

GILBERT

REG. U. S. PAT. OFF.

CHEMISTRY



BY

Alfred C. Gilbert, Yale University, 1909

AND

William J. Horn, Yale University, 1915

Printed in U. S. A.

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CHEMISTRY

GENERAL INSTRUCTIONS

Chemistry Sets are not intended for children who cannot read and understand the accompanying Instruction Books.

Before performing any experiments outlined in the manual, the following instructions should be read carefully and observed.

Before performing experiments, be sure to spread a thick layer of newspapers or other protective material over the table, so that hot liquids, candle grease, etc., will not injure the table. Gilbert Laboratory Sets are equipped with a metal tray on which experiments can easily be performed without using furniture about the house.

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

Gilbert Chemistry Sets do not contain dangerous

poisons.

Never point the open end of a test tube, while heating, at yourself or anyone nearby, as it may suddenly boil over, causing burns or injuring clothing. For the same reason never smell at the open end of a test tube while heating, or put your face near it.

TO MEASURE CHEMICALS

The apparatus for measuring dry chemicals is usually a measure (Figure 1) and teaspoon or the small blade of a pocket knife.

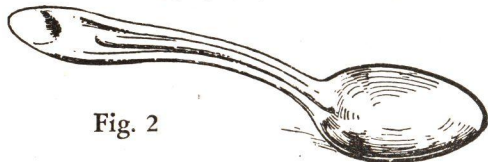
Fig. 1



One measure of a dry chemical means as much as the small flat end of the measure will hold after tapping it lightly or the amount that can be held on the end of the small blade of a pocket knife.

One teaspoonful of a dry chemical means as much as the spoon (Figure 2) will hold after tapping it lightly. The teaspoon is also used for heating solids.

Fig. 2



After using the measure and spoon always wipe them clean with a cloth or paper.

TO DISSOLVE CHEMICALS

Chemical solids can be dissolved much more quickly if stirred or shaken. When dissolving a solid in a test tube do not use the stirring rod. Close the mouth of the tube with your thumb and shake the tube back and forth. In other containers use the stirring rod.

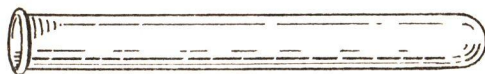


Fig. 3

Test tubes (Figure 3) are made of thin hard glass which can stand severe heating without cracking.

WARNING—Liquids may be boiled in these tubes, but care must be taken to see that the tube is never wet on the outside and that water is never poured into a hot dry test tube.

Always clean your test tubes after doing an experiment, using warm water when possible. Fill half full with warm water, close the mouth of the tube with your thumb and shake briskly.

HEATING LIQUIDS OR SOLIDS IN A TEST TUBE

Many of the experiments included in the manual can be performed with the aid of the candle. However, when a hotter flame is desired use can be made of the alcohol lamp or from a gas flame if such is available. Place the candle or lamp where it is free from draughts so that it will burn with a steady flame. When heating a test tube over a flame, hold it just over the top of the flame as shown in Figure 4 to avoid the deposit of soot or lamp black.

WARNING —

Never point the open end of a test tube, while heating, at yourself or anyone nearby, as it may suddenly boil over, causing burns or injuring clothing. For the same reason never smell at the open end of a test tube while heating, or put your face near it.

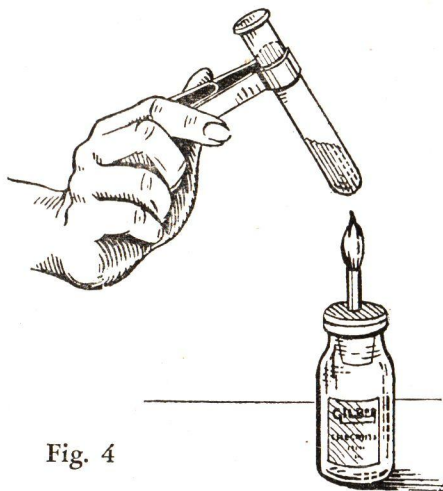


Fig. 4

STIRRING ROD

A stirring rod (Figure 5) is a very convenient piece of apparatus for mixing a solution when dissolving a solid in a liquid. It is a solid glass rod, round at both ends. Always clean the rod with water before using it in different solutions.



Fig. 5

TEST TUBES

If you have been heating a solid, let your test tube cool before washing it or adding liquid.

TEST TUBE HOLDER

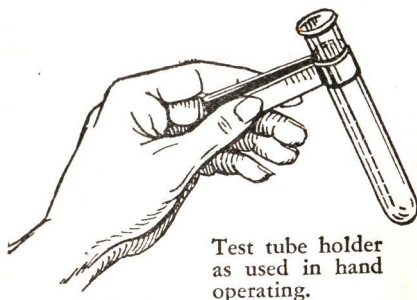
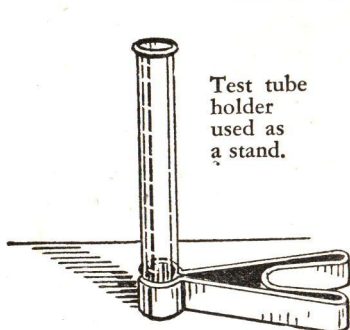


Fig. 6

Gilbert Test Tube Holder can be used for two purposes: when heating mixtures in a test tube it sometimes becomes too hot to hold with the fingers, and it is recommended to always use the test tube holder. The Gilbert Test Tube Holder can also be used as a stand. (See illustration, Figure 6.)

GAS DELIVERY TUBE



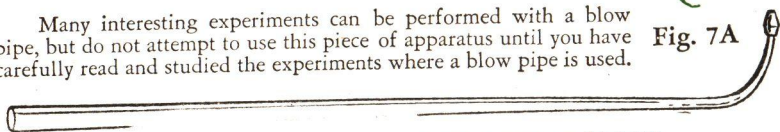
The gas delivery tube (Figure 7) is used whenever a gas is to be conducted from a test tube, in which it is formed, into another test tube or vessel.

Fig. 7

BLOW PIPE

Many interesting experiments can be performed with a blow pipe, but do not attempt to use this piece of apparatus until you have carefully read and studied the experiments where a blow pipe is used.

Fig. 7A



GENERAL NOTES ON APPARATUS

Bottles should always be kept corked tightly as many of the chemicals gradually lose their strength when exposed to the air.

Several tumblers or glasses will be found to be especially useful in the experiments where the use of tumblers or glasses is called for.

Before performing an experiment always spread several newspapers upon the table so that grease and hot liquids do not injure the surface.

Before beginning new experiments always read the instructions through first.

PART I.

INORGANIC CHEMISTRY AND ITS COMMERCIAL APPLICATIONS TO THE INDUSTRIES

ELEMENTS

By elements we mean those substances which have up to the present time resisted all attempts to decompose them. Compounds on the other hand are substances which may be decomposed or separated into other substances. Chemistry explains to us that all matter is made up of these elements of which there are between 85 and 90 known today. The number of chemical compounds that can be made from these elements is enormous compared with the number of elements themselves. When elements react with each other to form compounds they undergo a chemical change. In general there are four kinds of chemical changes and every chemical reaction would come under one of these changes.

We will illustrate by experiments three of the important types of chemical reactions of elements—first, that of Direct Union or the uniting of elements to form a compound; second, Decomposition, or the breaking up of a compound into its elements; third, Double Decomposition, or the exchange of two elements in two or more substances to form a new compound.

DIRECT UNION OF ELEMENTS

EXPERIMENT 1. Union of Zinc with Sulphur. Both Zinc and Sulphur are elements.

Mix one measure of powdered zinc with an equal amount of sulphur on a piece of paper. This is not a chemical compound for we could readily separate the sulphur from the zinc mechanically by treating the mixture with carbon bisulphide which would dissolve the sulphur and leave the zinc behind.

Place this mixture in the cover from a baking powder can and heat over the candle flame or alcohol lamp for a few minutes keeping the face a safe distance away from the cover until the reaction is apparently over. You will notice that the sulphur and zinc suddenly flash up and combine. The zinc reacts with the sulphur directly to form a compound called zinc sulphide. This substance is different than the original mixture for if we break this up into a powder and treat

the powder with carbon bisulphide we could not dissolve out the sulphur for it is now in chemical combination with the zinc.

Break up the zinc sulphide which you have just made into a powder and put some of this into a test tube. Add one measure of Sodium Bisulphate, a few drops of water and warm over a flame for a minute. Remove the test tube from the flame and smell cautiously the gas given off. This is hydrogen sulphide gas and is formed by the action of an acid upon a sulphide. This is the gas formed in eggs when they go bad.

DECOMPOSITION OR BREAKING UP OF A CHEMICAL COMPOUND

EXPERIMENT 2. Decomposition of Sodium Thiosulphate. Place three measures of Sodium Thiosulphate in a clean dry test tube and using a test tube holder so as not to burn the fingers, heat over the alcohol lamp. You will notice that moisture forms on the inside of the test tube and some steam is given off. Sodium thiosulphate contains water of crystallization which is driven off in the form of steam when the substance is heated. On further heating you will notice that sulphur is driven off and is deposited on the upper part of the test tube. Remove the tube from the flame and smell at the mouth of the test tube. You will recognize the odor of hydrogen sulphide gas. The material left in the bottom of the tube consists of sodium sulphate and sodium sulphide. The results of heating may be represented as follows:

Sodium Thiosulphate + heat = water + sulphur + hydrogen sulphide + sodium sulphate + sodium sulphide.

DOUBLE DECOMPOSITION OR THE EXCHANGE OF ELEMENTS

EXPERIMENT 3. Action of Ferric Ammonium Sulphate on Calcium Oxide. To a test tube half full of water add one-half measure of Ferric (Iron) Ammonium Sulphate. Place the thumb over the mouth of the tube and shake to dissolve the solid. Now add one half measure of Calcium Oxide and shake again. A reddish brown precipitate is formed.

The iron of the ferric ammonium sulphate changed places with the calcium of the calcium oxide to form calcium sulphate and ferric (iron) hydroxide which is insoluble in water and appears as a reddish-brown precipitate.

AIR-OXYGEN

By air we mean essentially a mixture of two elements, oxygen which comprises one-fifth of the air by volume and nitrogen four-fifths by volume. Oxygen is considered to be the most abundant of all the elements and the most

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widely scattered. Eight-ninths of the water by weight is combined oxygen. Such common materials as sandstone, limestone, brick, granite and clay contain about half their weight of oxygen.

Oxygen of the air plays a very important role in our everyday life. We breathe oxygen into our lungs and from here it is carried by the blood throughout the body to combine with waste materials. These waste materials are oxidized by the oxygen to carbon dioxide which is carried back by the blood to the lungs and is passed out into the air when we breathe out. It is very essential, therefore, that we breathe in fresh air continually in order to be in good health. Pure oxygen is an active substance and if it was not for the fact that the oxygen of the air is diluted with nitrogen, a very inactive substance, the world would soon burn up.

Oxygen is said to support combustion but will not burn itself. Fires will not burn unless fresh air is constantly supplied so that it can have oxygen. Substances cannot burn without oxygen.

Oxidation is a very important chemical process. We obtain heat to warm our homes and power to run our machinery by oxidizing wood and coal. Our houses are lighted by oxidizing gas or kerosene or with electricity that is made by machinery run by burning wood or coal. When gasoline is exploded in the engine of an automobile, the gasoline suddenly unites with the oxygen of the air which has been drawn into the cylinders. A furnace is an oxidizing machine and man and all other animals are oxidizing machines. By means of the heat obtained from the process of oxidation, metals are melted. By power obtained from the same process buildings are refrigerated and water is frozen to ice. Human life and all human activities depend upon oxidation and without oxygen our lives and our activities would cease.

EXPERIMENT 4. To Remove Oxygen from the Air.

Place a candle in the center of an ordinary wash pan by allowing a little of the melted wax to fall on the pan to stick the candle firmly. Then pour into the pan two inches of water. Light the candle and place over it a milk bottle or fruit jar. (See Figure 8.) Be sure that the bottle is high enough so that the flame does not come too close to the top of the bottle.

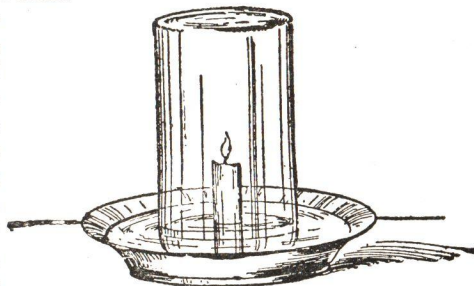


Fig. 8.

You will notice that very soon the flame grows dim and finally dies out, the oxygen of the air within the bottle having been entirely used up. Notice that the water begins to rise inside the bottle and stands at a higher level than the

BOY ENGINEERING

water in the pan. This is because the oxygen was removed forming a partial vacuum which drew the water up into the bottle. The oxygen in the bottle united with the carbon in the flame to form carbon dioxide, a gas which dissolves in water, and with hydrogen to form steam which condenses to water. The gas remaining in the bottle is nitrogen.

EXPERIMENT 5. Fire Ink or Oxidation Reaction. Place one-half spoonful of Potassium Nitrate in a test tube and add one half inch of water. Warm over the candle flame for a minute to dissolve all the material.

Now write with this liquid upon some unglazed or porous paper using a clean pen or small brush. Be sure that the strokes are heavy and all lines are connecting. After the lines are thoroughly dry apply a lighted match or better, a glowing spark to some of the writing. Blow out any flame that may result. If properly done the spark will travel along the lines where the liquid has been applied leaving the rest of the paper untouched.

This experiment is very mystifying and when performed in the dark is quite phenomenal and mysterious. The best results are obtained by using soft paper, and by making the lines heavy and connecting.

Cloth, wood, paper and other substances which burn easily may be rendered fire-proof by treating them with proper chemicals. The thing to be fire-proofed is dipped into a solution such as ammonium chloride and dried. When heated the ammonium chloride gives off vapors which smother the flame.

EXPERIMENT 6. To Fire-Proof Cloth or Paper. Take a slip of paper or linen and insert it in a solution made by dissolving one teaspoonful of Ammonium Chloride in a test tube one-third full of water. When the paper or linen is dry, try to light it with a match. You will see that it burns while held in the flame, but will go out just as soon as the flame is removed. This process of fire-proofing is quite generally used on curtains and scenery for theaters because materials treated this way cannot be set on fire by sparks or flame.

EXPERIMENT 7. To Fire-Proof Wood. Wood is also treated sometimes with a strong Ammonium Chloride solution. Another way to fire-proof wood is to paint it with water glass solution. Holding a match by the head, dip the other end in Sodium Silicate Solution. Allow the coating to dry for twenty minutes. Then light the match. The flame will go out just as soon as it reaches the portion that has been dipped.

The process of removing oxygen from a substance is called reduction and substances which remove oxygen from other substances are called reducing agents.

EXPERIMENT 8. Reduction of Ferric Sulphocyanate. Dissolve one-half measure of Ferric Ammonium Sulphate and one-half measure of Sodium Sulphocyanate in a test tube three-fourths full of water. Notice the red color due to the formation of ferric (iron) sulphocyanate.

Pour one-half of this solution into another test tube and add three or four measures of Sodium Bisulphite. Shake the contents of the test tube and notice

that the red color disappears or the solution is bleached. The sodium bisulphite reduced the ferric sulphocyanate, that is, removed oxygen from it, thereby changing its color.

EXPERIMENT 9. Reduction of Logwood. Put one measure of Logwood in a test tube half full of water and heat until the liquid becomes deeply colored. Pour some of this liquid into another test tube and add three measures of Sodium Bisulphite. Shake well and notice that the red color due to the logwood dye disappears and the solution becomes almost colorless. The same thing happened here as in the preceding experiment.

EXPERIMENT 10. Bleaching with Sulphur Dioxide. Place about six measures of Sodium Bisulphite and an equal amount of Tartaric Acid in a glass



Fig. 9

tumbler. Add a little water. Smell cautiously and note the odor of sulphur dioxide gas.

Moisten some red or blue flowers with water. Put them in the glass. Cover the glass with a saucer, (Figure 9) and allow to stand for about three-fourths of an hour. At the end of this time, the flowers will be white. The sulphur dioxide formed in the reaction bleached the colors out of the flowers.

EXPERIMENT 11. How to Make a Fuse. A very good fuse can be made by soaking a string in a solution of Potassium Nitrate for a few minutes and allowing the string to dry. You can time your fuse by using the proper length string. The solution of Potassium Nitrate is made up the same way as in experiment 5.

HYDROGEN

Hydrogen is a colorless, odorless, tasteless gas. It is the lightest substance known, being about $14\frac{1}{2}$ times lighter than air, 11,160 times as light as water and 151,700 times as light as the metal mercury. It enters into the composition of all plants and

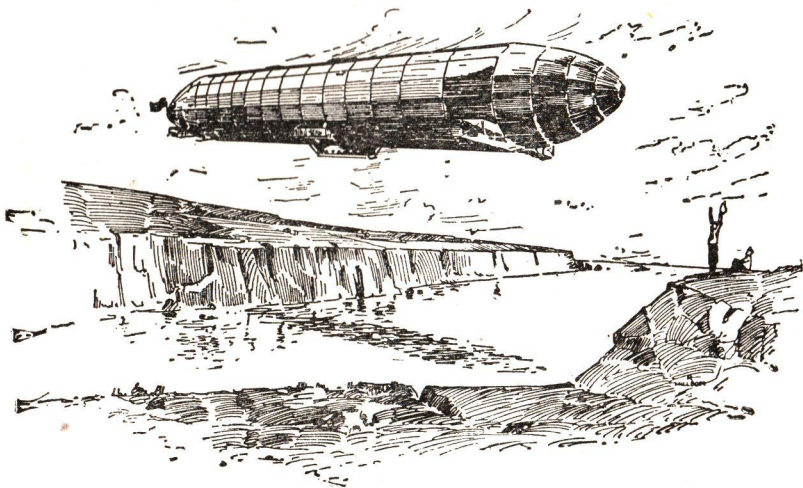


Fig. 10

animals and forms part of wood, coal and petroleum, but the great store of hydrogen in the world is in the vast amounts of water which are found on the surface of the earth. Hydrogen occurs in the free state in the gases from some volcanoes and natural gas wells, and in the atmosphere of the sun and some fixed stars.

Because of its lightness it is used for filling airships and balloons. (Figure 10.) During the last great war, hydrogen was prepared for filling airships and balloons by treating the metal aluminum with sodium hydroxide, a base. The reason for using these substances was because they were easily transported from place to place.

EXPERIMENT 12. Preparation of Hydrogen. Put together in a test tube, three measures of Sodium Bisulphate and four measures of Ammonium Chloride. Add about one inch of water, and warm until everything is in solution.

Then add one measure of Powdered Zinc and notice the violent reaction that takes place. This is due to the evolution of hydrogen gas. Hold a flame at the

mouth of the test tube and notice that the gas given off burns with a blue flame. It is hydrogen, combining with the oxygen of the air to form water.

In the reaction, the sodium bisulphate and ammonium chloride formed hydrochloric acid which reacted with the zinc to form a soluble compound, zinc chloride and hydrogen gas.

WATER AND WATER-OF-CRYSTALLIZATION

At ordinary temperatures, pure water is a tasteless, odorless, transparent liquid, colorless in thin layers, but distinctly blue when seen in large masses. It is about 773 times heavier than air.

Water consists of two elements, both gases, hydrogen and oxygen, and the occur in water in the proportion of 89% of oxygen to 11% of hydrogen by weight. By volume, water consists of two parts of hydrogen to one part of oxygen. Water occurs very abundantly throughout the earth. Vast areas of the polar regions are covered with it in the form of ice, while in the liquid state it covers about five-sevenths of the earth's surface, reaching in some places to a depth of nearly six miles. Large quantities occur in salt, and as a vapor it is an essential constituent of the atmosphere. More than half of living organisms consists of water; for example, nearly 70% of the human body is water.

A great many substances dissolve in water so that water is known as a very good solvent. A substance is said to be dissolved when none of the particles of the substance can be seen in the liquid or separated from the liquid by filtering. A dissolved substance can usually be recovered from the liquid by evaporating the liquid.

EXPERIMENT 13. A Soluble Substance—Solution. Dissolve one or two teaspoonfuls of common salt in a glass of water. Notice that you can no longer see the salt. If this liquid was filtered you would find that none of the salt would remain on the filter paper.

Pour the solution into a clean pan and heat on the stove until all the water is driven off. Notice that a white solid remains. Allow this to cool and taste a little of the solid. It is the same salt you dissolved in the water, proving that the salt when in solution had undergone a physical change only.

EXPERIMENT 14. An Insoluble Substance—Insolubility. Try to dissolve one or two measures of Sulphur in a test tube half full of water. Shake well and notice that the sulphur remains in the solid state and does not dissolve.

EXPERIMENT 15. Purification of Water by Distillation. Dissolve two measures of Nickel Ammonium Sulphate in a test tube one-third full of water. Now attach the gas delivery tube and place a test tube over the end of the delivery tube. Immerse this test tube in a tumbler full of water and heat the test tube containing the nickel solution over a flame holding the test tube by means of the

test tube holder so as not to burn the fingers. Notice that after boiling the solution for several minutes, steam is formed which condenses in the second test tube immersed in the cold water. Also notice that this condensed steam or water is colorless while the nickel solution was green.

This is one of the methods of making pure water. In this experiment we removed the nickel salt from the water by distillation.

Most chemicals, as a rule, do not react when brought together in the dry form. When water is present, however, they react very readily since the different particles of the compounds are then brought much closer together.

EXPERIMENT 16. Solution Promotes Chemical Reaction. Mix together on a sheet of paper one-half spoonful of Sodium Bicarbonate and one-half spoonful of Tartaric Acid. Notice that there is no reaction.

Transfer this mixture to a test tube and add a few drops of water, and notice the violent reaction which results, with the liberation of carbon dioxide gas, thereby proving that water is necessary to promote chemical reaction between these substances.

EXPERIMENT 17. A Color Change Due to Solution. Make a mixture of one measure of Tannic Acid and one measure of Ferric Ammonium Sulphate on a piece of paper and notice as in Experiment 16 that there is no evidence of reaction. Transfer this mixture to a clean dry test tube and fill half full of water. Notice that a black colored product is formed showing that there was chemical reaction due to the presence of water. Iron tannate was the black product formed.

While some compounds give off heat when dissolved in water, others take up heat; that is, it is possible to lower or to raise the temperature of water by dissolving different solids in it.

EXPERIMENT 18. Lowering of Temperature by Solution. Fill a test tube half full of water and notice the temperature by feeling of the test tube with the face or hand. Then add one-half spoonful of Ammonium Chloride and shake well to dissolve the salt. Again feel of the test tube and notice the change of temperature.

Compounds like ammonium chloride, sodium nitrate and many others, have what is known as a negative heat of solution; that is, they absorb heat from water when dissolved in it, thereby lowering the temperature or cooling the water.

EXPERIMENT 19. Raising of Temperature by Solution. Fill a test tube half full of water and notice the temperature by feeling with the face or hand. Now dissolve in the water half a spoonful of Magnesium Sulphate, and notice the temperature the same as before. This time the solution is warmer.

Compounds like magnesium sulphate, sodium hydroxide and some others have a positive heat of solution; that is, they give off heat when dissolved in water.

• The application of the so-called negative heat of solution of common salt is

made use of in the ice and salt freezing mixture so commonly used for making ice cream. Common salt, just like ammonium chloride, lowers the temperature of water when dissolved in it. Therefore, when salt is added to a mixture of ice and water, whose temperature is just at the freezing point, the salt dissolves and in doing so, lowers the temperature of the solution several degrees below freezing, thereby affording us a very convenient freezing mixture.

EXPERIMENT 20. How to Make a Freezing Mixture. Mix together a glass full of cracked ice and one-half glass full of salt.

Try the effect of this freezing mixture upon water by placing a test tube half full of water in it and allowing to stand for several minutes. Notice that the water in the test tube freezes to solid ice after a short time.

It is easily demonstrated that when a substance is dissolved in water, the freezing point of the resulting solution is lower than the freezing point of water. This is the reason why salt is sometimes thrown on slippery sidewalks. It melts the ice by lowering the freezing point of the water.

It can also be shown that when a substance is dissolved in water the boiling point of the resulting solution is higher than that of pure water.

EXPERIMENT 21. Solution Lowers the Freezing Point of Water. Make a freezing mixture as shown in Experiment 20. Now add a spoonful of common salt to a test tube half full of water and shake until dissolved. Place this test tube of salt solution with another test tube half full of water in the freezing mixture.

Notice after some time that the water freezes, but the salt solution does not, thereby proving that solution lowers the freezing point of water.

EXPERIMENT 22. Solution Raises the Boiling Point of Water. Make a salt solution by dissolving a spoonful of salt in a test tube half full of water. Now hold this solution, together with a test tube half full of water over a flame, giving them about the same amount of heat. Notice that the water will boil before the salt solution does, thereby proving that solution raises the boiling point of water.

It is possible to cool a liquid below its freezing point. Water, for example, can be cooled below its freezing point, 32° Fahrenheit, or 0° Centegrade, and still remain a liquid. When in this state water is said to be undercooled.

EXPERIMENT 23. Undercooled Water. Make a freezing mixture as explained in Experiment 20. Place in the freezing mixture a test tube one-third full of water, and keep the test tube quiet.

The temperature of the water in the tube may go down as far as 8 to 10 degrees below zero, Centegrade, or between 18 and 14 degrees, Fahrenheit, and the water still remains in the liquid form. If a small crystal of ice is now dropped into the test tube, or the water in the test tube stirred, it will immediately freeze, the temperature then rising to the freezing point, 0 degrees Centegrade or 32 degrees Fahrenheit.

Most substances dissolve more readily in hot water than in cold water. There are a few exceptions, however, calcium hydroxide being a good example of a substance which is more soluble in cold water than in hot water.

EXPERIMENT 24. Effect of Temperature on Solubility. Put two measures of Nickel Ammonium Sulphate in a test tube one-fourth full of water, and shake well. Notice that some of the solid remains undissolved. Now heat the test tube slightly and notice that the solid goes into the solution, showing that some substances are more soluble in hot water than in cold water.

Allow the test tube to cool undisturbed and notice the beautiful green crystals of nickel ammonium sulphate that separate out on cooling.

EXPERIMENT 25. Effect of Temperature on Solubility. Add three measures of Calcium Oxide to a test tube full of water. Shake several times and allow tube to stand until the liquid becomes clear. Pour some of this clear liquid into another test tube and heat slightly over a flame. Notice that the liquid becomes cloudy or turbid, proving that the calcium hydroxide which was formed when calcium oxide was added to the water, is less soluble in hot water than in cold water.

Many compounds contain chemically combined water, and water occurring in compounds in this way is known as "Water-of-Crystallization."

EXPERIMENT 26. Water-of-Crystallization. Put two measures of Nickel Ammonium Sulphate in a clean dry test tube and heat carefully over a flame, using the test tube holder so as not to burn the fingers.

You will notice that water in the form of steam is given off and some of this condenses on the inside of the test tube in the form of small drops of water. This water which was originally in the nickel ammonium sulphate is called Water-of-Crystallization.

Notice also that the salt remaining in the test tube has changed color from green to white. Most salts when they lose their water-of-crystallization in this manner also undergo a change in color. This colorless compound is known as anhydrous nickel ammonium sulphate, meaning without water-of-crystallization.

Some substances give up or lose their water-of-crystallization on simple exposure to the air. Such substances are called "Efflorescent Substances," and a good example of this class of substances is sodium sulphate.

On the other hand, certain substances on exposure to the air, take up water from the air, and in some cases dissolve in this water to form a liquid. Substances of this class are called "Deliquescent Substances," and a good example of this class of substances is calcium chloride.

Everybody at some time or other has eaten rock candy, or crystallized sugar. This is nothing more than sugar that has been allowed to crystallize from a solution of sugar in water. A substance crystallizing slowly tends to go out in the form of large shapely crystals, while when crystallizing quickly from a

solution it comes out in smaller crystals.

EXPERIMENT 27. Formation of Crystals (Rock Candy). Dissolve as much sugar as possible in a test tube half full of boiling water.

Suspend a thread or string in this solution by hanging a small weight on the end of it and allow the contents of the tube to cool. (Figure 11.) After a short time the sugar will appear in large crystals upon the string which is hung in the test tube. Large crystals of many compounds can be formed in this manner.

EXPERIMENT 28. How to Make Frosted or Crystallized Glass. If properly carried out, this experiment gives the glass a beautiful crystalline effect which is translucent and quite permanent. It is best to try it first on a small piece of ordinary window glass.

First clean the glass to be crystallized. In a test tube two-thirds full of water dissolve three teaspoonfuls of Ammonium Chloride.

Add one or two drops of mucilage or glue—no more. Boil, and apply while hot to the glass, using a small brush if you have one handy—a piece of paper will do.

When the solution begins to evaporate, crystals are formed which give the glass the appearance of a frosted pane. The glue helps to make the crystal effect more permanent. Either Epsom or Rochelle salts will do as well as Ammonium Chloride.

EXPERIMENT 29. Disappearing Ink. In a small test tube, make a solution of Cobalt Chloride by dissolving three measures of Cobalt Chloride in one-half inch of water. Shake thoroughly to dissolve all the solid. Procure a clean pen, or better, a toothpick and write upon a pink paper with the pale solution you have made. Allow this to dry. When dry, the writing will be invisible. To bring back to view the words you have written, merely heat the paper, taking care not to scorch or burn it. The writing appears in a beautiful cobalt blue color. To make the writing disappear again, allow to cool, or hold it over a steaming kettle.

Normally, cobalt chloride is blue. It has a great attractive power, however for water, and therefore in the presence of moisture it takes up what is known as

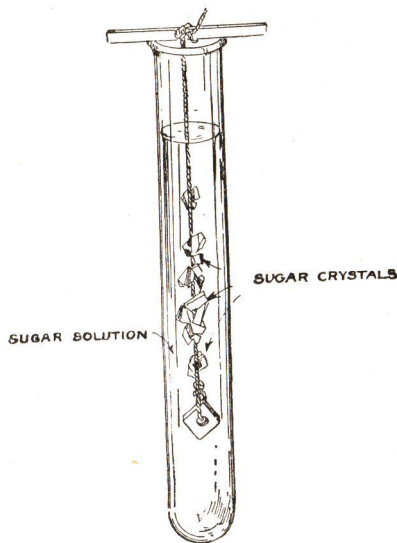


Fig. 11

water-of-crystallization. The blue crystals will then turn pink in color. Should the pink crystals be heated, they would turn blue again, due to the loss of water.

When the cobalt chloride solution dried upon your paper, minute crystals were deposited which contained water-of-crystallization. They were pink or colorless. When heated, these tiny crystals turned blue because the water was driven off. When the crystals cooled, they again gathered moisture from the water and became colorless. When the weather is very clear, or when the air in homes is hot and dry, especially in the winter, quite a time is required for the blue color to fade.

EXPERIMENT 30. How to Make a Weather Barometer. Soak a piece of unglazed paper in a concentrated solution of Cobalt Chloride, and allow to dry. The solution of Cobalt Chloride is made up the same as in Experiment 29, using three times the amounts.

The color of the paper indicates the state of the weather. When the paper is pink, wet or moist weather is foretold. When the paper turns blue, that is an indication of bright, clear atmosphere, or continued fair weather.

By Surface Tension, is meant the force which liquids possess due to the molecular attraction of the molecules in the liquids. It is this property which causes water, for example, to take a round form in the shape of drops, and also enables it to support a needle when properly floated upon it.

EXPERIMENT 31. Surface Tension of Water. Carefully lay a needle upon the surface of some water in a saucer or bowl and notice it will float and not sink to the bottom. It is necessary to have the needle and fingers dry in order to successfully float the needle.

When we heat a liquid, the liquid expands, and the specific gravity of the liquid becomes lower, that is, the liquid becomes lighter. When we heat a liquid in a vessel, we have produced what is known as Convection Currents. The warm water at the bottom of the vessel becomes lighter and rises to the top, while the cool, heavier portion at the top flows to the bottom to take its place. This phenomena is one of the causes of the great ocean currents.

EXPERIMENT 32. Convection Currents. Put a few pieces of blotting paper or shavings into a glass of water. Then drop into the water a hot marble or piece of hot metal and notice the currents that are produced. These are called Convection Currents.

By specific gravity, we mean the relation between the volume and the weight of a substance. Water is used as the standard; that is, one cubic centimeter of water at 4° Centigrade weighs one gram. Thus, if we have one cubic centimeter of a substance which weighs five grams, it has a specific gravity of five.

The specific gravity of a substance often enables us to tell whether or not that substance has been adulterated. For example, a certain oil may have a specific gravity of 2. If the specific gravity when measured is 1.7, for example, the oil has been adulterated with some other substance.

EXPERIMENT 33. To Demonstrate the Specific Gravity of Liquids.

Place a fresh egg in a glass full of water and notice that it sinks to the bottom. Now remove the egg and dissolve two spoonfuls of salt in the water. Then put the egg in the salt solution and notice that it floats.

The reason why the egg floated in the salt solution was because we increased the specific gravity of the water beyond that of the egg. The specific gravity of a solution is always greater than that of the pure liquid. This is the reason why it is easier to swim in salt water than in fresh water.

TESTING WATER

Absolutely pure water is never found in nature. The impurities found in water are of two classes, the inorganic, or those that have come from the rocks and the organic, or those that are formed from the decay of animal or vegetable substances.

The principal inorganic matter found in water is common salt and compounds of calcium, magnesium and iron. Waters containing such substances in solution are commonly spoken of as hard waters, or if large amounts of mineral matter are present, as mineral waters. Salts occurring in hard waters do not injure the water for drinking purposes, but they form insoluble compounds with soap, so that we cannot wash with them.

In addition to mineral matter, natural waters contain more or less organic matter in solution or held by suspension. This organic matter is not necessarily harmful, but quite often this is accompanied by certain forms of microorganisms or living bacteria which may be very injurious to life. Typhoid fever is often contracted from drinking water containing bacteria of this kind. Bacteria when found in drinking water is generally destroyed by adding bleaching powder or chloride of lime to the water. Chlorine gas and ozone are also used for the same purpose with good effect.

HARD WATER

When water does not lather well with soap, it is commonly known as hard water. There are two kinds of hard water; temporary and permanent.

EXPERIMENT 34. Temporary Hardness—How to Get Rid of It. If you are able to obtain some hard water in your locality, test a half test tube full of it for temporary hardness by boiling for three or four minutes over a flame. If the water after boiling becomes turbid, that is, takes on a white, milky color, it possesses temporary hardness.

Temporary Hardness is due to the presence of calcium bicarbonate, which is formed by the action on limestone (calcium carbonate) of the carbon dioxide dissolved in rain water. This form of hardness is easily gotten rid of by boiling. The heat drives off the excess carbon dioxide and the calcium carbonate precipitates, giving the water a turbid or milky appearance.

It is due to this precipitate that kettles and boilers become gradually covered inside with a brown deposit. In large boiler pipes, the deposit is known as boiler scale and constitutes a serious problem in manufacturing plants. On a large scale slaked lime (calcium hydroxide) made by adding water to lime is used to soften water. The soluble bicarbonate is converted into the insoluble carbonate which separates out and is removed by filtering.

EXPERIMENT 35. Permanent Hardness—How to Get Rid of It. Hard water, due to the presence of sulphate of lime, or of magnesia, cannot be softened by boiling and water of this kind is known as permanent hard water.

If you are able to procure a sample of hard water in your locality, treat a half test tube full of it with two measures of Sodium Bicarbonate. Shake well, and if a white precipitate is formed, the water possesses permanent hardness. This precipitate may be calcium carbonate or magnesium carbonate, or both.

Some waters contain in addition to dissolved substances, suspended matter. When such is the case, the suspended matter is removed by treatment with aluminum hydroxide or ferric hydroxide, gelatinous precipitates which upon settling carry down with them the suspended matter in the water.

EXPERIMENT 36. Clarifying Water. Add one-half measure of Aluminum Sulphate to a test tube three-fourths full of muddy water, prepared by adding a little clay to some muddy water and shaking. Then add one-half measure of Sodium Carbonate. Allow the tube to stand undisturbed for fifteen minutes and for proof of the experiment, prepare another test tube of muddy water in the same manner, but without adding the aluminum sulphate and sodium carbonate, and set it alongside of the first tube.

After fifteen or twenty minutes you will notice that the water in the first tube to which the aluminum sulphate and sodium carbonate were added is clear while the mud particles in the second tube remain suspended throughout the water. This is explained by the fact that the aluminum sulphate reacted with sodium carbonate to form aluminum hydroxide, a gelatinous precipitate, which settled to the bottom of the tube, carrying with it the suspended matter.

Aside from the salts which go to make water hard, natural waters quite often contain other mineral salts in solution. The so-called "Mineral Springs" contain some of these salts and in some cases have medicinal value.

Try the following experiments on any samples of water that you may obtain.

EXPERIMENT 37. Testing for Odor. Fill a test tube one-half full of water to be tested. Shake the tube well and then smell at the mouth of the tube. Gently heat the tube for a few seconds and then smell again. Notice any increase in the odor. Heating usually drives out any dissolved gases which may be in the water as impurities.

If the water has any disagreeable odor, it may be contaminated with sewage of some sort.

EXPERIMENT 38. A Test for Color and Clearness. Examine a

sample of water as follows: Hold a test tube of water in front of a white sheet of paper and notice whether the water is colored or cloudy. If the water is colored or cloudy, it is contaminated with impurities.

Quite often when water is drawn from a faucet it appears a little milky. This is due to the high pressure of water in the pipes. When this is so, allow the water to stand for two or three minutes and you will notice that the water is now clear.

EXPERIMENT 39. How to Test for Solid Matter in Water. Pour one-half test tube full of water to be tested in an ordinary tea cup and allow it to evaporate, slowly, down to dryness on the stove. Look for a residue or solid matter in the cup after all the water is driven off. Most waters contain small amounts of mineral salts and sometimes organic matter which are tested for in this way.

EXPERIMENT 40. How to Test for Free Alkali in Water. Add one or two drops of Phenolphthalein Solution to a test tube full of water to be tested. If the water is alkaline, it will take on a light pink or red color.

EXPERIMENT 41. How to Test for Acidity in Water. Add a small piece of Blue Litmus Paper to a test tube full of water. If the litmus paper turns pink, the water is slightly acidic.

EXPERIMENT 42. How to Test for Soluble Sulphates in Water. Add two measures of Strontium Nitrate to a test tube one-third full of water and shake until dissolved. If, after ten or twenty minutes, the water takes on a cloudy appearance, there are soluble sulphates present in the water.

EXPERIMENT 43. How to Test for Lime in Water. Add one or two measures of Sodium Carbonate to a test tube one-half full of water to be tested, and allow to stand for ten or twenty minutes. If the water becomes cloudy or turbid, lime is present.

EXPERIMENT 44. How to Test for Carbon Dioxide in Water. Add a few drops of clear lime water to a test tube three-fourths full of the water to be tested. A white precipitate or a milky color is a test for carbon dioxide.

Lime water is made by adding one measure of Calcium Oxide to a test tube half full of water, shaking well, and allowing any solid material to settle. The clear liquid is lime water.

Soda water is simply pure water which has been saturated with carbon dioxide gas under pressure. When the pressure is relieved, the carbon dioxide bubbles out producing effervescence.

EXPERIMENT 45. How to Test for Sulphur in Water. Test different samples of water with a piece of Sulphide Test Paper by dipping the paper into water. If sulphur is present, the paper will turn brown or black.

Sulphur occurs in water in the form of hydrogen sulphide, a gas which is fairly soluble in water and has the disagreeable odor resembling that of rotten eggs.

ACIDS, BASES AND SALTS—INDICATORS

Acids are compounds which have a sour taste, turn blue litmus paper red, are capable of dissolving many substances, and have the property of neutralizing or destroying alkalies or bases to form salts and water.

Bases are compounds which have a soapy taste, turn red litmus paper blue, are capable of dissolving some substances, and unite with acids.

Salts are compounds formed by the neutralization or uniting of acids with bases. Most salts formed in this way do not have any effect on blue or red litmus paper, and are called neutral salts. However, some salts may be acidic while other salts are basic.

Sulphuric Acid (H_2SO_4), nitric acid (HNO_3), hydrochloric acid (HCl), acetic acid (CH_3COOH) are a few examples of some of the common acids and the characteristics of acids namely, taste, effect on blue litmus paper, and formation of salts with bases are due to the replaceable hydrogen (H) which they contain.

Caustic soda or sodium hydroxide (NaOH), caustic potash or potassium hydroxide (KOH), lime water or calcium hydroxide ($\text{Ca}[\text{OH}]_2$) and ammonium hydroxide (NH_4OH) are a few examples of some common bases and the characteristics of bases namely, soapy taste, effect on red litmus paper and formation of salts with acids are due to the hydroxyl group (OH) which they contain.

Table salt or sodium chloride (Na Cl), sodium sulphate (Na_2SO_4) and potassium iodide (KI) are examples of salts. These compounds contain no hydrogen (H) or hydroxyl (OH) atoms so that they have neither the characteristics of acids or bases.

Acids, bases and salts are the three common classes of compounds that are capable of conducting an electric current and simultaneously decomposed by it. They are consequently called Electrolytes.

Indicators are substances usually organic compounds which are capable of turning one color in the presence of acids and another color in the presence of alkalies. Knowing these color changes, we are thus able to tell whether a substance is acidic, alkaline, or neutral.

Most of the elements can be made to combine with oxygen to form oxides and elements can be divided into two classes as follows:

Those elements whose oxides react with water to form bases, hydroxides or alkalies are called metallic elements and the oxides are said to be basic.

Those elements whose oxides react with water to form acids are called non-metallic elements and these oxides are said to be acidic.

Oxides of all the metals are basic while those of such substances as carbon, sulphur, phosphorus, chlorine, silicon, and several other elements are acidic.

EXPERIMENT 46. How to Make a Base—Calcium Hydroxide. Put half a spoonful of Calcium Oxide in a saucer, and moisten it with several drops of water. Now lay a small piece of Red Litmus Paper on the moistened calcium

oxide and notice that it turns blue, proving that a base or alkali is present.

Calcium oxide reacts with water to form the base calcium hydroxide which turns the red litmus paper blue. This proves that calcium is a metal.

EXPERIMENT 47. How to Make a Base—Sodium Hydroxide. To a test tube one-half full of water add two measures of Sodium Carbonate and two measures of Calcium Oxide. Heat the test tube for several minutes over a flame and allow the tube to stand until the liquid becomes clear.

Test a little of this liquid with Red Litmus Paper and notice that it turns blue proving that a base is formed. The calcium oxide reacted with sodium carbonate in the presence of water to form the salt calcium carbonate which is insoluble and sodium hydroxide a soluble base.

EXPERIMENT 48. How to Make an Acid—Carbonic Acid. Place two measures of Sodium Bisulphate and two measures of Sodium Carbonate in a test tube and fill half full of water. Notice the effervescence due to the liberation of carbon dioxide gas. Place a small piece of moistened Blue Litmus Paper over the mouth of the tube and notice that the blue litmus paper turns red, proving that an acid is formed. The carbon dioxide formed by the reaction of sodium bisulphate on sodium carbonate reacts with the water on the moistened litmus paper forming carbonic acid which turns the blue litmus paper red.

This experiment proves that carbon dioxide is an acidic oxide, and the element carbon is a non-metallic element, or commonly called a "non-metal."

EXPERIMENT 49. Neutralization or the Action of an Acid on a Base. Prepare Calcium Hydroxide by putting one-half measure of Calcium Oxide in a test tube half full of water. Shake well and allow the tube to stand for several minutes until the liquid becomes clear. Then pour this clear liquid into another test tube. This is calcium hydroxide or lime water.

Now add one measure of Sodium Bisulphate to a test tube half full of water. Shake until completely dissolved.

Add one drop of Phenolphthalein Solution to the solution of calcium hydroxide. Notice that the solution turns red, proving that it is basic. Now add slowly, drop by drop, some of the sodium bisulphate solution and notice that the red color gradually becomes fainter and fainter until finally the solution becomes colorless. The solution should now be neutral; that is, neither basic or acidic.

In neutralization, the hydrogen (H), of the acid combines with the hydroxyl (OH) of the base to form water. The other product formed is a salt.

EXPERIMENT 50. Action of an Acid on a Metal to Form a Salt. Put three measures of Sodium Bisulphate and four measures of Ammonium Chloride in a test tube one-fourth full of water. Heat the test tube until the contents boil and the solution becomes clear.

Now add one measure of Powdered Zinc and notice the violent action which occurs, due to the liberation of hydrogen gas.

Sodium bisulphate reacted with the ammonium chloride to form hydrochloric

ric acid. The zinc reacted with the hydrochloric acid to form the soluble salt, zinc chloride and hydrogen gas was liberated.

EXPERIMENT 51. Testing for Bases with Phenolphthalein. Dissolve one measure of Sodium Carbonate in a test tube two-thirds full of water. To the clear solution add two or three drops of Phenolphthalein Solution. A red color is the test for an alkali or a base.

Now add two measures of Tartaric Acid and shake the test tube thoroughly. A colorless solution indicates that the solution is now acidic.

Phenolphthalein is red in the presence of a base or alkali and colorless in the presence of an acid.

EXPERIMENT 52. Testing for Acids and Bases with Litmus. Place one measure of Sodium Carbonate in a tumbler one-third full of water and stir the solution with a stirring rod to dissolve the carbonate. Drop in a small piece of Red Litmus Paper and notice the color change. Bases turn red litmus paper blue. Now add three measures of Tartaric Acid and stir the solution. Notice that the litmus paper now turns red. Acids turn blue litmus paper red.

EXPERIMENT 53. An Indicator Trick. Dissolve one measure of Sodium Carbonate in a test tube half full of water.

Add three drops of Phenolphthalein Solution and shake. This gives a red colored solution. Now drop in a piece of Red Litmus Paper and behold! The red litmus paper turns blue. The fact that the red paper will turn blue in a red solution is mystifying to the person who does not know the secret. This is explained by the fact that an alkaline solution turns red litmus blue.

EXPERIMENT 54. A Common Household Indicator. Soak some red cabbage leaves in hot water for several minutes. To some of the clear liquid in a test tube add a little vinegar or a few drops of a solution of Tartaric Acid. Note the color change. Acids turn this solution red. Now make the solution alkaline by adding two or three measures of Sodium Carbonate and shake. Note the color change. Bases turn this solution green.

NITROGEN AND AMMONIA—AMMONIUM HYDROXIDE

Nitrogen is a colorless, tasteless gas. It forms four-fifths of the bulk of the air. It is a very inactive gas and if it was not the earth would have burned up long ago. Nitrogen of the air tends to dilute the oxygen thereby preventing all life, both living and inanimate, from oxidizing too rapidly. Nitrogen is slightly lighter than air.

Since nitrogen is a very inactive element, it combines with very few other elements. However, those elements with which it combines, form very interesting classes of compounds. The fact that nitrogen is a very inactive element would lead us to think that its compounds would be unstable and decompose easily. This is true and most of the high explosives used during the last war

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were such compounds. Many of the most highly explosives are compounds of nitrogen with hydrogen, oxygen and sulphur. The force of an explosion is due to the tremendous volume of gases that are simultaneously formed when an explosive compound is suddenly decomposed when exploded in a cannon or shell. Gun powder, nitroglycerine, picric acid, tri-nitrotoluene and tri-nitroaniline are some very common high explosives of nitrogen.

Nitrogen combines with oxygen to form several oxides. Nitric acid is a compound of nitrogen with hydrogen and oxygen. Nitric acid is really the basis of most explosives containing nitrogen. With hydrogen, nitrogen forms ammonia gas and this gas when dissolved in water forms the base ammonium hydroxide.

Inorganic nitrogen compounds are not plentiful. The main bulk of nitrates occur in Chile, as Chile salt peter, or sodium nitrate, (NaNO_3). Nitrogen occurs abundantly in ammonia, nitric acid, coal, flesh and other substances as cabbage, mushroom, and horse radish. It is also an essential constituent of many drugs as quinine, morphine, and strychnine.

Everybody is more or less familiar with the sharp odor of ammonia. Ammonia serves a great many purposes. In the household it is used to clean glassware and to soften water. Ammonium carbonate, a compound which gives up its ammonia fumes readily, is commonly known as smelling or aromatic salts. Ammonia is a gas which is very soluble in water. The commercial product is ammonia water because in that form it is easily transported.

EXPERIMENT 55. Nitrogen from the Air—Properties of Nitrogen. Place a candle in the center of a shallow pan by sticking it to two or three drops of molten wax. Then pour about two inches of water in the pan, light the candle and place an inverted bottle over the candle (Figure 12.) Allow the bottle to remain this way until the flame goes out and water rises inside the bottle.

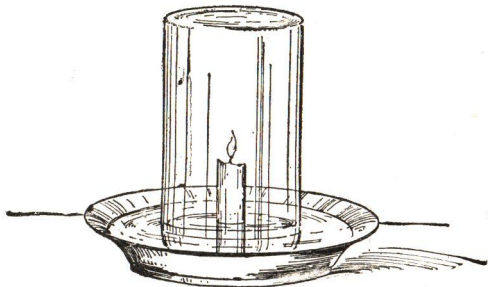


Fig. 12

The flame went out because it used up all the oxygen inside the bottle. Carbon dioxide was formed which dissolved in the water. The remaining gas was nitrogen. Remove the bottle from the pan by placing a small glass plate or piece of cardboard over the mouth of the bottle while under the water. Set the bottle right side up, keeping the cover on so as not to lose any of the gas.

Light a splinter of wood and removing the cover from the mouth of the bottle containing the nitrogen, insert the splinter in the bottle. Notice that the

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flame goes out, showing that nitrogen does not support combustion.

EXPERIMENT 56. Manufacture of Ammonia—Ammonia Water.

Put two measures of Ammonium Chloride in a test tube and add two measures of Calcium Oxide. Add three or four drops of water and heat for a moment, placing a wet piece of Red Litmus Paper over the mouth of the tube. When the litmus paper turns blue, showing the presence of a base, smell cautiously. This gas when passed into water forms the so-called ammonia water and is really the base ammonium hydroxide.

Most of the ammonia water of commerce is obtained from the destructive distillation of coal, and is a by-product in the manufacture of illuminating gas.

EXPERIMENT 57. Preparation of Ammonia. Put two measures of Sodium Carbonate and two measures of Ammonium Chloride in a test tube. Add ten drops of water. Heat gently. Remove the test tube from the flame and notice the odor of ammonia at the mouth of the test tube.

Any ammonium salt when heated in the presence of a base or alkali gives ammonia gas and this reaction is used as a test for the ammonium group (NH_4) in a compound.

EXPERIMENT 58. Properties of Ammonia Gas. To show the remarkable solubility of ammonia gas, proceed as follows:

Put two measures of Calcium Oxide or Sodium Carbonate and two measures of Ammonium Chloride in a test tube. Heat the test tube gently, holding a piece of cardboard over the mouth of the tube. After heating this way for four or five minutes, remove the test tube from the flame and place the thumb over the mouth of the tube. Now turn the cool test tube bottom side up and keeping your thumb over the mouth of the tube, hold the mouth under the surface of some water in a pan. Remove your thumb and notice that the water rushes part way up the tube, due to the ammonia dissolving readily in the water.

Some ammonium salts when heated, dissociate into different compounds which recombine on cooling to form the original compounds.

EXPERIMENT 59. Dissociation of Ammonium Chloride. Put one measure of Ammonium Chloride in a clean, dry test tube, and heat slowly over a flame. Notice that the Ammonium Chloride passes into the vapor state and apparently condenses on reaching the upper portion of the tube to form a white solid.

What really happened was that the ammonium chloride when heated, dissociated into ammonia gas and hydrogen chloride gas which recombined on reaching the upper portion of the tube, to again form the white solid, ammonium chloride.

Nitric Acid is a very important acid. It is used in the manufacture of many important commercial products such as dyes, fertilizers and explosives. It is manufactured on a commercial scale by treating sodium nitrate (Chile saltpeter) with concentrated sulphuric acid.

EXPERIMENT 60. Preparation of Nitric Acid. Put four measures of Potassium Nitrate and four measures of Sodium Bisulphate in a test tube. Add four or five drops of water. Moisten a piece of Blue Litmus Paper and place it over the mouth of the tube.

Now heat the test tube slowly over the flame and notice that the blue litmus paper turns red. Remove the test tube from the flame, and smell cautiously. The fumes that are given off are nitric acid fumes and if they were condensed they would give us nitric acid.

SULPHUR AND HYDROGEN SULPHIDE

Sulphur is a very important element. It is a yellowish, tasteless solid. The odor usually ascribed to sulphur is due to sulphur dioxide formed when sulphur burns.

In the free state, sulphur occurs chiefly in volcanic regions. Large deposits are found in Italy, Sicily, China, Ireland and India. Important deposits are found in this country in Louisiana and California. In Louisiana, the sulphur is melted under ground by means of superheated steam, and forced out under pressure through pipes. Sulphur also occurs in many important ores as sulphides, for example, galena, or lead sulphide; cinnabar or mercury sulphide; zinc blende or zinc sulphide; realgar or arsenic sulphide.

Sulphur is used extensively in the manufacture of many substances such as gun powder, fireworks, matches, dyes, and the very important substance, sulphuric acid. It is also used in the vulcanization of rubber, and in the preparation of sulphur dioxide for bleaching and disinfecting.

EXPERIMENT 61. Behavior of Sulphur at Different Temperatures. Heat ten measures of Sulphur in a small dry test tube. Apply the heat very slowly and notice the different changes. First the sulphur melts to a light straw colored liquid. Pour a little of this liquid into a glass of water and then continue the heating and observe, second, the change of color to brownish black and the liquid becoming almost solid. On further heating, third, this solid becomes liquid again. Pour this liquid sulphur into another glass of water.

The sulphur obtained when the straw colored liquid was poured into water is called rhombic sulphur, while that formed when the dark black liquid was poured into water is called plastic sulphur or elastic sulphur. This substance becomes brittle on standing a few days. Sulphur undergoes three distinct changes then on heating, and each change corresponds to a certain temperature.

EXPERIMENT 62. Preparation of Lime—Sulphur Solution. Put into a test tube one-third full of water one measure of Calcium Oxide and one measure of Sulphur, and heat the test tube over a flame. Boil for several minutes. Notice the yellowish colored solution that is formed. This solution is known as lime sulphur solution, and is used on a large scale for spraying fruit trees and destroying fungi.

The calcium oxide reacted with the sulphur to form calcium sulphide and water.

Allow one or two drops of this solution to fall on a silver coin. Let it stand for several minutes. Wash off the liquid and notice that a black spot of silver sulphide is formed.

OXIDES AND OXYGEN ACIDS OF SULPHUR

Sulphur unites with oxygen to form two important oxides, sulphur dioxide and sulphur trioxide. Sulphur dioxide when passed into water forms sulphurous acid, while sulphur trioxide when passed into water forms sulphuric acid.

EXPERIMENT 63. Sulphur Dioxide from Burning Sulphur. Put two measures of Sulphur in a spoon and heat over a flame. The sulphur will suddenly take fire and burn with a blue flame. The gas produced having a suffocating odor, is sulphur dioxide and is formed by the oxidation of sulphur when it burns in the air.

EXPERIMENT 64. Sulphur Dioxide from Sodium Bisulphite. Put two measures of Sodium Bisulphite in a test tube one-third full of water and add a few drops of acetic acid (vinegar). Smell cautiously at the mouth of the tube and notice the odor of burning sulphur.

Sodium Bisulphite when treated with an acid reacts to form sulphur dioxide, water and a salt.

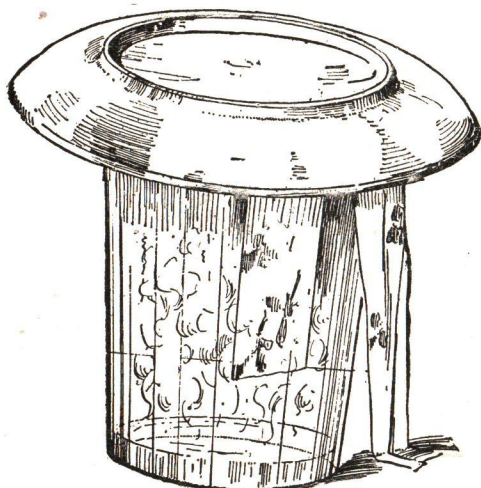


Fig. 13

EXPERIMENT 65. Bleaching with Sulphur Dioxide. Put five measures of Sodium Bisulphite in a glass tumbler. Now obtain some colored flowers or pieces of cloth and moisten them with water. Put a teaspoonful of vinegar in the tumbler and quickly introduce the flowers or pieces of colored cloth. Place a saucer over the mouth of the tumbler and set aside for one-half hour (Figure 13.)

Notice the vigorous reaction which takes place when the vinegar is added. This is due to the liberation of sulphur dioxide gas. At the end of one-half hour ex-

amine the flowers or cloth, and notice that some of the colors have been bleached out. Sulphur dioxide will bleach certain colors, but not all colors.

Sulphur dioxide is used commercially in bleaching straw, silk, and woolen goods or any material that would be injured by chlorine.

Sulphuric Acid is a very important acid. The reactions involved in the manufacture of this acid are more complicated than those in the manufacture of the other acids because it must be built up from its elements. Sulphuric acid is made commercially by either one of two methods.

First, the "Lead Chamber Process" or the older method. In this process, sulphur dioxide is prepared by burning sulphur or an ore of sulphur such as iron sulphide or pyrite. The sulphur dioxide is then conducted into large lead chambers where it comes in contact with oxygen, oxides of nitrogen and steam. These react to form sulphuric acid which is concentrated by heat treatment.

The second method known as the "Contact Process," is the more recent method and gives an acid of much higher purity. This is a more expensive method but this is compensated for by the degree of purity in the acid produced. In this process, sulphur dioxide is formed the same as in the lead chamber process. It is then passed through a tube heated at 400° Centegrade and containing a substance known as a catalytic agent. The catalytic agent has the property of making the sulphur combine with more oxygen to form sulphur trioxide and this is passed into water, forming concentrated sulphuric acid.

EXPERIMENT 66. Preparation of Sulphuric Acid. Mix together on a piece of paper one-half measure of Sulphur and one-half measure of Potassium Nitrate. Put one-fourth of this mixture—no more—in a clean dry test tube and heat slowly over a flame. Notice the white fumes which are given off. These fumes are sulphur trioxide. After the fumes stop coming off, stop the heating and place the thumb over the mouth of the tube.

After the tube has become cold, fill the test tube one-half full of water and shake the test tube, holding the thumb over the mouth. Test the liquid with Blue Litmus Paper and notice that it turns red. Sulphur trioxide combined with the water to form sulphuric acid.

THE INSOLUBLE SULPHATES

The salts formed from sulphuric acid are called sulphates. All sulphates are soluble, except those of barium, strontium, and lead. The sulphates of these metals can be precipitated, therefore, from their solutions.

EXPERIMENT 67. How to Make Strontium Sulphate. Dissolve one measure of Aluminum Sulphate in a test tube one-fourth full of water. In another test tube one-fourth full of water dissolve two measures of Strontium Nitrate. Now, mix the two solutions and notice the white precipitate of strontium sulphate which is formed.

Aluminum sulphate reacts with the strontium nitrate to form a soluble com-

pound of aluminum nitrate and an insoluble compound of strontium sulphate.

SULPHIDES

Sulphides are salts of the weak acid hydrogen sulphide. Some sulphides are insoluble in acid solution while others are soluble. The chemist makes use of this fact in separating certain metals from each other.

EXPERIMENT 68. How to Make Hydrogen Sulphide. Cut a piece of paraffin from your candle or a piece of paraffin wax about the size of a pea and put it in a test tube. Add two measures of Sulphur, place a piece of moistened Sulphide Test Paper over the mouth of the tube, and heat slowly. Notice that the test paper turns black. This is a test for hydrogen sulphide gas. The test paper contains lead acetate and when the hydrogen sulphide comes in contact with it, it forms a black precipitate of lead sulphide.

Remove the tube from the flame and smell cautiously at the mouth of the tube. Note the resemblance of the odor to that of rotten eggs. As a matter of fact, this is the gas produced when eggs go bad.

Hydrogen sulphide is given off from several organic compounds, for example, when cabbage is cooked.

Hydrogen sulphide is inflammable and when burned, the hydrogen combines with oxygen to form water, while the sulphur combines with oxygen to form sulphur dioxide.

EXPERIMENT 69. How to Make Hydrogen Sulphide Water. Generate hydrogen sulphide gas as shown in Experiment 68, and attach the gas delivery tube to the test tube. Pass the gas into a test tube half full of water for one or two minutes. Now drop into the water a piece of Blue Litmus Paper and notice that it turns red. This shows that hydrogen sulphide water is acidic.

EXPERIMENT 70. Action of Hydrogen Sulphide on Silver. Moisten a silver coin with water and hold the coin in front of the delivery tube so that the hydrogen sulphide gas, prepared as in Experiment 68, can come in contact with it. Notice after a short time that the coin turns black. This black stain is due to a precipitate of silver sulphide formed by the action of hydrogen sulphide on silver. This is the same action that takes place when household silver tarnishes or turns black.

You probably have noticed that some white paints turn black after standing for several days. This is because these paints contain lead salts chiefly lead carbonate which slowly react with traces of hydrogen sulphide gas in the air to form the black compound, lead sulphide. To prevent this, zinc oxide is used in some of the paints in place of the lead compound, for when zinc reacts with hydrogen sulphide, a white precipitate of zinc sulphide is formed.

EXPERIMENT 71. How to Restore the Color of White Paint. Obtain some white oil paintings which have become dark by the action of hydrogen sulphide. Wash these paintings with a little hydrogen peroxide solution and notice that they become white again.

If you cannot obtain any oil paintings, wet the test paper which was turned black in Experiment 68 with hydrogen peroxide, and notice that the black color disappears. What really happens is that the black lead sulphide is oxidized to a white compound, lead sulphate.

In analytical chemistry, certain metals are separated from certain other metals by passing hydrogen sulphide gas into an acid solution of the salts of these metals. One group of metallic sulphides are insoluble in acid solution while the other group is soluble. By filtering off the insoluble sulphides, we can separate one group of the sulphides from the other group in this manner.

EXPERIMENT 72. How to Make Nickel Sulphide. Dissolve one measure of Nickel Ammonium Sulphate in a test tube one-fourth full of water and pass into this solution, hydrogen sulphide gas by means of a gas delivery tube as described in Experiment 68. Allow the gas to bubble through the nickel solution for several moments. Notice the black precipitate which is formed. This precipitate is nickel sulphide.

EXPERIMENT 73. How to Make Cobalt Sulphide. Dissolve one-third measure of Cobalt Chloride and one-third measure of Sodium Carbonate in a test tube one-third full of water. Notice the blue precipitate which is formed. This precipitate is cobalt carbonate. Now pass into this solution, hydrogen sulphide gas by means of the gas delivery tube as described in Experiment 68, and after a few moments, notice the formation of a black precipitate. This precipitate is cobalt sulphide. Hydrogen sulphide reacts with cobalt carbonate to form cobalt sulphide and carbonic acid.

THE HALOGENS—THE CHLORINE FAMILY

The elements that go to make up the Chlorine family are fluorine, chlorine, bromine, and iodine. These elements are called halogens, meaning salt producers. They all resemble each other very much in chemical properties, but differ widely in physical properties. Fluorine is a colorless gas, chlorine a greenish yellow gas, bromine a brownish red liquid, and iodine a purplish black solid.

The Halogens are very active substances; therefore, they are never found in the free state in nature. Their compounds are very abundant. Those of chlorine, bromine and iodine occur in sea water. The most common of these is sodium chloride or common table salt.

As already stated, the halogens are very active substances. They combine with metals like copper, sodium, potassium, gold, silver, platinum, etc., to form salts of these metals. They also react with non-metals like sulphur, antimony and arsenic to form compounds with these substances. They react with hydrogen to form the corresponding acids, namely hydrofluoric, hydrochloric, hydrobromic and hydriodic acids. Of the halogens, fluorine is the most active and iodine the least active.

Chlorine is used extensively as a bleaching agent and germicide. It comes on the market known as bleaching powder or chloride of lime. The corresponding acid, hydrochloric acid, is an important technical acid and is used for a number of purposes.

Bromine is used principally in the preparation of bromides which are used to a considerable extent in photography and in medicine. It is also used in the preparation of a number of organic drugs and dyestuffs.

Iodine is used extensively in medicine, especially in the form of tincture of iodine. It also finds important uses in the preparation of iodides and of certain dyes and drugs. The antiseptic, iodoform, is a compound of iodine with carbon and hydrogen. This compound is analogous to chloroform, which is a compound of chlorine with hydrogen and carbon.

POISONOUS WAR GASES—THE GAS MASK

During the world war, chlorine gas and compounds containing chlorine were used extensively, and made up the bulk of the so-called poisonous gases. Chlo-

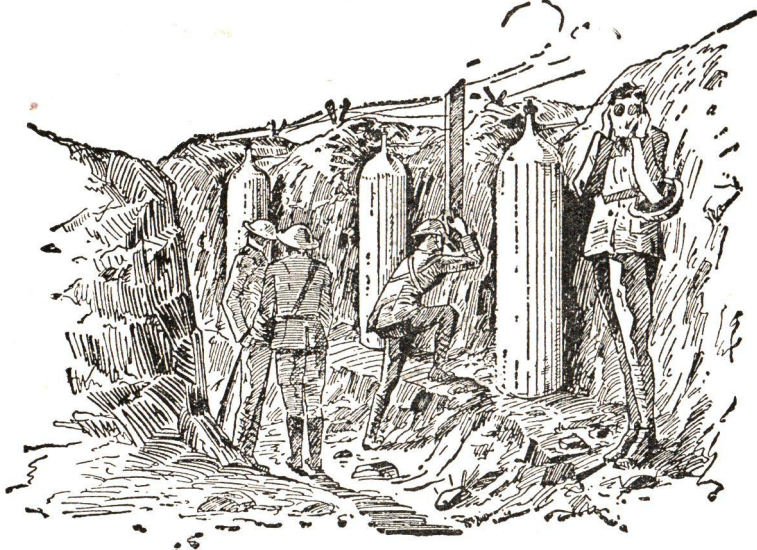


Fig. 14.

rine is a heavy suffocating gas and is easily transported in steel cylinders. During the early part of the war this gas was blown across "No Man's Land" into the enemy trenches by means of a nozzle, by relieving the gas under pressure in

the steel cylinders. (Figure 14) However, changing winds soon caused this gas to be abandoned as it was sometimes blown back into the home trenches.

Some of the highly poisonous compounds of chlorine that were used during the war were organic compounds containing chlorine. Phosgene was one of these very poisonous gases, while chlorpicrin and mustard gas were very poisonous liquids. Phosgene, chlorpicrin and mustard gas were sent over into the enemy trenches in shells which, on exploding, scattered the deadly gas in the form of a fine vapor or spray in all directions.

As a preventative against gas poisoning, the well-known gas mask was invented. This consisted of a face piece to shut out the gases from the nose, mouth and eyes, and from this ran a flexible rubber tube to a cannister or container which held the chemicals for neutralizing the poisonous gases. On breathing in, the poisonous air passes into the cannister where the deadly gases are removed, allowing the good air to pass up through the flexible tube, the end of which is held in the mouth, and then into the lungs. The exhaled air is passed out through a rubber slit in the lower part of the face piece. The chemicals used to remove the gases were principally a mixture of charcoal and soda lime.

EXPERIMENT 74. How to Make Chlorine Gas. Put two measures of Potassium Nitrate, two measures of Sodium Bisulphate and two measures of Sodium Chloride (common table salt) in a test tube, and heat the test tube gently over a flame for a few moments. Remove the test tube from the flame and smell cautiously the gas which is given off. This is chlorine gas.

Sodium bisulphate reacted with sodium chloride to form hydrogen chloride gas which was oxidized by oxygen from the potassium nitrate to form water and chlorine gas.

EXPERIMENT 75. To Show the Bleaching Properties of Chlorine. Prepare chlorine gas as in Experiment 74, placing a small piece of moistened Blue Litmus Paper over the mouth of the test tube before heating. Notice on heating that the blue litmus paper turns white, showing that chlorine gas has the property of bleaching certain colors.

What happened was that the chlorine gas reacted with water on the blue litmus paper, forming hydrochloric acid and oxygen. It is really this free oxygen that does the bleaching.

EXPERIMENT 76. How to Make Hydrochloric Acid. Put two measures of Ammonium Chloride and two measures of Sodium Bisulphate in a test tube. Now heat the tube slowly over a flame for a few minutes. Notice that the litmus paper turns red, proving that an acid has been formed. Remove the test tube from the flame and smell cautiously. The gas that is given off is hydrogen chloride gas.

Dip the glass stirring rod in a little household ammonia and hold the rod over the mouth of the test tube. Notice the white fumes that are formed. These fumes are ammonium chloride fumes.

Hydrogen chloride gas, as prepared in this experiment when dissolved in water forms hydrochloric or muriatic acid. Commercially, hydrochloric acid is manufactured by heating sodium chloride with sulphuric acid.

EXPERIMENT 77. How to Make Iodine. Put four drops of Sodium Iodide Solution into a test tube one-fourth full of water and mix the contents of the tube by shaking. Now prepare chlorine gas as shown in Experiment 74 and fit the test tube with a gas delivery tube. Allow the chlorine gas to bubble through the sodium iodide solution prepared as above, and notice after a few moments that the solution turns brown.

Chlorine gas reacts with sodium iodide to form sodium chloride and free iodine. It is this free iodine that gives the solution its brown color.

EXPERIMENT 78. How to Test for Iodine. Prepare some starch solution by putting one measure of powdered household starch in a test tube, and moisten with a few drops of water. Now heat a test tube half full of water to boiling, and pour the hot water into the test tube containing the starch paste. To this starch solution, add five drops of Sodium Iodide Solution.

To a dry test tube add two measures of common table salt or Sodium Chloride, two measures of Potassium Nitrate and two measures of Sodium Bisulphate. Insert the perforated cork with the gas delivery tube and heat the test tube slowly over a flame. After the gas starts to come off freely, insert the end of the delivery tube into the test tube containing the starch solution and sodium iodide and allow the chlorine gas to bubble through the starch solution for several moments. Notice the blue color which is formed. This is the test for free iodine.

The chlorine gas displaced the iodine in the sodium iodide solution, liberating free iodine. The free iodine, in the presence of starch produced a blue color.

CARBON, CARBONIC ACID, CARBONATES— COMBUSTION

Carbon is found in nature in the free condition in several forms. The diamond is practically pure carbon while coal and graphite contain small percentages of other substances besides carbon as mineral matter. Its natural compounds are very numerous and are found in the form of gases, liquids and solids. Carbon dioxide is the most familiar gaseous compound. Illuminating gas and petroleum are composed chiefly of compounds of hydrogen with carbon.

The carbonates, especially calcium carbonate go to make up a large portion of the rocks and are found in most localities. Carbon constitutes a large percentage of living organisms, both plant and animal and more than 200,000 organic compounds of carbon are now known. It is the element most commonly associated with life itself.

Coke is a fuel used in smelting processes and in large boiler engines and is one of the forms of carbon. It is made by heating bituminous or as it is commonly called, soft coal, until the gases which are in the coal are driven off. This heating is done without access of air and on a commercial scale the heating is done in large ovens.

EXPERIMENT 79. Preparation of Coke and Coal Gas. In a small clean dry test tube put three measures of soft coal. Heat over the flame for about five minutes. Remove the tube from the flame and smell of the escaping gas. Try to light it. Notice that it burns with a blue flame. The gas evolved is essentially coal gas and burns with a blue flame.

After the gas stops coming over, allow the test tube to cool, then dump the contents on a paper. Notice the spongy mass. This is coke and is almost pure carbon. In performing the experiment, if it is possible, heat the test tube over a gas flame.

CARBON

The element carbon is probably one that the present world could not get along without. All the motive power derived from steam engines, all the furnaces making iron and steel, indeed our whole present day civilization may truly be said to rest upon the use of carbon as fuel.

The four distinct forms in which the element carbon occurs are (1) diamond, (2) graphite, (3) charcoal, and (4) coke, which we have already described.

HOW DIAMONDS HAVE BEEN MADE

Pure carbon (sugar carbon) is mixed with soft iron in a crucible. This is heated to 4000° Centegrade at which temperature iron melts like wax. Molten iron dissolves carbon much as water dissolves sugar. When cooled at ordinary pressure carbon separates as graphite.

At extraordinary pressure carbon crystallizes and forms the diamond. The greater pressure is obtained by throwing the molten mass of iron into cold water. A hard steel jacket is formed. Now iron decreases in volume when passing from the liquid to the solid state. This causes a contraction of the iron shell and thus an enormous internal pressure is produced under which the dissolved carbon separates out as crystals or diamonds.

GRAPHITE

Graphite, the second form of carbon, is the black substance which forms the core in lead pencils. It is sometimes called lead, however, it is not lead. Graphite is made from ordinary carbon by subjecting it to very intense heat. At 4000° Centegrade carbon vaporizes and this vapor on condensing, forms graphite.

Graphite is used in the manufacture of crucibles, as a lubricant, as a protective covering such as stove polish and in the manufacture of lead pencils.

CHARCOAL

Charcoal is made by the Destructive Distillation of sugar, wood or bones. By destructive distillation is meant heating without access to air. In this way the gases are driven off, leaving charcoal. If heated with admission of air the charcoal would burn up forming carbon dioxide gas.

Charcoal is a splendid deodorizer and decolorizer. It is full of pores and absorbs odors and gases.

Charcoal is heavier than water but ordinarily it floats in water. This strange behavior is due to the fact that the charcoal has absorbed a quantity of gas from the air.

EXPERIMENT 80. Preparation of Charcoal—Pyro-Ligneous Acid.

Break up a few toothpicks or pieces of wood and place them in the bottom of a test tube. Now put a piece of moistened Blue Litmus Paper over the mouth of the test tube and heat over an alcohol lamp or gas flame. Notice that the paper turns red proving that an acid is evolved. This acid is called Pyro-Ligneous acid and is essentially acetic acid.

Now insert the perforated cork with delivery tube, continue the heating and light the gas that comes off. Notice that it will burn. This gas is similar to that obtained from the distillation of coal.

When no more gas is evolved allow the tube to cool, then empty the contents of the test tube on paper. This is charcoal and is practically pure carbon.

When fat pine is distilled, turpentine and tar oils are derived from it. The turpentine is the volatile oil, that is, it passes off as vapor. The tar oils are the heavy resinous oils, brown in color such as you may see at the bottom of your test tube.

To summarize; when coal is heated without admission of air, coal gas, ammonia and coal tar are obtained. The gas is used for lighting and heating. The ammonia which is derived is purified and finds many uses. From the coal tar are derived intermediates from which aniline dyes, disinfectants, such as carbolic acid, high explosives and many other valuable products are manufactured.

It can be seen, therefore, that enormous industries are based upon this process of heating wood and especially coal without admission of air.

EXPERIMENT 81. Preparation of Carbon Dioxide—Effervescence.

Make a solution of Sodium Bicarbonate by shaking up a test tube one-third full of water containing two measures of Sodium Bicarbonate. In another test tube make a solution of Tartaric Acid by shaking up a test tube one-third full of water containing two measures of Tartaric Acid. Now pour the tartaric acid solution into the solution of Sodium Bicarbonate.

Notice the violent effervescence due to the chemical action and liberation of carbon dioxide gas. You will notice that it has no odor. This is the same gas that you see bubbling out of soda water.

EXPERIMENT 82. To Show That Carbon Dioxide is Heavier Than Air and Will Not Burn. Light the candle and set it firmly on a board by sticking it to a little melted wax from the flame of the candle.

Now put one-half teaspoonful of Sodium Bicarbonate or common baking soda in a glass and add some vinegar or a solution of Tartaric Acid to the glass. A violent reaction takes place with the evolution of carbon dioxide gas. Now pour the gas in the glass on to the flame just as though you were pouring water out of the glass, taking care not to spill any of the acid out of the glass. (Figure 15.) Notice that the flame goes out proving that carbon dioxide is heavier than air and will settle to the earth and also that it will not burn.

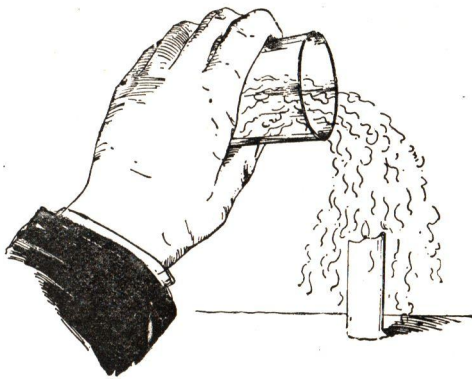


Fig. 15.

EXPERIMENT 83. Sodium Bicarbonate, a Fire Extinguisher. Wrap in a sheet of paper a spoonful of Sodium Bicarbonate or baking soda, set the paper in a saucer and light the paper. Notice that the flame soon goes out. This is due to carbon dioxide being liberated.

When sodium bicarbonate is heated, it decomposes readily into sodium carbonate, water and carbon dioxide gas.

EXPERIMENT 84. Chemistry of the Flame. Examine closely your alcohol flame or candle flame and notice that it consists essentially of three cones. (Figure 16.) First, a dark cone just around the wick, second, a yellow cone which produces light and third, a semi-transparent cone of heat around the outside.

The dark cone of the flame consists of unburned gases which are given off from the wick of the candle. The paraffin is melted by the heat and drawn into the wick by capillary action. To prove this hold one end of a glass tube, in the flame just over the wick. Now apply a flame to the other end of the tube and notice that it takes fire. The gas in this cone is relatively cool for if a match stick is placed in it the portion of the stick which was in the dark cone will not burn as soon as the portion passing through the sides of the flame.

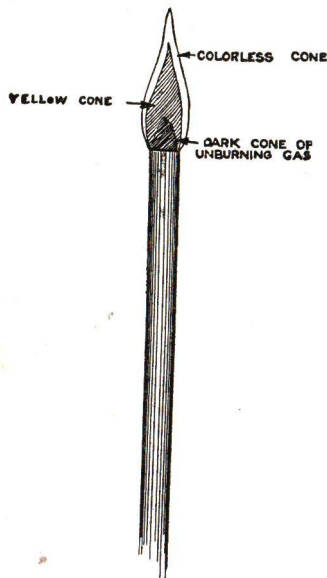


Fig. 16

The second or yellow cone of the flame consists of particles of carbon that have been heated to white heat so they glow brightly.

Hold a cold spoon or glass rod in this cone for a minute and notice that it is covered with a black deposit of carbon called lampblack, thus proving that this cone consists of small particles of carbon. The cold spoon chilled the flame, thereby causing the carbon particles to be deposited. Lampblack is made upon this principle on a manufacturing scale.

The third or outer cone of the flame consists of the gases formed by the complete burning of the carbon particles to carbon dioxide gas. This is the hottest portion of the flame and whenever heating a liquid in a test tube, for example, it is important, in order to obtain the highest heat possible and to prevent the deposit of soot, to hold the test tube at the tip of the luminous or light-giving part of the flame.

EXPERIMENT 85. Carbon Dioxide from a Burning Candle. Make some lime water by putting two measures of Calcium Oxide in a test tube one-half full of water and shaking the test tube well for three or four minutes. Allow this solution to stand until clear, then pour the clear liquid into another test tube. You now have a clear solution of lime water or calcium hydroxide.

Now hold a wide mouthed bottle or fruit jar over a candle flame as shown in (Figure 17) so that the burning gases from the flame may enter the mouth of the bottle. After allowing the gases to enter the bottle for about a minute, close the mouth of the bottle with the palm of the hand and inverting the bottle pour the lime water into it. Again put the palm over the mouth of the bottle and shake for a moment. Notice that the lime water becomes turbid or milky. This turbidity is due to a white precipitate of calcium carbonate formed by the action of carbon dioxide on calcium hydroxide.

EXPERIMENT 86. How to Make Water from Fire. Hold a cold glass tumbler over a flame so that the tip of the flame just enters the mouth of the glass. After a few moments remove the glass and notice that moisture has been deposited on the inside of the glass.



Fig. 17.

We have already said that carbon dioxide is one of the products of combustion. Water is another product and is usually given off in the form of vapor or steam. In this experiment the steam condensed on striking the cold glass, therefore, forming a deposit of moisture.

EXPERIMENT 87. Carbon Dioxide in the Breath. Make up a solution of Lime Water as shown in Experiment 85.

Now take a hollow glass tube, put one end into the test tube containing the lime water and allow your breath to bubble through the lime water (Figure 18). Notice that very soon the water becomes turbid and after a short while a white precipitate is formed. This precipitate is calcium carbonate and is formed by the action of carbon dioxide in the breath upon lime water or calcium hydroxide.

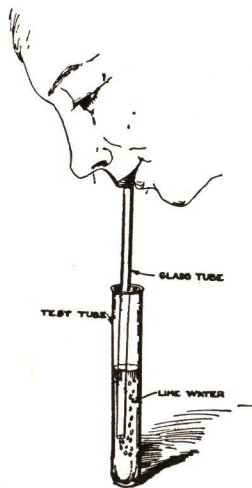


Fig. 18.

EXPERIMENT 88. Carbon Dioxide in the Air. Make up a solution of Lime Water as shown in Experiment 85 using twice the amounts. Pour the lime water into a saucer and allow it to stand for a day. Notice that a white crust has formed on the surface of the lime water or calcium hydroxide. This solid is calcium carbonate formed by the action of carbon dioxide of the air upon the lime water.

EXPERIMENT 89. How to Test for Carbonates in Some Household Materials. Test portions of the following substances for carbonates by putting two measures of the powdered substance in a test tube and add eight or ten drops of vinegar. A violent reaction or effervescence shows that a carbonate is present in the substance.

1. Baking Soda (sodium bicarbonate)
2. Washing Soda (sodium carbonate)
3. Baking Powder (a mixture of sodium bicarbonate with potassium acid tartrate and potassium acid phosphate or alum)
4. Oyster shells and egg shells (chiefly calcium carbonate)
5. Chalk (calcium carbonate)
6. Toothpowder (calcium carbonate)
7. Plaster (calcium carbonate)

EXPERIMENT 90. How to Make Baking Powder. Put two measures of Sodium Bicarbonate and two measures of Tartaric Acid into a test tube. Mix thoroughly by closing the mouth of the tube with your thumb and shaking back and forth. Notice that nothing happens. Now add a half test tube full of water and notice the sudden reaction. These are the two active constituents of baking powder. The gas liberated is carbon dioxide.

Baking powder is composed of two or sometimes more chemicals which when dry are not active. When water or moisture is applied the tartaric acid and sodium bicarbonate are put into forms whereby they react readily upon each other the sodium bicarbonate giving up its carbon dioxide. This gas is the same gas exactly as that formed in the lungs or in soda water.

BAKING POWDER IN BREAD MAKING

In making bread, baking powder is thoroughly mixed with the dry flour. Water is then added, the flour is kneaded into a dough and put in a warm place to rise. Heat nearly always hastens a chemical reaction; that is why dough rises quicker in a warm place than in a cool place.

The moisture plus the tartaric acid act upon the sodium bicarbonate and start the formation of carbon dioxide. Soon the dough begins to rise due to the gas being liberated. The powder has been distributed throughout the mass, so that a million gas bubbles are formed which puff out the dough making it porous. During the process of baking the gas and the remaining constituents of the baking powder are converted into harmless substances.

Most of the carbonates are insoluble compounds and can therefore be precipitated from solutions of their soluble salts by carbon dioxide or a soluble carbonate.

Some of these insoluble carbonates are beautifully colored and make very interesting experiments.

EXPERIMENT 91. How to Make Nickel Carbonate. Make a solution of Sodium Carbonate by dissolving one measure of the compound in a test tube one-fourth full of water. Make a solution of Nickel Ammonium Sulphate by dissolving one measure of this compound in a test tube one-fourth full of water. Now add some of the sodium carbonate solution to the nickel solution and notice the formation of a light green precipitate of nickel carbonate.

EXPERIMENT 92. How to Make Cobalt Carbonate. Repeat Experiment 91 using one measure of Cobalt Chloride in place of the nickel salt. Notice the formation of a light blue precipitate of cobalt carbonate.

EXPERIMENT 93. How to Make Manganese Carbonate. Repeat Experiment 91 using one measure of Manganese Sulphate in place of the nickel salt. Notice the formation of a white precipitate of manganese carbonate.

EXPERIMENT 94. How to Make Strontium Carbonate. Repeat Experiment 91 using one measure of Strontium Nitrate in place of the nickel salt. Notice the formation of a white precipitate of strontium carbonate.

SILICON AND SILICATES

Next to oxygen, silicon is the most abundant element. The solid crust of the earth contains 28 percent of silicon. Granite, gneiss, sandstone, shale, clay and marl contain large percentages of the element. In inorganic chemistry silicon is the common element just as carbon is the outstanding element in organic chemistry.

A great many very important industries are based upon the silicates and the chemical transformation which they undergo. The first of these and oldest are those which manufacture bricks, tile, terra cotta, dishes, porcelain and glass. Glass making and the making of porcelain and the glazing of clay vessels are very similar from a chemical standpoint. This can also be said about the making of cement. These three industries, namely glass, porcelain and cement are collectively known as the ceramic industries and are all based upon the conduct of metallic silicates.

Silicon, the element, forms an oxide with oxygen, namely, silicon dioxide, and as such is found in nature as quartz, sand and flint. It also forms compounds with metals and as such are called silicates. Some of our minerals are complex silicates. Did you ever know that the mica in your stove door, the talcum powder that you buy at a drug store, the asbestos curtains in a theatre are all complex silicates of silicon with hydrogen, oxygen and metals?

GLASS MAKING

Glass and pottery are the earliest products of man's chemical industry. Both were known as far back as 4000 B. C., almost 6000 years ago. Sculptures of glass blowers have been found in the tomb of Beni-Hassan, an ancient king who reigned about 1800 B. C.

Glass making had its birth in the far East. From there the knowledge of glass making spread to Greece and Rome. The Romans carried the art with them when they started to conquer and civilize what is today Europe.

The essential materials in glass making are:

1. Sand, chemically known as silica.
2. Calcium oxide (lime) or lead oxide.
3. Sodium carbonate or potassium carbonate.

These materials are mixed together in the proportions suitable for the kind of glass required. There are many different kinds of glass, depending on the purpose to be served. The mixture is put into earthen vessels of special design and fused in a furnace.

In order to give glass brilliant colors various oxides of metals are added. Copper oxide gives glass a ruby red color. Cobalt gives a wonderful blue, a fact which was known centuries ago. The green color in ordinary glass is due to the iron in the sand batch.

Cut-glass ware is made with lead oxide. Lead oxide gives an added brilliancy and weight. Imitation paste jewelry is also made from lead oxide glass or lead glass, as it is commonly known.

Glass can be spun as fine as silk floss. In this state it is called glass wool and is used for insulating purposes in electric lamps and for ink erasers.

HYDRAULIC CEMENTS

Hydraulic cements, of which Portland cement is an example, is made by burning limestone that contains aluminum silicate. The fact that it sets or hardens when mixed with water is due to the formation of silicates of calcium and aluminum. Since these silicates are insoluble in water, the cement may be used for submerged masonry.

ORDINARY CLAY

Ordinary clay is an impure aluminum silicate. When mixed with water it forms a plastic mass which can be easily molded into any desired shape. On baking and drying these molds become hard, brittle and very durable. The common clays are used in the manufacture of tile, bricks and earthenware.

Earthenware and tile are rendered water proof by glazing. This is done by throwing common salt into the furnace just before the "firing" is finished. The salt volatilizes forming a glass like coating of sodium and aluminum silicate on the surface of the earthenware.

PORCELAIN CLAY

Porcelain clay or kaolin is a very pure silicate of aluminum, silicon, oxygen and hydrogen. In making porcelain a mixture of kaolin, feldspar, flint and quartz is used. This mixture is molded by machinery in a moistened condition, dried and then ignited in a biscuit kiln. On strong heating feldspar fuses, filling the pores of the clay thus furnishing a fused transparent mass. This gives an unglazed porcelain.

To make a glazed product the porcelain after being molded and dried is sprayed with or dipped in a glazing mixture consisting essentially of powdered feldspar in water suspension. The article is now raised to white heat, at which temperature a thin smooth glassy coating is formed on the porcelain due to the fusion of the feldspar. To produce a colored glaze the proper metallic oxide is added to the glazing mixture before it is sprayed on the article.

Sodium silicate known as water glass and commonly used for preserving eggs over winter is one of the soluble silicates.

EXPERIMENT 95. Colloidal or Orthosilicic Acid. Put one-half spoonful of Water Glass in a test tube one-fourth full of water. Mix thoroughly by shaking.

Then make a solution of Sodium Bisulphate in another test tube by adding five measures of Sodium Bisulphate to a test tube one-third full of water and shake until completely dissolved.

Now mix the two solutions and notice that a jelly like substance is slowly formed. This is known as colloidal or orthosilicic acid and has the formula H_4SiO_4 .

EXPERIMENT 96. Silicon Dioxide. Remove some of the jelly like substance prepared in Experiment 95 from the test tube by means of a stirring rod and place it on the spoon. Now heat the spoon in an alcohol lamp or gas flame until the precipitate is dry and a white solid is left. This material is silicon dioxide and is the same as ordinary pure sand. On heating the silicic acid, the water was simply driven off leaving silicon dioxide.

Most of the metallic silicates are insoluble and are formed by treating a soluble silicate like sodium silicate or water glass with a metallic salt. Many of these insoluble silicates are highly and beautifully colored.

EXPERIMENT 97. Blue Cobalt Silicate. Dissolve one measure of Cobalt Chloride in a test tube one-third full of water and add two or three drops of Water Glass. Notice the beautiful blue precipitate of cobalt silicate which is formed.

EXPERIMENT 98. Pink Manganese Silicate. Dissolve two measures of Manganese Sulphate in a test tube half full of water, heating if necessary to dissolve all the solid. Add two or three drops of Water Glass and notice the formation of a pink manganese silicate.

EXPERIMENT 99. Green Iron Silicate. Dissolve two measures of Ferrous Ammonium Sulphate in a test tube half full of water and add two or three drops of Water Glass. Notice the formation of a green precipitate of ferrous silicate.

EXPERIMENT 100. Reddish-Brown Iron Silicate. Dissolve two measures of Ferric Ammonium Sulphate in a test tube half full of water. Add two or three drops of Water Glass and notice the formation of a reddish-brown precipitate of ferric silicate. In these two compounds, namely ferrous and ferric silicates the difference in color is due to the condition of the iron present. In ferrous silicate the iron has a valence of two while in ferric silicate it has a valence of three.

EXPERIMENT 101. Green Nickel Silicate. Dissolve two measures of Nickel Ammonium Sulphate in a test tube half full of water and shake well to dissolve the solid. Add two or three drops of Water Glass and notice the beautiful green precipitate of nickel silicate.

EXPERIMENT 102. White Strontium Silicate. Dissolve two measures of Strontium Nitrate in a test tube half full of water and add two or three drops of Water Glass. Notice the formation of a white precipitate of strontium silicate.

EXPERIMENT 103. White Aluminum Silicate. Dissolve one measure of Aluminum Sulphate in a test tube one-third full of water. Add two or three drops of Water Glass and notice the formation of a white bulky precipitate of aluminum silicate.

BORON AND BORATES

The element boron resembles silicon very much in its chemical properties. It has been found in nature in the form of boric acid in many hot springs, particularly in Italy and California. It occurs in large quantities in the form of its sodium salt known as borax and in this form is found in the desert regions of

California and Nevada. It is also found occurring as complex minerals such as boracite, a magnesium salt found in Stassfurt deposits of Germany and colemanite, a calcium salt found in some deposits in California. Boron can be prepared in such a way that it resembles the diamond in hardness.

Boric acid, which is easily prepared by treating a solution of borax with an acid, is used as a mild antiseptic in surgery and in talcum powder. It is also used as a preservative in some instances.

Borax is much used in the place of soap in household cleaning and for softening of hard water. When heated borax swells up to a bulky mass, loses its water-of-crystallization and then melts to a clear glass. This glass readily dissolves various metallic oxides which impart characteristic colors to the glass. This property is made use of in testing for certain metals in chemical analysis. For this same reason borax is used as a flux in brazing or hard soldering. The metallic oxides which coat the surfaces of the metals to be joined are dissolved by the borax and a clean surface is produced to which the solder will adhere.

One of the chief applications of borax is its use in connection with enamels. When borax is mixed with an enamel it gives the enamel the property of binding itself to iron or other metals thereby making a good covering material.

EXPERIMENT 104. How to Test for Boric Acid. Dissolve two measures of Boric Acid in a test tube one-third full of alcohol. Now pour this solution into a saucer, darken the room and light the alcohol with a flame. Notice that the alcohol burns with a green flame. This is a test for boron or boric acid.

EXPERIMENT 105. Borax Glass Bead. Clean the end of the Nickel-steel Wire with a little moist sand or file. Wipe dry with a cloth and make a loop in the clean end by curling it around the sharpened end of a pencil. The loop should be about one-fourth of an inch long and one-eighth of an inch wide.

Now heat the loop in the flame and dip it into Borax powder. Heat the powder in the alcohol flame or gas flame as hot as possible. Notice that the borax swells up and froths. On further heating it will melt together and on cooling will form a thin transparent glass bead. What made the borax swell up? Borax, when heated, loses its water-of-crystallization and it was this water going off in the form of steam that made the borax puff up. The glass bead remaining consists of two molecules of boric oxide with one molecule of sodium oxide.

Many metallic oxides dissolve in borax glass imparting to it the characteristic color of the metal. Therefore use is made of this in testing for certain metals in analytical chemistry.

EXPERIMENT 106. Nickel Borax Bead. Repeat Experiment 105 and just before the glass bead is cool touch it to a bit of Nickel Ammonium Sulphate about the size of a pin head, no more. Now heat the bead in the flame again for several minutes until the nickel salt has completely dissolved throughout the bead. Then allow to cool and notice the brown color due to the nickel.

EXPERIMENT 107. Cobalt Borax Bead. Repeat Experiment 105 and just before the glass bead is cold touch it to a bit of Cobalt Chloride the size of a pin head, no more. Now heat the bead in the flame again for several minutes until the cobalt salt has completely dissolved throughout the bead and allow the bead to cool. Notice the bright blue color due to cobalt.

EXPERIMENT 108. How to Make Manganese Tetraborate. Make a solution of Manganese Sulphate by dissolving two measures of the compound in a test tube one-fourth full of water. In another test tube make a solution of Borax by dissolving two measures of this compound in a test tube one-fourth full of water. Now mix the two solutions and notice the formation of a white precipitate of manganese tetraborate. The other product formed in the reaction is sodium sulphate.

EXPERIMENT 109. How to Make Nickel Tetraborate. Repeat Experiment 108 using two measures of Nickel Ammonium Sulphate in place of the manganese salt. Notice the formation of a green precipitate of nickel tetraborate. The other products formed in the reaction are ammonium sulphate and sodium sulphate.

EXPERIMENT 110. How to Make Cobalt Tetraborate. Repeat Experiment 108 using two measures of Cobalt Chloride in place of the manganese salt. Notice the formation of a precipitate of cobalt tetraborate. The other product formed in the reaction is sodium chloride.

EXPERIMENT 111. How to Make Aluminum Tetraborate. Repeat Experiment 108 using two measures of Aluminum Sulphate in place of the manganese salt. Notice the formation of a white precipitate of aluminum tetraborate. The other product formed in the reaction is sodium sulphate.

STRONTIUM AND THE MANUFACTURE OF FIREWORKS

Certain metals, as we shall show in some later experiments in flame colors of metals, impart a characteristic color to the flame when burned. Strontium is one of these metals and is used in the preparation of fireworks to give a red light or fire.

EXPERIMENT 112. How to Make Red Fire. Mix together thoroughly on a pan two measures of Strontium Nitrate, one measure of Potassium Nitrate, one measure of Sulphur and two measures of Powdered Charcoal. Make into a small pile and keeping the face at a safe distance light the pile with a match. Notice that the mass takes fire readily and burns with a red light due to the strontium. The sulphur and charcoal act as combustible materials while the potassium nitrate furnishes oxygen for the reaction.

EXPERIMENT 113. How to Make Green Fire. Zinc, when in the form of a powder burns with a green flame.

Repeat Experiment 112 using two measures of Powdered Zinc, two measures of Potassium Nitrate, two measures of Powdered Charcoal and one measure of Sulphur. Notice that this mixture when ignited will burn with a green flame. These mixtures can be ignited to good advantage by the use of a fuse. The fuse is prepared by soaking a piece of ordinary string in a strong solution of Potassium Nitrate and allowing the string to dry.

EXPERIMENT 114. How to Make Yellow Fire. Sodium when burned produces a yellow flame.

Repeat Experiment 112 using one measure of dry Sodium Chloride, two measures of Potassium Nitrate, one measure of Sulphur and two measures of Powdered Charcoal. Ignite the mixture and notice that it burns with a yellow flame.

TESTING METALS BY THEIR FLAME COLORS

Certain metals when burned in a colorless flame give the flame a characteristic color. By means of the color flames therefore, it is sometimes possible to tell what metal is present in a compound.

EXPERIMENT 115. Flame Color Test for Sodium. Throw one measure of table salt (sodium chloride) upon some burning coals. Notice that a yellow flame is produced. This is the flame color for the metal sodium.

Throw a little baking soda upon some burning coals. What is the metal present in baking soda?

EXPERIMENT 116. Flame Color Test for Strontium. Repeat Experiment 115 using one measure of Strontium Nitrate in place of sodium chloride. Notice that a red flame is produced this time. This is the flame color test for the metal strontium.

EXPERIMENT 117. Flame Color Test for Zinc. Repeat Experiment 115 using one measure of Powdered Zinc in place of the sodium chloride. Notice the bluish-white color produced by this metal. This is the flame color test for zinc.

EXPERIMENT 118. Flame Color Test for Boron. Repeat Experiment 115 using one measure of Boric Acid in place of sodium chloride. Notice the green flame produced by this compound. This is the flame color test for boron.

PART II.

ORGANIC CHEMISTRY AND ITS COMMERCIAL APPLICATIONS TO THE INDUSTRIES.

THE SOAP AND GLYCERINE INDUSTRY

Most of us are familiar with soap and its cleansing properties, but how few of us understand the chemistry of soap making and the part soap plays in cleansing. Soap was made in early history by treating fat with the lye obtained by extracting wood ashes with water and lime. What really happens when ashes are treated in this way is that potassium carbonate which occurs in wood ashes is dissolved by the water. This water solution of potassium carbonate then reacts with the lime, or calcium oxide to form an insoluble compound of calcium carbonate and a soluble compound of caustic potash, potassium hydroxide or lye as it is commonly called. Fats or grease, which are compounds of glycerine with fatty acids are then boiled with the proper proportion of lye. During the reaction the glycerine of the fat is set free and a compound of the fatty acid with the lye is formed, which is the soap.

If too much alkali is used in making a soap, the soap will contain free alkali which is bad. If not enough alkali is used the soap will be greasy which is also bad. It is up to the chemist in the soap factory to determine exactly what the suitable proportions are for every sample of soap to be made. In making fine soaps such as Castile soap and the high grade toilet soaps olive oil is used instead of fat and in the manufacture of many soaps, perfumes and coloring matters are mixed with the other material. Ordinary white soaps are made from cotton seed oil. Cheap laundry soaps are made from impure fats obtained from kitchen grease, bones, etc. Glycerine soaps are made by melting hard soap and adding an equal amount of glycerine.

The difference between hard and soft soaps is due to the materials contained in them. Soaps made from caustic potash or potassium soaps are soft, while those made from caustic soda or sodium soaps are hard.

In making hard soap, caustic soda and fat are boiled together and when the contents of the vessel are thoroughly united a strong solution of sodium chloride

or common salt is added and the mixture heated again. The heating is then stopped and the contents allowed to stand for several hours. During this time the contents of the vessel separate into two portions, the lower one consisting of glycerine, salt and all impurities and the upper one of soap. The glycerine is separated from the water and is used in medicine and in the manufacture of high explosives such as nitroglycerine and dynamite.

Did you ever stop to think what happens when you wash your hands with soap? The soap removes grease or oil from your hands by breaking it up into tiny droplets that are washed away by the water. In other words, when you produce a lather on the hands with soap you emulsify the oil or grease and in this condition it is easily removed.

EXPERIMENT 119. Making Soap. Make a solution of caustic soda or lye by putting three measures of Sodium Carbonate and four measures of Calcium Oxide into a test tube one-half full of water and boil for two or three minutes. Allow the tube to cool and when the liquid has settled pour the clear liquid into another test tube. Now add a piece of lard or butter about the size of a marble and boil the liquid again for a few minutes being careful that the liquid does not bump out of the test tube. You can prevent this by shaking the tube in the flame while heating. Notice that the lard or butter dissolves very readily in the hot alkali.

Now add three measures of common salt and heat the mixture again for two or three minutes. Allow the contents of the tube to cool and notice that the soap separates out as the upper layer. The liquid layer below contains glycerine, salt and impurities. Try washing your hands with the soap you have made.

EXPERIMENT 120. Why Soap Cleanses. Put a little kerosene or oil into a test tube one-third full of water and shake the contents of the tube. Notice that the oil has been broken up into minute droplets. Allow the tube to stand and now notice that the oil runs together and rises to the top of the water.

Repeat this experiment using the white of an egg in place of the water. Notice that this time the oil is broken up into minute droplets as before but remains in this condition and does not run together and rise to the top of the mixture. This forms what is called an emulsion, the oil being emulsified.

Repeat this experiment using a soap solution in place of the white of an egg and convince yourself that the soap forms a true emulsion with the oil. It is due to this fact that oil, grease and dirt are easily removed from the hands when washed with soap.

EXPERIMENT 121. How to Test for Free Alkali in Soap. Test samples of household soap, both laundry and toilet soaps for free alkali by cutting a fresh surface on the soap with a knife and dropping on to the fresh surface one or two drops of Phenolphthalein Solution. If the phenolphthalein turns red the soap contains free alkali.

BOY ENGINEERING

Laundry soap usually contains free alkali. Toilet soap should be nearly or quite free of alkali as it roughens and chaps the skin.

EXPERIMENT 122. Making Metallic Soap. Dissolve a piece of soap about the size of a pea in a test tube half full of water by shaking the test tube and warming a little if necessary. Allow the soap solution to cool, then add one measure of Nickel Ammonium Sulphate and shake the contents of the test tube again. Notice the formation of a green precipitate. This is green nickel soap. Iron, copper and lead soaps could also be made in this way.

THE INK INDUSTRY

Most of the common black inks are made from nut-galls and ferrous (iron) sulphate. The nut-galls are rich in tannic acid and this with ferrous sulphate gives a black precipitate. Colloidal or jelly like substances, such as gum arabic or dextrin are sometimes added as these substances delay the precipitation, although the very black color is produced at once. Some preservative is usually added to prevent the ink from moulding.

Today very good black inks are made from derivatives of the organic compound aniline. Aniline is a compound obtained indirectly from coal tar.

Much time has been devoted to finding an ink that would be permanent and resist all attempts to remove it from paper. Most inks can be erased from paper without much difficulty. Printers ink, however, which is made from lampblack, has been found to be the most permanent as the finely divided carbon which is held firmly within the pores of the paper is insoluble in all liquid solvents so that it cannot be removed by washing. It is also very difficult to erase it without destroying the paper.

Silver nitrate when in contact with an oxidizable material such as cloth is reduced in the presence of light to black metallic silver. Because of this fact it is used in the manufacture of indelible inks.

Quite often it is desirous of making several copies from a single document. In order to do this an exact copy of the document is made on heavy paper using copying ink. The desired copies are then made by using very thin unsized paper and placing them on the copy prepared with copying ink. Pressure is then applied to the copies so that the inks penetrate through the duplicates. It is possible by this method to prepare as many as half a dozen duplicate copies at one time from the original copy.

EXPERIMENT 123. How to Make Black Writing Ink. Dissolve one measure of Tannic Acid in a test tube one-third full of water. Then in another test tube one-third full of water, dissolve one measure of Ferric Ammonium Sulphate. Now mix the two solutions and notice the intense dark black color formed by the reaction of the two substances. The black color and precipitate is due to the formation of iron tannate. Try writing with this ink, using a clean pen.

If you wish to make up a bottle of black ink to use permanently proceed as follows: Dissolve four measures of Tannic Acid in a test tube three-fourths full of water. Pour this solution into a glass, containing six test tubes full of water. In another test tube three-fourths full of water dissolve four measures of Ferric Ammonium Sulphate and one measure of Gum Arabic. Heat the test tube in order to dissolve these substances. Then pour the contents of this tube into the glass and stir well with a stirring rod. Add one or two drops of oil of wintergreen to keep the ink from moulding and pour the ink into a bottle. This will give a black writing ink that can be used from time to time.

EXPERIMENT 124. How to Make Blue Ink. Prussian Blue Ink may be made by dissolving two measures of Ferric Ammonium Sulphate in a test tube one-third full of water and adding this solution to a solution of Sodium Ferrocyanide made by dissolving two measures Sodium Ferrocyanide in a test tube one-fourth full of water. The blue precipitate formed in the reaction is a compound of ferro-ferricyanide. Write with the ink.

EXPERIMENT 125. How to Make Purple Ink. Put three measures of Logwood into a test tube one-third full of water and boil for several minutes until the solution is deeply colored. Then add one measure of Aluminum Sulphate and heat to boiling again. Notice the beautiful dark colored purple ink which is formed. Write with the ink using a clean pen.

EXPERIMENT 126. How to Make Red Ink. Repeat Experiment 125 adding one measure of Sodium Bisulphate in addition to the other compounds. This gives a red ink. Write with this ink using a clean pen.

EXPERIMENT 127. How to Make Green Ink. Put two measures of Nickel Ammonium Sulphate and one measure of Sodium Ferrocyanide in a test tube one-third full of water and shake well. Now add one-half measure of Ferric Ammonium Sulphate and shake well again. Notice the formation of a deep green color and precipitate. Write with this solution using a clean pen.

THE TANNING OR LEATHER INDUSTRY

Tanning is the process of making leather from the pelts or skins of animals. Hides or skins of animals, if allowed to remain moist soon decay or putrefy while if dried they become hard and horny. Therefore, in order to make a hide permanent and at the same time soft and flexible for the purposes for which leather is intended, it is put through the process of tanning.

The first operation in the process of tanning is soaking with water. This removes any dirt, blood, or salt and softens the skins which have been dried. The next operation consists in removing the hair and this is done by treatment with lime or calcium oxide. It is then put through a process known as fleshing which any fat or flesh is removed. The hides are then washed to remove all

traces of lime since its action would be harmful when brought in contact with tanning materials. After all the lime is removed the hides are then placed in the tanning liquors which consist essentially of tannic acid and allowed to remain in these liquors for different periods of time, from several weeks to several months, depending upon the kinds of leather to be tanned and the method used in tanning. After this the leather is scoured which removes the dirt and other things from the surface of the leather. The leather is then put through the process of "stuffing" in which operation the fibers are surrounded with fat and oil which lubricate them and render the leather more pliable. The leather is then dried on stretchers after which they are given a coating of finishing material such as shellac, wax or gelatine. They are then ready for the market.

Leather is colored different shades by dyeing with the proper color or dye.

Patent leather is made by varnishing ordinary leather and putting it through a definite process.

EXPERIMENT 128. Tanning and How It Is Done. You can illustrate very nicely what happens when a skin or hide is tanned with Tannic Acid by the following experiment:

Put six or eight drops of the white of an egg in a test tube half full of water and shake the contents of the tube. Now add to this solution a few drops at a time of Tannic Acid solution made by dissolving one measure of Tannic Acid in a test tube one-third full of water. Notice the white precipitate which is formed. What really happened was that the albumen, which is the principal constituent of the white of the egg was coagulated or precipitated out by the tannic acid. Skins and hides also contain large amounts of albuminous substances and when treated with tannic acid these substances are coagulated or set forming a tough pliable mass or leather.

Tannic acid is obtained mostly from the sumac bush or the bark of the hemlock or oak trees. It also occurs in several other substances. A substitute for tannic acid is made synthetically by treating carbolic acid (phenol) with formaldehyde and sulphuric acid.

EXPERIMENT 129. Tannic Acid from Oak Bark. Obtain some oak bark and cut it up into fine shavings. Put some of these shavings in test tube one-half full of water and boil for two or three minutes. Allow the test tube to cool and pour the liquid into another test tube. Add a pinch of Ferric Ammonium Sulphate and notice the black color produced showing that tannic acid occurs in the bark of the oak tree.

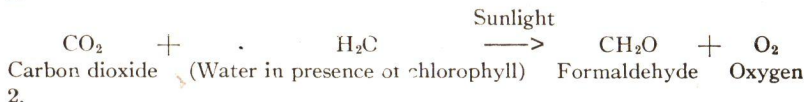
EXPERIMENT 130. Tannic Acid from Tea. Put one spoonful of tea leaves in a test tube half full of water and boil for a few minutes. Pour the liquid into another test tube and test it for tannic acid the same way as shown in Experiment 129. Notice the formation of a black color, proving that tea leaves also contain tannic acid.

THE STARCH AND SUGAR INDUSTRY

Before we say anything about this industry, we will discuss briefly how starch and sugar is being made every day by nature in plant life and the changes these compounds undergo in animal life.

The carbon dioxide which is always found in the air is made by the heat of the sun to combine with water in the plant tissues to produce a compound formaldehyde. Formaldehyde in turn undergoes what is known as polymerization in the plant to form sugars. By polymerization we mean, several molecules of the substance combining to form a more complex compound. The sugar is changed to starch by plant ferments or enzymes. In the process of converting carbon dioxide and water by the plants into sugar and starch, oxygen is liberated and given off into the air. These processes may be expressed very clearly as follows:

1.



2.



Man is dependent upon plants for starches and sugar. When these foods are taken into the body they are changed back again with the aid of the oxygen, which we breathe into the lungs from the air, into water and carbon dioxide. The carbon dioxide is constantly being passed out of the body when we breathe the air out of the lungs.

To summarize then we can say that carbon dioxide of the air is taken up by plants and oxygen given off. In animal life oxygen is removed from the air and carbon dioxide given off.

Nearly all plant and vegetable matter contain starch; potatoes, corn, wheat and rice containing a large percentage of this substance. Sugar cane and beets on the other hand are the chief sources of sugar and contain large amounts of this substance.

Starch and sugar come under the class of compounds known as carbohydrates. That is, they are compounds of carbon with hydrogen and oxygen. In the United States starch is obtained chiefly from corn while in Europe potatoes are the chief source. Starch consists of minute granules. These granules are composed of a substance known as granulose which is surrounded by a membrane composed principally of cellulose. Starch does not dissolve in cold water because the granulose which is soluble in water is protected from the action of water by the

insoluble cellulose membrane. When heated with water the granules burst and the granulose dissolves forming the well known starch paste.

Besides its commercial use in the laundry, starch is manufactured for the purpose of making the commercial products known as glucose, grape sugar, malt glucose, dextrin, British gums and soluble starch. These compounds are all formed from starch by hydrolysis with suitable reagents. They are all important compounds and are widely used. Corn syrup is nothing more than glucose which originally came from starch.

Cane sugar or ordinary household granulated sugar is obtained from the sugar cane through a process of refining. It is the sweetest of all natural sugars and is called sucrose. It has the formula $C_{12}H_{22}O_{11}$. On hydrolysis with acids this sucrose may be broken down into two other sugars, dextrose and levulose, having the same formula $C_6H_{12}O_6$, but differing in physical properties. Levulose is sweeter than dextrose and is the chief component of honey. Dextrose is found chiefly in commercial glucose or corn syrup. Maltose is the sugar that is formed by the action of enzymes, such as diastase on starch. It has the same formula as dextrose and levulose and is the sugar from which alcohol is prepared.

EXPERIMENT 131. How to Make a Starch Paste. Starch as already explained does not dissolve in cold water because the soluble material called granulose is surrounded by a membrane of cellulose. On treating the starch with boiling water these membranes burst and the starch then dissolves forming a paste.

Mix a small quantity of starch with just a little water in a tin cup and stir well. Then fill the cup with boiling water and heat for a few minutes. You will now have a jelly like starch paste.

EXPERIMENT 132. How to Make Starch from Flour. Besides starch, flour contains an organic compound called gluten. In order to separate the starch from the gluten proceed as follows:

Put two tablespoonfuls of flour in a cup and add just enough water to make the flour into a stiff dough. This can be done by working the moist flour with the fingers until it is kneaded into a round ball the same as your mother does when she prepared bread dough for making bread. Now take this ball of dough and holding it in a glass half full of water work it with the fingers so that all portions of it will come in contact with the water. Notice that the starch separates from the dough and settles in the water, leaving a very sticky mass of gluten in the fingers.

EXPERIMENT 133. To Show the Composition of Starch. Put two or three measures of starch in a clean dry test tube and heat the tube slowly over an alcohol flame. Notice that steam is given off, part of which condenses on the inside of the tube to form water. On further heating you will notice that the starch gradually turns brown, then black. This black substance is carbon. Starch, therefore, like sugar contains carbon, hydrogen and oxygen (water).

EXPERIMENT 134. Changing Starch into Dextrin. Put six measures of starch into a clean dry test tube and heat slowly over a flame. When the starch turns brown stop heating and examine the material which remains in the tube. It is dextrin and is the same material which is used for making mucilage.

EXPERIMENT 135. How to Make Dextrin Mucilage. Add a little water about eight to ten drops to the dextrin prepared in the preceding experiment and notice that the dextrin dissolves in cold water. This solution makes a very good mucilage and is called dextrin paste or British gum. This is the mucilage used on envelopes and postage stamps. Taste a little of it and notice that it has a slightly sweetish taste.

EXPERIMENT 136. To Show the Composition of Sugar. Put half a spoonful of sugar in a clean dry test tube and heat slowly over an alcohol flame. Notice that steam is given off, part of which condenses on the inside of the test tube to form water. Notice that the sugar first turns brown and on further heating a black substance is formed, namely; pure carbon. It was from this sugar carbon that the first artificial diamonds were made.

EXPERIMENT 137. How Burnt Caramel is Made. Put a half spoonful of sugar in a clean dry test tube and heat it slowly over an alcohol flame until the sugar turns brown. Remove the tube from the flame and smell at the mouth of the test tube. Do you recognize the odor of caramel? This is the material used so much for flavoring sweet substances as candies and also as a coloring material for vinegar and beverages.

THE DYEING AND TEXTILE INDUSTRY

Before we say anything about dyes or dyeing we will mention a few words about fabrics or textile fibers to which the dyes are applied.

There are really two classes of fibers, vegetable such as cotton and linen, and animal, such as silk and wool. Cotton and linen consist of smooth hollow fibers of cellulose which are readily attacked and broken down by acids. Wool consists of scaly hollow fibers and silk of solid filaments. They are made up of nitrogenous substances chiefly amino acids which are destroyed by alkali but not by acids. Since cotton is not attacked by alkalies the textile expert can easily determine exactly how much cotton and wool there is in a piece of cloth containing a mixture of these goods by treating with a solution of alkali. The woolen fibers will be dissolved leaving the cotton fibers behind. The same thing can be done in the case of a mixture of cotton and silk.

Formerly, natural occurring dyestuffs such as logwood, indigo, cochineal and a few others were used almost exclusively for dyeing fabrics. For this reason only a few bright shades were obtained. Today matters are entirely different. Most of the dyes are being manufactured synthetically. That is, by starting with a certain raw material, any desired color or dye can be built up by the proper treat-

ment with certain reagents or compounds in a manner similar to the building of a house. Over 5,000 different dyes are now known, although only about 900 are in use.

Practically all of the synthetic dyes are made from the compounds benzene, toluene and naphthalene, which are obtained from coal tar, the black heavy mass produced from the destructive distillation of soft coal. The advantage of these dyes over the natural occurring dyes is that practically any shade can be obtained and in the quantity desired. Before the great war, Germany was the master of this wonderful industry and most of the world was dependent upon her for their dyes. Today it is a different story. The United States and England are now independent of Germany. Millions of dollars are invested in this industry in the United States and dyes are being made which are in some cases superior to those made in Germany. The fact that Germany had developed her dye industry so tremendously is what enabled her to be so well prepared for and to carry on the war. Dye factories contain the necessary equipment and chemicals for manufacturing explosives and poisonous gases.

Dyes are divided into three classes, (1) insoluble dyes, (2) mordant or adjective dyes, and (3) direct, or substantive dyes.

Insoluble dyes are dyes which will not dissolve in water. When goods are dyed with insoluble dyes the dye is first converted into a soluble material. The goods are then placed in a solution of the soluble dye and then treated with a chemical which precipitates the colored insoluble dye. This precipitate is held in the fibers and since it is insoluble it cannot be washed out. This class of dyes works well on cotton and woolen goods. As an example, a piece of cotton is soaked in a solution of lead acetate, a colorless solution. It is then put through a hot solution of potassium chromate when it becomes dyed a beautiful fast yellow due to the formation of a yellow insoluble precipitate of lead chromate.

A mordant is a substance, usually a metallic hydroxide, for fixing the dye in the fibers. Some goods like cotton are not active chemically and therefore, in some cases, cannot absorb dyes directly. As an example, suppose we wished to dye cotton red with the dye alizarin. We could not dye the cotton directly with alizarin for it would run out on washing. The cotton is first treated with soluble chromous acetate solution to which is added a little sodium hydroxide. This forms chromium hydroxide, a precipitate which is the mordant. If the goods are now treated with alizarin, the chromium hydroxide absorbs the dye and deposits it in the fibers of the cotton as a very insoluble dye. A precipitate formed when a dye is absorbed in this way by a mordant is called a lake. Different mordants produce different colors with the same dye. Besides alizarin, cochineal, malachite green and methylene blue are mordant dyes.

The third class of dyes, namely; direct or substantive dyes are usually very fast dyes, that is, will not run on washing, and are used extensively in dyeing wool and silk goods.

A certain class of organic dyes known as sulphur dyes are made commercially by heating some organic substances like dimethyl aniline and diphenyl amine with sulphur and iodine. The iodine acts as a catalytic agent, that is, hastens the reaction and increases the yield of the dye. Sulphur colors can also be made by treating certain compounds with sulphur in the presence of an alkali. Let us make one or two of these dyes.

EXPERIMENT 138. How to Make a Brown Sulphur Dye. Put five drops of Glycerine in a dry test tube and add one measure of Sulphur and one measure of Sodium Carbonate. Heat the test tube over an alcohol or gas flame for several minutes and then allow the test tube to cool.

Now add a little water to the test tube and allow the test tube to stand for half an hour until the cake is loosened in the bottom of the tube. Now pour the contents of the tube into a glass of water and notice that the dye dissolves and the water is colored brown.

EXPERIMENT 139. How to Make a Black Sulphur Dye. Mix together on a piece of paper one measure of Tannic Acid, one measure of Sodium Carbonate and one measure of Sulphur. Put this mixture in a clean dry test tube and heat the tube over an alcohol or gas flame for four or five minutes.

Now remove the tube from the flame and after it is cool fill the test tube half full of water and allow the test tube to stand for half an hour. Now shake the contents of the tube thoroughly and then pour it into a glass three-fourths full of water. If any dye remains in the test tube add a little more water, shake again and pour it into the glass. Notice the dark black color of the water produced by this dye.

EXPERIMENT 140. How to Make Dark Red Logwood Dye. Dissolve one measure of Cobalt Chloride in a test tube one-third full of water.

In another test tube half full of water put two measures of Logwood and boil this solution for four or five minutes. Pour this solution into the test tube containing the solution of cobalt chloride and notice the dark red solution which is formed.

EXPERIMENT 141. How to Make Black Logwood Dye. Dissolve one measure of Ferric Ammonium Sulphate in a test tube one-third full of water.

In another test tube half full of water put two measures of Logwood and boil for four or five minutes until the solution is colored a bright red. Pour this solution into the test tube containing the solution of Ferric Ammonium Sulphate and notice the black colored solution which is formed.

EXPERIMENT 142. How to Make Blue Horse-Chestnut Dye. Put several chips of the bark from a horse chestnut tree into a test tube half full of water and boil for four or five minutes. Now add a little household ammonia and boil again for two or three minutes. Notice the blue colored solution which is formed.

EXPERIMENT 143. Changing Red Logwood Solution Yellow, Then Blue. Put two measures of Logwood in a test tube half full of water and boil for four or five minutes. Then pour this solution into a test tube containing one measure of Sodium Bisulphate. Notice that the solution turns from red to yellow in the presence of an acid.

Now add to this solution two or three measures of Sodium Carbonate and notice on shaking the color changes from yellow to reddish-blue or purple. Red Logwood solution is yellow in the presence of an acid and blue in the presence of an alkali.

EXPERIMENT 144. How to Dye Cloth Red. Put two measures of Ferric Ammonium Sulphate in a test tube one-third full of water and shake the tube until all the solid is dissolved. Now place a small piece of cloth to be dyed in this solution and after it is thoroughly wet, remove the cloth and allow it to dry.

Now dissolve two measures of Sodium Sulphocyanate in a test tube one-third full of water and place in this solution the dry cloth which was treated with the ferric ammonium sulphate solution. Notice that the cloth is dyed red. Remove the cloth from the solution and allow it to dry.

EXPERIMENT 145. How to Dye Cloth Black. Dissolve two measures of Ferric Ammonium Sulphate in a test tube one-third full of water and place in this solution a small piece of cloth to be dyed. When the cloth is thoroughly wet remove it and allow it to dry.

Now dissolve two measures of Tannic Acid in a test tube one-third full of water. Place the dry cloth in this solution and after shaking the test tube a few times remove the cloth and allow it to dry. This time the cloth is dyed a black color.

EXPERIMENT 146. How to Dye Cloth Dark Blue. Dissolve two measures of Sodium Ferrocyanide in a test tube one-third full of water and place in this solution a small piece of cloth to be dyed. When the cloth is thoroughly wet, remove it and allow it to dry.

Now dissolve two measures of Ferric Ammonium Sulphate in another test tube one-third full of water. Place the dry cloth in this solution. When the cloth is thoroughly wet remove it and allow it to dry. This time the cloth is dyed a beautiful dark blue known as Prussian Blue.

EXPERIMENT 147. How to Dye Cloth Light Blue. Dissolve three measures of Sodium Ferrocyanide in a test tube one-third full of water and place in this solution a small piece of cloth to be dyed. When the cloth is thoroughly wet remove it and allow it to dry.

Now dissolve two measures of Ferrous Ammonium Sulphate in a test tube one-third full of water. Place the dry cloth in this solution and shake the test tube a few times. Remove the cloth and allow it to dry. This time the cloth will be dyed a light blue known as Turnbull's Blue.

EXPERIMENT 148. How to Dye Cotton Iron Buff. Make a solution of Ferric Ammonium Sulphate by dissolving two measures of the compound in a test tube one-third full of water. Place in this solution a small piece of cotton cloth to be dyed and shake the contents of the test tube thoroughly. Remove the cloth and allow it to dry.

Now dissolve two measures of Sodium Carbonate in a test tube one-third full of water and place the cloth in this solution. Shake the contents of the test tube thoroughly and then remove the cloth. Wash the cloth with water and allow it to dry. The cloth will be dyed an iron buff. This color is produced by the precipitation of iron oxide upon the fiber by the alkaline salt, sodium carbonate.

THE CHEMISTRY OF FOODS

While there is quite a variety of foods and the compounds present in foods are very numerous and often very complex, yet they may all be included in a few general classes. The edible portion of our foods consist essentially of proteins, fats, carbohydrates, mineral matter and water.

Proteins, which occur to a larger extent in animal foods, serve to replace the worn-out tissues of our bodies and to supply material for growth. The carbohydrates and fats are both oxidized in the body to carbon dioxide and water and consequently serve as a source of heat and muscular energy. If carbohydrates or fats are lacking in the foods we eat, the proteid material in them furnish the necessary material for building up the solid tissues of the body besides taking other complex parts.

Proteins occur in both animal and vegetable foods and are composed of the elements, carbon, hydrogen, oxygen, nitrogen and small amounts of sulphur and phosphorus. Carbohydrates are chiefly found in vegetable foods in the form of starch and sugars and are composed of the elements, carbon, hydrogen and oxygen. Fats occur in both classes of foods, but occur in much larger quantities in animal foods. They are compounds of glycerine with organic acids and are composed of the elements, carbon, hydrogen and oxygen.

It is important since the various constituents of our foods serve different purposes, that we use the proper proportion of these materials in order to keep up a healthy body. For example, during the winter months we should eat a larger amount of animal foods since they contain a larger proportion of fats necessary to keep the body warm. During the warm weather we should eat less meats or animal foods and more vegetables or fruits. They contain carbohydrates which serve to keep up the necessary body heat and energy. How often people are made very uncomfortable and sometimes sick by their ignorance of the amounts and kinds of foods that the body requires during the different periods of the year.

Did you ever realize that sometimes a heavy cold is brought about by over-eating? This happens quite often when we are not exercising the body enough; the foods

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are not oxidized or burned up, the blood becomes stagnant and we are sick. The body is a very intricate form of machinery, each part performing its own particular function the same as the different parts of a watch. If we abuse any one of these parts by eating too much with an insufficient amount of exercise or by not eating the right kind of foods, something goes wrong and we are sick.

Throughout the country there are chemical laboratories which are conducted by the government and local public health boards for the purpose of analyzing and testing foods as to their purity. A few years ago the government enacted the Pure Food Law which requires that foods which are bought by the public should be free of impurities or adulterants as they are called. Adulterants are materials sometimes mixed with foods to make them cheap. For example, oleomargarine was quite often used to take the place of good butter, whereas, it was a very poor substitute. In other foods harmful chemicals were often used to preserve them. Quite often foods were adulterated to give them weight or bulk. For example, coffee was often weighted with chicory. Today things are quite different, most of the foods on the market are pure or nearly so.

EXPERIMENT 149. How to Make a Solution for Testing Starch. A solution for testing starch in substances can be made by adding to a test tube half full of water one measure of Sodium Bisulphate, one measure of Ferric Ammonium Sulphate and eight or ten drops of Sodium Iodide Solution. Shake the contents of the test tube by placing the thumb over the mouth of the tube and notice the reddish-brown colored solution formed by the separation of iodine. Save this solution for the following experiment.

EXPERIMENT 150. Testing for Starch in Potatoes. Boil a small piece of potato about the size of a pea in a test tube half full of water for three or four minutes. Allow the test tube to cool and add two or three drops of the iodine solution prepared in the preceding experiment. Notice the blue color which is formed. This is a test for starch.

Test other materials such as rice, corn, oatmeal, barley, etc., for starch in a similar manner.

EXPERIMENT 151. How to Test for Proteins in Eggs. Put a half spoonful of the white of an egg in a test tube, add two measures of Calcium Oxide and three or four drops of water. Warm the test tube over a flame for a few minutes then remove the test tube from the flame and smell at the mouth of the tube. Do you recognize the odor of ammonia? Hold a piece of moistened Red Litmus Paper over the mouth of the tube and notice that it turns blue.

EXPERIMENT 152. Baking Powders and How They Are Made. Put four measures of Tartaric Acid and four measures of Sodium Bicarbonate in a dry test tube and shake the test tube until the compounds are thoroughly mixed. Now fill the test tube half full of water and notice the violent reaction or effervescence which takes place. This is due to the action of the tartaric acid on

the sodium bicarbonate to form sodium tartrate with the liberation of carbon dioxide gas. It is because of the liberation of this carbon dioxide gas that bread raises when mixed with baking powder.

Baking powders are of three kinds, named from the kind of acid or acid salt used. For example, tartrate powders have tartaric acid or acid potassium tartrate (cream of tartar); phosphate powders have an acid phosphate such as lime or potassium; and alum powders have as an acid aluminum sulphate.

The reactions which take place in these different baking powders may be expressed as follows:

1. Acid potassium tartrate + Sodium Bicarbonate = carbon dioxide + sodium potassium tartrate (Rochelle Salts).
2. Acid potassium phosphate + sodium bicarbonate = carbon dioxide + sodium potassium phosphate.
3. Aluminum sulphate + sodium bicarbonate = carbon dioxide + aluminum hydroxide + sodium sulphate (Glauber's Salt).

EXPERIMENT 153. How to Test Flour. If you wish to determine whether flour is artificially bleached to make it white test a sample of flour according to the following procedure.

Put a tablespoonful of flour to be tested in a glass and fill the glass half full of gasoline. Stir the contents of the glass for two or three minutes then allow the solid material to settle. If the gasoline is yellow in color the flour is not bleached while if the gasoline remains colorless the flour has been artificially bleached.

EXPERIMENT 154. How to Test for Copper in Canned Goods. Test a small amount of canned spinach, beans, peas or any other canned products for copper according to the following procedure:

Mash a tablespoonful of the sample to be tested in a tea cup together with two tablespoonfuls of water and four measures of Sodium Bisulphate. Place the cup in a pan of hot water and put the pan on the stove. Then put a clean wire nail into the tea cup and boil the water in the pan for fifteen or twenty minutes, stirring the contents of the cup from time to time. Now remove the nail from the cup and see if it is coated red with copper. If so the sample contained a soluble copper salt and the product is injurious to health.

EXPERIMENT 155. How to Test Butter. Place a small piece of butter about the size of a pea in your spoon and heat slowly over a flame. If the butter foams and froths on boiling the butter is fresh. On the other hand, if it sputters or pops it is either oleomargarine or renovated butter.

Another test that may be applied to butter to show whether it is adulterated is as follows:

Heat a half cupful of milk until it is very hot. Then put into the milk a piece of butter about a half inch square to be tested and stir until it is all melted. Now place the cup in a pan of cold water containing a little ice and stir the milk

continually until the milk becomes cold and the butter solidifies. If the butter is pure or renovated it will solidify into small particles throughout the milk. If it is oleomargarine it will solidify into one solid cake.

Pure fresh butter contains water and butter fat. Butter fat consists principally of the fats olein, palmitin and stearin. The flavor of the butter is due to the presence of a small amount of butyrin, which is an ester of butyric acid and glycerine.

Oleomargarine is made from the fat of cattle and hogs together with small amounts of cotton seed oil and milk or butter. The milk or butter is added to furnish enough butyrin to give the butter flavor.

Renovated butter is stale or rancid butter made over by chemical treatment.

EXPERIMENT 156. How to Test for Impurities in Coffee. Put one spoonful of ground coffee in a glass full of water and stir for a few moments. Most of the coffee, if pure, will float on top of the water. Any adulterants or impurities, such as chicory, peas or beans will settle to the bottom along with a small amount of coffee.

EXPERIMENT 157. How to Make Casein. Put three measures of Sodium Bisulphate in a test tube one-third full of water and shake until it dissolves. Now add a few drops at a time with constant shaking some of this solution to a half test tube full of milk. Notice that suddenly a white curdy precipitate is formed. This precipitate is casein. This is the same precipitate that is formed when milk turns sour or curdles. The souring of milk is brought about by the formation of lactic acid due to the fermentation of the milk.

Casein, besides being used as a food in cheese, has many other important uses today. It is used in the manufacture of adhesives, paints, in dyeing, in medicine, as electrical insulators and in making plastic masses as in stoneware, toys, etc. In the manufacture of these things the casein is put through a certain chemical treatment.

CHEMISTRY IN THE HOME

Did you ever stop to consider how few of us there are who understand the Chemistry involved in many of the natural processes taking place in the home. Many of us are apt to work mechanically, that is, we do this or that according to the directions, but very seldom stop to consider what is taking place chemically. It is for this reason that I am going to give a few experiments in household chemistry and endeavor to show you the relationship of chemistry to every day life. Sometimes some of the things which you use in the home may be adulterated. With a simple knowledge of chemistry and by the application of a few chemical tests you will be able to tell for yourself whether this is so. Again, a knowledge of the chemical action taking place between certain substances enables us to tell whether or not to use these substances in contact with each other.

Let us now look into the chemistry of some of these natural processes taking place in the home.

EXPERIMENT 158. How to Test for Ammonia in Silver Polish.

Put two or three measures of silver polish to be tested in a test tube, add one measure of Calcium Oxide and three or four drops of water. Place a piece of moistened Red Litmus Paper over the mouth of the tube and heat the tube slowly over a flame for several moments. Remove the test tube from the flame and smell at the mouth of the tube. Do you recognize the odor of ammonia gas? Does the red litmus paper turn blue? If so the silver polish contained an ammonium salt. Ammonium salts together with sodium carbonate are often put in silver polishes to aid its cleansing properties.

EXPERIMENT 159. How to Clean Silver Ware Chemically. Dissolve three measures of Sodium Thiosulphate in a test tube one-third full of water. Rub the tarnished silver ware to be cleaned by means of a cloth with a little of this solution. Notice that the black stain of silver sulphide is easily removed leaving the silver bright and clean. Complete the cleansing by washing the silver with water. The sodium thiosulphate reacts with silver sulphide and in this way causes the black stain to dissolve.

EXPERIMENT 160. The Use of Zinc Vessels in the Home. Test the solubility of small amounts of Powdered Zinc in acid solution and in alkaline solution. Use Sodium Bisulphate for an acid and a little common household lye for an alkali. Notice that zinc is attacked by both of these substances.

Therefore, it is essential in cooking foods containing acids not to use zinc vessels. Citric acid, tartaric acid, vinegar or other acids would attack zinc and contaminate the foods with injurious zinc compounds.

EXPERIMENT 161. The Use of Copper Vessels in the Home. Test the solubility of copper in acid solution by boiling a test tube half full of water, containing three measures of Sodium Bisulphate and a small piece of copper, for several minutes. Add a few drops of household ammonia and notice the formation of a blue color in the solution. This is a test for copper in solution.

Therefore, copper vessels should never be used for cooking foods containing acids, as acids would attack the copper to form injurious copper compounds.

EXPERIMENT 162. The Use of Aluminum Vessels in the Home. If you have an old aluminum vessel put a little vinegar in it and heat the vessel for a few minutes on the stove. Notice that the vessel is corroded by the action of the vinegar. Repeat this experiment using a little water containing some household lye. Notice that the same action takes place. Both zinc and aluminum are what are known as amphoteric substances, that is, they are attacked by acids and bases.

Aluminum vessels, therefore, should never be used for cooking foods containing acids.

EXPERIMENT 163. How to Test for Acid Mouth. Moisten a small piece of Blue Litmus Paper with the tongue and see if the litmus paper turns red. If it does, the mouth is acid. Acid mouth is usually caused by an upset stomach or by decayed teeth. Normally the mouth should be neutral or only slightly alkaline.

THE CHEMISTRY OF FERTILIZERS—FARMING

Did you ever know that chemistry plays a very important part in farming and in the fertilization of soil? No doubt you have often seen the farmer cover his soil in the spring with manure or other forms of fertilizers and later work them into his soil. You probably asked the question why are these fertilizers put into the soil and found that they make the crops grow better. That is true, the crops do grow better, but why is this so? By repeated experiments it has been found out that there are certain substances which are very essential to plant growth. We have already learned how plant compounds, such as starch, are built up in the plant by means of carbon dioxide and moisture in the air with the aid of the sun's rays. On the other hand, there are other important substances which are taken up by the plant in the soil to form complex compounds. These are potassium, nitrogen and phosphoric acid. These substances must be introduced into the soil in the form of their soluble compounds as they are taken up by the plant roots by means of absorption.

Nature plays a very important part in the formation of nitrogenous substances in the soil. You probably do not know that in most fertile soils there exists millions of bacteria which have the property of converting decayed nitrogenous organic matter into nitrates which are taken up by the plants. Now it is very important in farming to see that the soil is kept in a condition whereby these bacteria are able to thrive in order to keep the soil fertile. Soils which contain large amounts of decayed organic matter and are kept in a moist condition so that the air does not get at them are quite often apt to be acidic. The nitrate forming bacteria are not able to live in soils which are acid so that it is very important to see that these acids are destroyed. Acid soils also render other fertilizing substances, such as phosphates, insoluble or in a condition such that the plant is unable to absorb them in the ordinary process of plant growth. This acidic condition of the soil is generally destroyed by neutralization of the acids with lime.

In the ordinary processes of farming since the plants are continually removing the nitrogen, potassium and phosphorus compounds from the soil it is necessary to replenish the soil with fertilizing material. Now the amounts and kinds of fertilizer to be put into a certain grade of soil depend upon the condition of the soil and kinds of crops to be raised. One class of plants will require more

phosphorus than another class. Many formulas have been worked out including the kinds and amounts of fertilizing substances to be used for different kinds of plants.

Soils are fertilized in four ways, namely: by decayed vegetable matter, by rotation of crops, by animal manure and by artificial or commercial fertilizers.

Decayed vegetable matter such as leaves, grass, &c., is often worked into the soil as a natural fertilizer, but since they contain only small amounts of the essential fertilizing substances, their use alone would be inadequate.

The second method of fertilization namely: the rotation of crops is widely used in farming and consists in planting fertile land one season with corn, wheat or other crops and the following season with clover, cow-peas or alfalfa. These latter plants have the property of converting nitrogen from the air into soluble nitrates which are restored to the soil to take the place of that used up by the corn, wheat and other crops in the preceding season. The conversion of the nitrogen of the air into nitrates is accomplished by certain germs or bacteria which occur in tubercles or swellings on the roots of clover, cow-peas, and alfalfa plants.

Natural or animal manures are used extensively as fertilizing materials as they contain large amounts of nitrogen compounds. They also tend to keep the soils loose so that the air can penetrate them. Guano, cow dung and sheep dung are important natural manures containing relatively large amounts of nitrogen. Guano is the excrement of sea-birds and is found off the coast of Peru. Guano is rich in phosphorous, nitrogen and potash.

Artificial fertilizers are used very widely today and several important industries are involved in their manufacture. These are chemical compounds or substances that are rich in nitrogen, phosphorus and potassium. Phosphorus is used in these fertilizers in the form of its soluble compound such as calcium acid phosphate. Potassium is used principally in the form of potassium chloride, potassium sulphate and potassium carbonate while nitrogen is used in the form of ammonium nitrate and sodium nitrate. The commercial fertilizers which are put out on the market are complete fertilizers such as dissolved potash and phosphates, wood ashes, ground bones, dissolved bones, tankage, dry ground fish, nitrate of soda, dried blood, cotton seed meal, linseed meal and castor pomace.

EXPERIMENT 164. Testing Soil for Acid. Obtain some of the soil to be tested and make a paste with it by using a little water. Now lay a small piece of Blue Litmus Paper on the paste and allow it to stand for several minutes. Remove the litmus paper and examine it. If it has turned pink the soil is acid.

Soils which are in this condition should be neutralized by introducing lime into the soil.

**LIST OF CHEMICALS WITH THEIR FORMULAE AND APPARATUS
NECESSARY TO PERFORM THE EXPERIMENTS
INCLUDED IN THIS BOOK**

1.	Aluminum Sulphate.....	$\text{Al}_2(\text{SO}_4)_3$
2.	Ammonium Chloride.....	NH_4Cl
4.	Borax.....	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
5.	Boric Acid.....	H_3BO_3
6.	Blue Litmus Paper.....	
11.	Calcium Oxide.....	CaO
16.	Cobalt Chloride.....	$\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$
21.	Ferrous Ammonium Sulphate.....	$(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$
22.	Ferric Ammonium Sulphate.....	$(\text{NH}_4)_2\text{SO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
24.	Glycerine.....	$\text{CH}_2\text{OHCHOHCH}_2\text{OH}$
28.	Logwood.....	
31.	Manganese Sulphate.....	$\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$
32.	Nickel Ammonium Sulphate.....	$(\text{NH}_4)_2\text{SO}_4 \cdot \text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
33.	Phenolphthalein Solution.....	$(\text{C}_6\text{H}_4\text{OH})_2\text{COC}_6\text{H}_4\text{CO}$
34.	Potassium Nitrate.....	KNO_3
37.	Powdered Charcoal.....	C
40.	Powdered Zinc.....	Zn
41.	Red Litmus Paper.....	
42.	Sodium Bicarbonate.....	NaHCO_3
43.	Sodium Bisulphate.....	NaHSO_4
44.	Sodium Bisulphite.....	NaHSO_3
45.	Sodium Carbonate.....	Na_2CO_3
46.	Sodium Ferrocyanide.....	$\text{Na}_4\text{Fe}(\text{CN})_6 \cdot 12\text{H}_2\text{O}$
47.	Sodium Iodide Solution.....	NaI
48.	Sodium Silicate Solution (Water Glass).....	Na_4SiO_4
49.	Sodium Sulphocyanate.....	NaCNS
50.	Sodium Thiosulphate.....	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
51.	Strontium Nitrate.....	$\text{Sr}(\text{NO}_3)_2$
52.	Sulphide Test Paper.....	
53.	Sulphur.....	S
54.	Tannic Acid.....	$\text{C}_{14}\text{H}_{10}\text{O}_9$
55.	Tartaric Acid.....	$\text{COOH}(\text{CHOH})_2\text{COOH}$
	Alcohol Lamp	
	Candle	
	Gas Delivery Tube with Cork Stopper	
	Glass Tube	
	Measure	

