdered Zinc (No. 11) in a spoon over a gas or alcohol lamp flame until it catches fire.

THE SOAP INDUSTRY

Fats such as lard, butter, and tallow, and also vegetable oils such as olive oil, cotton-seed oil, and linseed oil, are compounds of glycerine with what are known as "fatty acids." If fats and oils are treated with an alkali the glycerine is set free and a compound of the alkali and the fatty acid is formed which is soap. Fine soaps are made from olive oil, cocoanut oil, etc., ordinary white soaps are made largely from cotton-seed oil, while in making cheap laundry soaps, kitchen grease recovered from garbage, and other impure fats, are used.

Experiment 77—The Manufacture of Soap.

Put 2 measures of Sodium Carbonate (No. 4) and 3 measures of Calcium Oxide (No. 20) into a test tube. Fill 1-3 full of water and boil for two or three minutes.

Allow it to settle and pour off the clear liquid into another test tube. Add a lump of lard or butter about the size of a pea, and boil the liquid again for a few minutes.

The fat will first melt, then dissolve in the liquid, forming a soap. Pour out a few drops on your hand and rub it; note the soapy feel.

The soap can be precipitated from the liquid by adding 2 measures of common table salt and shaking for a few minutes. Let stand and the soap will form a layer at the top. The liquid underneath contains dissolved in it the glycerine which was in the fat.

Experiment 78—Testing for Free Alkali in Soap.

With a clean knife cut a fresh surface on a piece of dry soap and allow a drop of Phenolphthalein Solution (No. 22) to fall on the exposed surface. If a red color appears where the drop of Phenolphthalein is in contact with the soap, the soap contains free alkali.

Try this experiment with laundry and toilet soap. Laundry soap usually contains free alkali. Toilet soap should contain little or no free alkali as it roughens and chaps the skin. This is a very delicate test.

THE DYEING INDUSTRY

Textile fibres may be divided into two classes. Vegetable fibres such as cotton and linen consists chiefly of cellulose and are readily attacked by acids. Animal fibres such as wool consist largely of compounds containing nitrogen. These withstand the action of acids but are readily destroyed by alkalies.

In the process of dyeing the coloring matter is dissolved in water (other solvents are not frequently used), and the material to be dyed is passed through the solution.

Many dyes unite directly with the fibre of the cloth, forming in some cases colors which are insoluble and will withstand washing, in other cases the colors formed in this manner are not entirely "fast" and will "run" or "bleed" to some extent when the cloth is washed.

There are also a great variety of coloring matters which are dyed on fabrics by the aid of metallic mordants. A mordant is a metallic salt which will combine both with the fibre of the cloth and with the dye-stuff. Salts of aluminum, iron, and tin are generally used. The cloth to be dyed is first passed through a solution of the mordant which unites chemically with the fibre, then through the dye solution, the dye in turn uniting with the mordant and forming a "fast" color.

The same dye-stuff frequently gives different shades of color when used with various mordants.

Experiment 79—Dyeing Fabrics Light Blue.

Prepare a solution of 4 measures of Sodium Ferrocyanide (No. 6) in a test tube half full of water. Cut a small piece of absorbent cloth about 1 inch or ½ inch square and place it in the bottom of a clean tumbler. Now pour the solution of sodium ferrocyanide into the tumbler and saturate the cloth thoroughly with the solution. Remove the cloth and while it is drying, prepare the following solution: 2 measures of Ferrous Ammonium Sulphate (No. 17) in a test tube half full of water. When the cloth has dried place it in the bottom of a clean tumbler and pour this solution over it. Stir it around well so that the solution wets every part of it. Now remove the cloth from this solution and you will find that it is dyed a light blue color due to the precipitate which was formed in the fabric.

Experiment 80—Dyeing Fabrics Dark Blue.

Prepare a solution of 4 measures of Sodium Ferrocyanide (No. 6) in a test tube half full of water. Place a small square of cloth in a tumbler and moisten it with this solution as in the perceding experiment. After the cloth is dried moisten it again with a solution of 2 measures of Ferric Ammonium Sulphate (No. 21) in a test tube half full of water. This time the cloth will be dyed dark blue, due to the formation of soluble Prussian blue in the fabric.

Experiment 81—Dyeing Fabrics Red.

Dissolve 2 measures of Sodium Sulphocyanate (No. 26) in a test tube half full of water and moisten a small square of cloth with the solution as in Experiment 79. Now prepare a solution of 2 measures of Ferric Ammonium Sulphate (No. 21) in a test tube half full of water, and when the cloth is dry moisten it with this solution. In this case the cloth will be dyed red.

Experiment 82—Dyeing Fabrics Black.

Prepare a solution of 2 measures of Tannic Acid (No. 15) in a test tube half full of water and moisten a small square of cloth with the solution as in the preceding experiment. When the cloth becomes thoroughly dried moisten it again with a solution of 2 measures of Ferric Ammonium Sulphate (No. 21) in a test tube half full of water. This time the cloth will be dyed black.

Experiment 83—Dyeing Fabrics Brown.

Prepare a solution of 2 measures of Sodium Carbonate (No. 4) in a test tube half full of water and moisten a small square of cloth with the solution as in the preceding experiment.

When the cloth becomes thoroughly dry moisten it again with a solution of 2 measures of Ferric Ammonium Sulphate (No. 21) in a test tube half full of water. The cloth will be dyed brown.

Experiment 84—Dyeing with a Mordant.

Put 4 measures of Logwood (No. 29) in a glass and pour in one test tube full of hot water. Let the solution stand for half an hour to extract the color.

Cut a small slip of white cloth about 2 inches square and wet one corner of it with a solution of 2 measures of Aluminum Sulphate (No. 12) in half a test tube of water. Put this where it will dry.

After the logwood solution has stood for half an hour add 3 measures of Sodium Carbonate (No. 4) to it and stir well. Now put the piece of cloth, which must be dry, into this solution and let it soak for about 10 minutes.

When the cloth has been taken out and dried you will see that it has been dyed two colors, the part which was treated with a solution of aluminum sulphate being darker than the rest of the cloth.

Formerly most of our dye-stuffs were imported from Germany, and on the outbreak of the European war this source of supply was cut off and for a time there was a great scarcity of dyes in this country. At the present time, however, the United States has a large and flourishing dye manufacturing industry. Before the development of the artificial dye industry coloring matters were used.

Experiment 85—Some Naturally Occurring American Dye-Stuffs.

Place a few chips of the bark of the horse-chestnut or buckeye tree in a test tube filled with water to which a small quantity of household ammonia has been added. In a few minutes streamers of blue fluorescent dye will descend from the chips of bark.

The wood of the Osage Orange tree contains a valuable yellow dye. If you can obtain a few chips of this wood boil them with a little water to extract the color.

Logwood is taken from the heart of a tropical tree which grows in Central America. The wood is cut into chips and the coloring matter which it contains is extracted with water as in the preceding experiment. This coloring matter forms many different colored dyes when treated with the proper chemicals. It is used frequently in dyeing cloth.

Experiment 86—The Effect of Acids and Alkalies on Logwood.

Put 2 measures of Logwood (No. 29) in a test tube and fill the tube ¾ full of water. Boil for a few minutes to extract the color. In another test tube ¼ full of water dissolve 1 measure of Sodium Bisulphate (No. 7).

Pour the red logwood solution into the sodium bisulphate solution and a very pretty yellow color results.

Now add 2 measures of Sodium Carbonate (No. 4). The solution boils violently and gradually changes to a dark purple color.

Experiment 87—Logwood Black.

Boil 2 measures of Logwood (No. 29) in a test tube ¾ full of water as in the preceding experiment. In another test tube ¼ full of water dissolve 1 measure of Ferric Ammonium Sulphate (No. 21).

Pour the logwood solution into the ferric ammonium sulphate solution and a very intense black color results.

Experiment 88—Dark Red Logwood Color.

Boil 2 measures of Logwood (No. 29) in a test tube ¾ full of water as before. Prepare a solution of 1 measure of Cobalt Chloride (No. 27) in a test tube ¼ full of water and pour the red logwood solution into this. This time a very pretty dark red color is formed.

ORGANIC CHEMISTRY

General chemistry was at first divided into two parts, inorganic and organic. Those compounds belonging to the mineral kingdom were classed as inorganic substances while those found in plant and animal matter were considered under the head of organic chemistry.

Every animal and vegetable substance contains carbon in combination with hydrogen and also in most cases oxygen and nitrogen. It was at one time supposed that the artificial production of these substances was impossible, and that their preparation required the intervention of life. In 1828, however, Woehler, a German chemist, succeeded in preparing one of these compounds artificially. Since that time a great many organic compounds have been prepared in laboratories by artificial means, and thousands of other organic substances unknown to animal or vegetable life, including many valuable drugs and dyes, have been added to the catalogue of chemical compounds.

The term organic chemistry is now understood to mean "The Chemistry of the Compounds of Carbon." Several hundred thousand of these compounds are now known to the chemist.

A series of organic coloring materials may be prepared by heating certain organic substances with sulphur in the presence of an alkali. These colors are chiefly used in dyeing cotton fabrics.

Experiment 89—The Manufacture of Sulphur Colors.

In a dry test tube put 1 measure of Tannic Acid (No. 15), 1 measure of Sodium Carbonate (No. 4) and 1 measure of Sulphur (No. 1). Shake the tube gently to thoroughly mix the powder and then heat over a flame for three or four minutes or until sulphur vapor is no longer given off. Set the tube aside to cool.

When the tube is cool, fill it three-quarters full of water, close the mouth with your thumb and shake well. Pour the dark solution obtained into a glass, add fresh water to the tube and shake again to dissolve any remaining dye. Dilute the dye solution with clear water and notice the intense coloring power.

A great many organic compounds are composed of hydrogen, oxygen and carbon. Some of these compounds may be broken up on heating, into water and carbon.

Experiment 90—The Decomposition of Sugar.

Place 3 or 4 measures of ordinary granulated sugar in a spoon and heat over a flame for a few minutes. The sugar first melts and then turns brown, caramel. Water is given off in the form of steam and finally there remains only a black porous mass which consists almost entirely of carbon. Notice that this black residue has none of the properties of sugar. Sugar is a compound of hydrogen, oxygen and carbon. When heated the hydrogen and oxygen are driven off in the form of water and the carbon remains.

Test the vapor which is driven off with moisture test papers to prove that it is water (see Experiment 23).

Experiment 91—The Perparation of Casein.

Obtain a small quantity of skimmed milk and dilute it with from 3 to 4 parts of water. Now dissolve 4 measures of Sodium Bisulphate (No. 7) in a test tube half full of water and add this solution to some of the skimmed milk contained in another test tube. Shake the milk every time a little of the sodium bisulphate solution is added.

You will notice that a precipitate is formed in the milk and upon allowing it to stand for awhile the precipitate becomes heavier. It consists principally of casein. When milk sours, lactic acid is formed; this precipitates the casein and the milk is then "curdled." Casein is the principal ingredient of cheese.

Experiment 92—The Chemistry of Tanning.

Dissolve a few drops of the white of an egg in half a test tube of cold water. In another test tube dissolve 1 measure of Tannic Acid (No. 15) in half a test tube of water.

Add the solution of tannic acid, a few drops at a time, to the solution of the white of egg and notice the precipitate which is formed.

Skins of animals contain a large amount of albuminous substance, and when they are exposed to a solution containing tannic acid, this substance is changed to a tough, pliable mass. If hides and skins were not tanned they could not be used for the purposes for which leather is used.

THE CHEMISTRY OF FOODS

Foods consist chiefly of compounds or mixtures of compounds containing the elements carbon, hydrogen, oxygen and nitrogen. There are three principal classes of foods, carbohydrates, fats and proteids. Carbohydrates include sugars and starches and are found chiefly in vegetable foods, while fats and proteids are found mainly in animal foods.

Starch in foods may be recognized by the chemical test with iodine.

Experiment 93—A Test for Starch.

Put ½ measure of Ferric Ammonium Sulphate (No. 21) and ½ measure of Sodium Bisulphate (No. 7) in a test tube and fill the tube three-quarters full of water; shake well. Add to this solution about 10 drops of Sodium Iodide Solution (No. 23) and shake the tube well. Ferric ammonium sulphate in the presence of an acid liberates iodine from sodium iodide so you now have a solution containing free iodine. Free iodine gives a blue color with starch.

This starch test solution, directions for making which have just been given, should be put in a small bottle and saved for use in following experiments.

Now take a bit of potato or bread about the size of a pea, boil in a test tube about one-third full of water for a minute or two and let cool. The solution must be perfectly cold, otherwise the test for starch will not work. Now add 2 or 3 drops of the starch test solution. A blue color will be formed, showing the presence of starch.

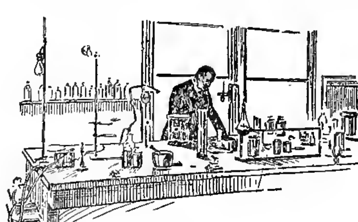
Instead of potato or bread a few grains of rice or a little starch may be used in this experiment.

Proteids are distinguished by containing nitrogen, and by chemical treatment this element can be driven off in the form of ammonia.

Experiment 94—Testing for Proteids.

Place in a test tube a small bit of lean meat or some white of an egg, together with 2 measures of Calcium Oxide (No. 20) and two or three drops of water. Heat gently and test for ammonia by placing in the upper part of the test tube a piece of moistened red litmus paper (see Experiment 42).

Adulteration of foods was at one time very general and is still sometimes met with, although the pure food laws have largely done away with the more harmful forms. The National Government and the various health boards maintain chemical laboratories in most of the larger cities for the purpose



of testing foods, and the following experiments are given as examples of the methods used in this work.

Experiment 95—Testing Baking Powder.

Baking powder consists of sodium bicarbonate mixed with either cream of tartar, alum, or calcium acid phosphate. Starch is frequently added as a harmless though inert filler.

Put 2 measures of any baking powder in a test tube, fill half full of water and when the liquid has stopped foaming, heat it to boiling. A clear solution shows a pure cream of tatar baking powder. Let cool and test for starch by adding a little of the starch test solution as in Experiment 93.

Experiment 96—Testing Flour.

Flour is practically never adulterated in this country, but it is sometimes artificially bleached by a chemical process. Artificially bleached flour may be detected as follows:

Place 2 heaping teaspoonfuls of flour in a glass, fill half full of gasoline (not included in outfit), stir for several minutes and allow to settle. If the flour is unbleached the gasoline will be distinctly yellow. while if bleached it will remain nearly colorless.

Experiment 97—Testing Butter.

Oleomargarine is an artificial butter made from cotton seed oil and other materials. It is not necessarily inferior to real butter. Renovated or process butter is prepared from rancid or spoiled butter by a chemical process.

Place a small lump of butter in the spoon and heat over the candle flame. If it is fresh butter, it will boil over, producing a large amount of foam. If it is either oleomargarine or process butter it will sputter and crack like a green stick in a fire.

Fill a tumbler ¼ full of sweet milk, set it in a pan of water and heat to boiling. When thoroughly heated add a teaspoonful of the butter to be tested and stir until it is melted. Now remove the tumbler, set it in a pan of cold water (preferably ice water) and continue stirring until the butter solidifies. If the sample is either fresh butter or renovated butter it will be solidified in a granular condition and distributed through the milk in small particles. If it is oleomargarine it solidifies in one cake and may be lifted from the milk with the stirring rod or spoon.

Experiment 98—Testing Canned Goods for Copper.

This test may he tried on articles such as canned peas, beans, spinach, pickles, etc. Mash a small portion of the sample with a spoon and place a spoonful of the pulp in a teacup with 3 spoonfuls of water and 2 measures of Sodium Bisulphate (No. 7).

Heat the cup in a saucepan containing boiling water and place the saucepan on the stove. Now drop a bright wire nail into the cup and keep the water in the pan boiling for 20 minutes, stirring the contents of the cup frequently with a splinter of wood. Examine the nail and if it appears reddish in color due to a plating of copper having been formed on it the sample which you tested was colored with copper compounds, probably copper sulphate.

Experiment 99—The Manufacture of Baking Powder.

Mix together thoroughly five measures of Tartaric Acid (No. 14) and 4 measures of Sodium Bicarbonate (No. 25). Place this mixture in a test tube and fill the tube half full of water; notice that an action takes place and that a gas is given off. This gas is carbon dioxide.

When baking powder is mixed with dough and moistened, carbon dioxide is set free and causes the dough to become porous or light. In addition to carbon dioxide other products are formed when baking powder is moistened, depending on the materials used in the baking powder. In the case of calcium monophosphate and baking soda the other products are calcium phosphate and sodium phosphate, both of which materials remain in the food. They are, however, quite harmless. Other acid substances besides calcium monophosphate are frequently mixed with baking soda in the manufacture of baking powder. Those most commonly used are tartaric acid, potassium acid tartrate and alum. An inert substance such as flour or starch is also sometimes added to baking powder. This substance is added to prevent the reaction from taking place too soon in case the baking powder is exposed to moist air.

Experiment 100—A Test for Acid Mouth.

Cut a small piece of Blue Litmus Paper (No. 18) and place it in your mouth for a moment. If when you remove the paper it is turned red, you have "acid mouth."

Decayed teeth or an up-set stomach are generally the cause of "acid mouth." Perhaps you have seen advertisements of tooth paste which offers test paper for "acid mouth." These test papers are blue litmus paper.

TESTING SOILS

The chemical constituents of soil vary greatly in different localities, depending on the composition of the rock from which the soil was derived.

All soils contain silicon and aluminum, but in addition to these the elements, nitrogen, phosphorus and potassium are essential to plant growth. Most soils contain an abundant supply of these elements, but they are frequently combined in such a way as not to be readily absorbed by the plants. These conditions are especially apt to exist in an acid or sour soil. By treating such soil with an alkali, such as lime (calcium oxide or calcium hydroxide) the acidity is neutralized and a portion of the unavailable elements necessary to the growth of plants are converted into readily available forms.

Experiment 101—A Test for Acid Soil.

Obtain a sample of soil and mix with it sufficient clear water to make a thin mortar or paste. Imbed a strip of Blue Litmus Paper (No. 18) in the mixture and allow it to remain for half an hour. Withdraw carefully and rinse in clear water. If the paper has turned pink the soil is acid.

This test may also be carried out by making a mud ball, pressing a piece of blue litmus paper against it, and allowing it to stand half an hour.

Sorrel and moss thrive in acid soils. Clover, alfalfa, peas and beans will not grow, and wheat, corn and most crops do poorly in acid soil.

PART II
CHEMICAL MAGIC

This section contains many new experiments which are especially adapted for exhibition as magic. Certain experiments given in Part I which are of particularly spectacular or mystifying nature, are referred to from time to time.

MAGIC INKS AND PAPERS

In addition to the new experiments listed under this head, Experiment 9 Fire Ink, and Experiment 24 Sympathetic Ink, are especially appropriate.

Prepare some drawings or writings beforehand, following directions given in Experiment 9. Tell your audience that you have trained fire to be your servant, and that it will burn out a design or word as you direct.

There are great possibilities in Experiment 24 for making Chemical Magic. You can draw pictures with the ink prepared in this experiment and it will be perfectly invisible, but when you hold the blank paper near a stove or over a lamp the drawing or writing suddenly appears. The effect is startling. This ink and also a number of those described in the following experiments are frequently used by spies in transmitting secret dispatches. We have many instances during the past years where important military secrets have been

written with some of these inks and have been sent to an enemy's country.

Experiment 102—Magic Writing.

Make up three solutions as follows:

First, 1 measure of Sodium Ferrocyanide (No. 6) in a test tube half full of water.

Second, 1 measure of Sodium Sulphocyanate (No. 26) in half a test tube of water.

Third, 1 measure of Tannic Acid (No. 15) in half a test tube of water.

Using a soft brush, coat a piece of white writing paper with solution number 1, a second piece with solution number 2, and a third piece with solution number 3. Be sure to clean your brush well each time you use it for a fresh solution.

Set the three pieces of treated paper aside to dry and prepare a solution of 2 measures of Ferric Ammonium Sulphate (No. 21) in half a test tube of water.

Now when the sheets of paper are thoroughly dry, write on each one with the solution of ferric ammonium sulphate, using a clean pen. The same liquid writes a different color on each sheet of paper.

An interesting variation to this experiment can be worked by painting the three solutions first prepared, in streaks on the same piece of paper. Now when lines are made on the paper with ferric ammonium sulphate solution they will change color every time they are drawn over a new streak.

Experiment 103—Magic Inks.

Set 3 glasses in a row and number them 1, 2 and 3. Put 4 teaspoonfuls of water in each glass.

In the first glass dissolve 1 measure of Tannic Acid (No. 15).

In the second glass dissolve 1 measure of Ferric Ammoinum Sulphate (No. 21).

In the third glass dissolve 1 measure of Sodium Ferrocyanide (No. 6).

Number three pieces of writing paper, 1, 2 and 3. Using a clean pen, write on each piece of paper with the solution in the glass of the same number, thus paper number 1, would be written on with the solution in glass number 1. Be sure to wipe your pen carefully each time you use it for a fresh solution.

When the writing on the papers has dried wet paper number 1 with solution number 2, using a small soft brush or sponge to apply the solution (be sure to wash the brush or sponge thoroughly when changing it from one solution to another). Wet part of paper number 2 with solution number 1, and part of it with solution number 3, wet paper number 3 with solution number 2.

The many colors in which the writing appears makes this a very mystifying experiment to show to your friends.

Experiment 104—Magic Writing Paper.

Lay a sheet of ordinary writing paper on a smooth flat surface, put ½ measure of Tannic Acid (No. 15) and ½ measure of Ferric Ammonium Sulphate (No. 21) on it and mix them together. Now rub this mixture all over the sheet using a small piece of paper to rub with. Your hands and also the paper must be perfectly dry, as the slightest trace of moisture will cause black smudges. When the mixture has been rubbed all over the paper shake off the remaining powder and write on the prepared surface with water. The written characters will be black just as if you had used ink.

Prepare another sheet of paper in the same way, using ½ measure of Sodium Ferrocyanide (No. 6) and ½ measure of Ferric Ammonium Sulphate (No. 21). Characters written with water on this sheet are blue.

Some people will not believe that you can write with plain water, but just fix up some sheets of paper in this way and let them try it.

MAGIC CHANGES

Under this section Experiment 12, Bleaching with Sulphur Dioxide (Changing Colored Flowers White) may be used to good advantage. This is a very mysterious trick to those who do not understand the chemistry of it. The colored flowers upon being hung in the glass are changed to white before the eyes of your audience.

Experiment 105—Changing Red, White and Blue to Blue.

Arrange three glasses in a row. In the first put ½ measure of Sodium Ferrocyanide (No. 6), 3 or 4 drops of Phenolphthalein Solution (No. 22) and ½ measure of Calcium Oxide (No. 20). In the second put ½ measure of Sodium Ferrocyanide (No. 6), 3 measures of Aluminum Sulphate (No. 12) and 3 measures of Strontium Nitrate (No. 10). In the third put ½ measure of Sodium Ferrocyanide (No. 6) and ½ measure of Ferrous Ammonium Sulphate (No. 17). Fill each of the glasses two-thirds full of water and stir each one. The first glass will contain a red, the second white, and the third a blue liquid.

In the fourth glass put 2 measures of Ferric Ammonium Sulphate (No. 21) and 2 measures of Tartaric Acid (No. 14). Fill the glass full of water and stir for a minute.

Now pour the liquid in the fourth glass into the other three glasses, filling each one. Instead of red, white and blue liquids, three blue solutions remain.

Experiment 106—Changing Water to Wine and Wine to Water.

(a)—Pouring Water and Wine out of the same Pitcher.

Pour a glass of water into a pitcher or similar container and add 2 or 3 drops of Phenolphthalein Solution (No. 22).

In one glass put 1-3 measure of Sodium Carbonate (No. 4) and in another 1 measure of Tartaric Acid (No. 14). If you wish, a few drops of water may be added, thus dissolving the solid so that to anyone watching the experiment the glasses will appear to be only a little wet inside.

Now pour from your pitcher into the first glass and a rich red liquid will result. Fill the glass about half full. Pour into the second glass and it remains plain water. If you wish you may then pour the contents of the second glass into the first and the red color will disappear.

(b) Changing Water to Wine and Wine to Water.

Fill two tumblers half full of water and add to each 1 or 2 drops of Phenolphthalein Solution (No. 22). To the first one add also 1-3 measure of Sodium Carbonate (No. 4).

Now one glass contains a red liquid (wine) and the second glass apparently plain water. To the first or red liquid add 1 measure of Tartaric Acid (No. 14) or a little vinegar, and to the second or colorless liquid add 1-3 measure of Sodium Carbonate (No. 4). Now the colors have become reversed, the red liquid being in the second glass and the colorless liquid in the first.

To change them back again add to the first glass 3 measures of Sodium Carbonate (No. 4) and to the second 2 measures of Tartaric Acid (No. 14) or some vinegar.

Experiment 107—Changing Water to Milk.

Fill 2 glasses each half full of water and dissolve in one 2 measures of Manganese Sulphate (No.24). In another dissolve 2 measures of Sodium Carbonate (No. 4).

Now pour the contents of one glass into the other and a thick white precipitate will be formed, making it seem as though the glasses were full of milk.

Experiment 108—Changing Water to Blood and Blood to Stone.

Put one inch of Water Glass (No. 19) in a test tube and add water until the tube is 1-3 full. In another test tube put 2 or 3 drops of Phenolphthalein Solution (No. 22) and fill 1-3 full of water. In another test tube 1-3 full of water put 5 measures of Aluminum Sulphate (No. 12) and shake until dissolved.

Now hold the tubes in your hand and pour their contents all at once into a clean glass. The three colorless liquids coming together immediately form a red blood-like liquid, which in a few minutes will turn into a red, solid mass.

MAGIC COLORS

The experiments listed under this head are very pretty as well as mystifying, and lend themselves especially well to exhibition.

Experiment 109—Pouring Many Colors from the Same Vessel.

Arrange nine dry, clean glasses in a row. In the first glass put 1 measure of Ferric Ammonium Sulphate (No. 21) and 1 measure of Tannic Acid (No. 15).

In the second put 3 measures of Strontium Nitrate (No. 10) and 3 measures of Sodium Carbonate (No. 4).

In the third put 1 measure of Sodium Sulphocyanate (No. 26) and 1 measure of Ferric Ammonium Sulphate (No. 21).

In the fourth put 3 measures of Cobalt Chloride (No. 27) and 2 measures of Sodium Carbonate (No. 4).

In the fifth put 1 measure of Calcium Oxide (No. 20) and 1 or 2 drops of Phenolphthalein Solution (No. 22).

In the sixth put 3 measures of Sodium Ferrocyanide (No. 6) and 3 measures of Nickel Ammonium Sulphate (No. 13).

In the seventh put 1 measure of Ferric Ammonium Sulphate (No. 21) and 4 measures of Sodium Carbonate (No. 4).

In the eighth put 1-3 measure of Sodium Ferrocyanide (No. 6) and 1-3 measure of Ferric Ammonium Sulphate (No. 21).

In the ninth put 2 measures of Cobalt Chloride (No. 27) and 1 measure of Sodium Ferrocyanide (No. 6).

Now get a large pitcher of water and fill the glasses, stirring each one slightly after you have filled them all. The water will turn a different color as it goes into each glass. The effect is startling as well as beautiful.

Experiment 110—Pouring Ink and Milk from the Same Vessel.

In one glass place 1 measure of Tannic Acid (No. 15) and in a second glass place 2 measures of Strontium Nitrate (No. 10). Add about a teaspoonful of water to each glass and stir until the chemicals are dissolved.

Now in a small pitcher or other vessel dissolve 5 measures of Ferric Ammonium Sulphate (No. 21) in about a glass of water.

When ready to exhibit pour half of this liquid into each of the first two glasses. The liquid in the first one will become intensely black like ink, and that in the second will become milky white.

Experiment 111—Pouring Red, White and Blue from the Same Vessel—Patriotic Colors.

Fill 3 glasses 2-3 full of water. In the firs[illegible]e 1 measure of Sodium Sulphocyanate (No. 26). In the s[illegible]ssolve 3 measures of Strontium Nitrate (No. 10) and i[illegible]d dissolve ½ measure of Sodium Ferrocyanide (No. 6). [illegible]

In another glass 1-3 full of water dissolve 5 measures of Ferric Ammonium Sulphate (No. 21). Pour some of this solution into each of the other 3 glasses and stir.

The liquid in the first glass will turn red, in the second white, and in the third blue.

Experiment 112—Pouring Wine and Water Into the Same Glass.

Put 3 measures of Sodium Bisulphate (No. 7) in a glass full of water and add 2 or 3 drops of Phenolphthalien Solution (No. 22). In another glass put 1 measure of Sodium Carbonate (No. 4) and add just enough water to dissolve the solid.

Now pour from the first glass into the second. At first a red color will result, but as you add more of the solution from the first glass the red color will mysteriously disappear and apparently only water is in the glass.

Experiment 113—Pouring White and Red Into the Same Glass.

Dissolve 3 measures of Sodium Carbonate (No. 4) in a glass full of water and add 2 or 3 drops of Phenolphthalein Solution (No. 22). In another glass dissolve 2 measures of Sodium Bisulphate (No. 7) in 3 or 4 drops of water. Now pour the red solution in the first glass into the second. At first the red liquid will turn white, but as you add more it will change to red again.

CHEMICAL SORCERY

Experiment 114—Chemical Ice.

Pour ½ inch of Water Glass (No. 19) in a test tube and add 3 or 4 drops of water. Shake to mix the liquids.

In another test tube put 4 measures of Sodium Bisulphate (No. 7) and fill ¼ full of water. Shake until the solid is dissolved.

Pour the liquid in the first tube into the second. The mixture will gradually freeze into a transparent solid, becoming hard first at the surface and gradually solidifying through the entire mass. In a minute or two the test tube can be inverted as there will be no liquid to spill.

Experiment 115—Chemical Soda Water.

Put 4 measures of Nickel Ammonium Sulphate (No. 13) in a test tube ½ full of water, and boil for 2 or 3 minutes to dissolve all of the solid.

Add to the hot solution 1 measure of Sodium Carbonate (No. 4). When the action has stopped add to the solution 2 measures of Sodium Bisulphate (No. 7).

The soda water is now finished, but it will not do for drinking purposes.

Ex[illegible]hemical Plants.

Put 1 [illegible] of Water Glass (No. 19) and 4 teaspoonfuls of water in a clean glass. Stir slightly to thoroughly mix the liquids. Now take 1 measure of Aluminum Sulphate (No. 12), 1 measure of Nickel Ammonium Sulphate (No. 13), 1 measure of Ferrous Ammonium Sulphate (No. 17), 1 measure of Ferric Ammonium Sulphate (No. 21) and 1 measure of Cobalt Chloride (No. 27) and drop them all into the water glass solution.

Watch! In a few minutes trees, grass and all manner of chemical vegetation will begin to sprout and grow. In a short time the liquid will be filled with variously colored chemical plants and trees. The thickness of the jungle may be varied by the amount of salts put in. The glass should be set in a place where it will not be shaken.

Experiment 117—Chemical Snow.

Dissolve 2 measures of Strotium Nitrate (No. 10) in a test tube nearly full of water.

In a second test tube put 2 measures of Sodium Carbonate (No. 4) and add ½ inch of water. Heat until the sodium carbonate is dissolved.

Carefully pour the contents of the second test tube into the first. A thick white precipitate will form at the top of the tube and as the particles slowly settle to the bottom the effect is very much like a miniature snow storm.

Sodium carbonate and strontium nitrate react, forming sodium nitrate and strontium carbonate. The latter is not soluble in water and hence separates out of the solution in solid particles.

Experiment 118—A Chemical Clock.

Prepare in several glasses a series of solutions of Sodium Thiosulphate (No. 16) of decreasing strengths; for example, place in the first glass 10 measures of sodium thiosulphate, in the second 6 measures, in the third 3 measures, and in the fourth 1 measure. Fill each glass half full of water and stir until the solid is dissolved.

Prepare a solution of 6 measures of Sodium Bisulphate (No. 7) in a test tube of water, and add an equal portion of this to each glass. A white precipitate of sulphur will appear after a few minutes, but it will form in the different glasses in different lengths of time according to the concentration of the thiosulphate solution. A little experimenting makes it possible to cause the appearance of the precipitate within any specified time.

CHEMICAL COLORS

Colors of every shade and variety may be produced by mixing various chemicals. The following experiments give a few examples.

Experiment 119—Clots of Color.

Put a spoonful of Water Glass (No. 19) in a glass and add two spoonfuls of water. Mix well.

Fill a test tube half full of water and add 3 measures of Strontium Nitrate (No. 10). Shake well.

Now pour a few drops of the solution in the test tube into the glass containing the water glass. Beautiful white clots of precipitate will form.

Add 1 or 2 drops of Phenolphthalein Solution (No. 22) to the remaining strontium nitrate solution. Now pour a few more drops from the test tube into the glass. This time red clots of precipitate will form among the white ones.

Experiment 120—A Potpourrie of Colors.

Put ½ inch of Water Glass (No. 19) in a test tube and add water until the tube is 1-3 full.

In a second test tube make a solution of 2 measures of Cobalt

Chloride (No. 27) in ½ inch of water. Heat the solution for a minute to completely dissolve the solid.

Now pour a very few drops of the water glass solution from test tube number 1 into a third clean test tube and add an equal amount of cobalt chloride solution from test tube number 2. The two liquids together should not equal more than ½ inch in the test tube. A blue precipitate will form.

You are now through with the cobalt chloride solution contained in test tube number 2, so that tube may be cleaned and used for making up the next solution.

A few drops of a solution of a measure of Strontium Nitrate (No. 10) in ½ inch of water should now be added to the blue precipitate and an equal amount of water glass from the solution in test tube number 1. This will form a white color on top of the blue.

To make a green color dissolve 1 measure of Nickel Ammonium Sulphate (No. 13) in ½ inch of water. This solution must be boiled for a few minutes to dissolve the solid. Add a few drops to the color test tube and a few drops of the water glass solution as before.

To add a brown color make a solution of 1 measure of Ferric Ammonium Sulphate (No. 21) in ½ inch of water. Heat the solution and add a few drops to the color test tube and a few drops of water glass solution.

To add a red color dissolve 1 measure of Strontium Nitrate (No. 10) in ½ inch of water and add 1 or 2 drops of Phenolphthalein Solution (No. 22). Add a few drops of this and some water glass solution.

Your test tube should now be full of a mixture of colors. Blue—white—green—brown and red. This is not an easy experiment to do, but it is very pretty and by following the directions closely and working carefully good results can be obtained.

Experiment 121—Green Alcohol.

Dissolve 2 measures of Boric Acid (No. 2) in a test tube 1-3 full of alcohol. Pour a few drops on a large spoon and light it. You will find the flame will be bright green in color.

Any alcohol lamp or stove can be made to burn with a green flame by adding boric acid to the alcohol used in the proportion of six measures of boric acid to each test tube full of alcohol.

Experiment 122—A Color Chase.

Arrange 5 dry glasses in a row. Put in the first ½ measure of Ferric Ammonium Sulphate (No. 21), in the second ½ measure of Sodium Sulphocyanate (No. 26), in the third ½ measure of Sodium Ferrocyanide (No. 6), in the fourth a spoonful of Water Glass (No. 19), and in the fifth 2 or 3 drops of Phenolphthalein Solution (No. 22).

Fill the first glass with water and stir to dissolve the solid. Now pour the contents of the first glass into the second, the second into the third, etc. Stir well each time a change is made to bring out the color.

Experiment 123—Changeable Colors.

Fill two glasses each half full of water. In the first glass put 2 or 3 drops of Phenolphthalein Solution (No. 22). In the second 1-3 measure of Ferric Ammonium Sulphate (No. 21), and 1-3 measure of Sodium Ferrocyanide (No. 6); stir the contents of each glass slightly.

In the third glass put a spoonful of Water Glass (No. 19) and 2 spoonfuls of water; stir slightly to mix.

Now take the first glass containing the colorless liquid in one hand and the second glass containing the blue liquid in the other hand; pour them both at once into the water glass solution. A glass full of bright red liquid will result.

Experiment 124—A Fugitive Color.

Mix a small amount of starch about the size of a pea (or 1 measure of powdered starch), with a few drops of water, pour the mixture into a test tube half full of hot water, and boil for a minute. If the solution obtained becomes stiff on cooling add water until it is fairly fluid.

When the solution is perfectly cold add to it a few drops of the starch test solution prepared in Experiment 93. A deep blue color will be obtained. Now heat this blue solution to boiling and the color will entirely disappear, leaving a clear solution. On cooling the blue color will again appear. The change may be repeated as often as desired.

Experiment 125—A Magic Pitcher of Ink.

This experiment and the two following are especially good to entertain your friends.

Obtain a good sized pitcher; a glass pitcher will not do for this experiment, as you need one which is not transparent. Place the pitcher on a tray or a table, fill it with water and arrange five clean glasses around it. In one glass place 5 measures of Tannic Acid (No. 15). In another 4 measures of Ferric Ammonium Sulphate (No. 21) and in the third 10 measures of Sodium Bisulphate (No. 7). The remaining glasses are used only to make the experiment seem more complicated to the audience, and need not be used unless you wish. Add a few drops of water to each glass to dissolve the chemicals. Be sure to remember which glass contains the sodium bisulphate.

Now you can show the pitcher to the audience and let them see that it contains only water. Fill each of the glasses with water from the pitcher and then pour the contents of each glass back into the pitcher except the sodium bisulphate solution. Now you can do some magic talk, etc., over the pitcher, and then pour the contents into the empty glasses. The liquid will be black.

Now empty all of the glasses into the pitcher again, this time including the sodium bisulphate solution, then after you have cast your magic spell over the pitcher, pour the contents into the glasses again and it will be clear water once more.

MISCELLANEOUS

Experiment 126—Chameleon Paper.

Hold the Chameleon Paper (No. 28) over a heater, near a stove or in any warm place and notice the color change which takes place. Do not hold the paper over a flame or too close to a very hot surface, as this will harm it.

Some substances undergo a change when heated and on being cooled return to their original form. In this case the change effects the color of the substance and the paper may be made to change color whenever desired, as long as it is not heated too hot.

Experiment 127—Chameleon Liquid.

Place 1 measure of Cobalt Chloride (No. 27) in a test tube and add 2 drops of water. A pink solution will be formed. Heat the tube gently over a flame and the solution will turn deep blue in color; on cooling the color again changes to pink.

This change can be repeated as often as you wish, although it may be necessary to add another drop of water occasionally

Experiment 128—Rainbow Streamers.

Fill a large glass pitcher, milk bottle or similar vessel of clear glass with water. Allow it to stand for ten minutes where it will not be shaken so that the water will become perfectly quiet.

Now drop 1 or 2 measures of Mixed Dyes (No. 30) on the surface of the water. Watch closely the beautiful action which follows.

Experiment 129—Changing Rainbow Streamers into Moss.

Dissolve 2 measures of Sodium Carbonate (No. 4) in a glass of water. Allow the glass to stand until the water becomes perfectly quiet and then add 1 or 2 measures of Mixed Dyes (No. 30). Wait until the streamers of color from the dyes have reached the bottom of the glass, then add 2 measures of Aluminum Sulphate (No. 12) without stirring. As the aluminum sulphate dissolves it forms a precipitate with the sodium carbonate. This precipitate absorbs a large amount of the color from the streamers and carries it to the surface of the water. The changing colors and the motion in this experiment make it very beautiful and interesting to watch.

Experiment 130—The Magic Handkerchief.

Prepare a solution of 2 measures of Cobalt Chloride (No. 27) in a test tube ¾ full of water. Now obtain a small handkerchief and put it in the test tube so that it soaks up the cobalt chloride solution.

Remove and dry handkerchief on a heater or over a stove, and you will find it blue when it is thoroughly dry and warm. Here's where you have some fun.

Show the handkerchief to someone while it is blue, and then crush it between your hands and blow through it for a few minutes. It will become colorless. You can repeat this as often as you wish, turning the handkerchief blue by warming it.

INSTRUCTIONS FOR OBTAINING ADDITIONAL SUPPLIES OF CHEMICALS AND APPARATUS

Additional supplies of any chemical or extra apparatus can be obtained by sending direct to The Porter Chemical Co., Hagerstown, Md.

All prices include postage paid. Refill Chemicals are packed in the same style containers as in the original outfits and the price includes new containers. In ordering refills, state the number of your outfit and the edition of your Chemcraft book.

Coins sent by mail should be very carefully wrapped and unless letter is registered, are at the sender's risk. Canadian or foreign coins or stamps will not be accepted. The best way to send money is by postal or express money order.

Please write order on a separate sheet of paper and sign your name and address, in fact, use a separate sheet for letters, questions, experiments, orders, etc. Be sure to sign your name and address on each sheet.

CHEMCRAFT

LIST OF CHEMICALS—PRICE OF REFILLS

Number	
1—Sulphur	$ .10
2—Boric Acid	.10
3—Powdered Charcoal	.10
4—Sodium Carbonate	.10
5—Sodium Bisulphite	.10
6—Sodium Ferrocyanide	.15
7—Sodium Bisulphate	.15
8—Potassium Nitrate	.15
9—Ammonium Chloride	.10
10—Strontium Nitrate	.15
11—Powdered Zinc Metal	.10
12—Aluminum Sulphate	.10
13—Nickel Ammonium Sulphate	.10
14—Tartaric Acid	.15
15—Tannic Acid	.10
16—Sodium Thiosulphate	.10
17—Ferrous Ammonium Sulphate	.10
18—Litmus Paper	.10
19—Sodium Silicate Solution (Water Glass)	.15
20—Calcium Oxide	.15
21—Ferric Ammonium Sulphate	.10
22—Phenolphthalein Solution	.15
23—Sodium Iodide Solution	.10
24—Manganese Sulphate	.10
25—Sodium Bicarbonate	.10
26—Sodium Sulphocyanate	.10
27—Cobalt Chloride	.10
28—Chameleon Paper	.10
29—Logwood	.10
30—Mixed Dyes	.10
31—Sulphide Test Paper	.10
Stirring Rod	.05
Glass Tube	.05
Gas Delivery Tube and Stopper	.10
Spoon	.10
Measure	.05
The Chemcraft Book—Outfit Number 2	.25

Test Tubes—5c each.
3 for 10c. 30c per dozen.