ORIGIN OF THE WORD "CHEMISTRY"

The first literary work in which the word—"Chemistry"—is found was written by Plutarch, a Roman historian who lived from 46-120 A.D. In a treatise entitled—"Isis and Osiris"—that philosopher mentions that "Egypt" in the dialect of the country, was called the same name as the black of the eye, "Chemia," and from this he infers that the word meant "Black" in the Egyptian language. Some science historians believe that our word "Chemistry" means "The Egyptian Art." Others think that the word was coined to mean "The black art." Still others think that the word meant "The dark or hidden art." Another school of thinkers believes that the word has no connection with Egypt at all, but that it comes from the Hebrew word—"Chaman," meaning mystery. Another possible derivation, according to some historians, is from the Arabic word "Chema"—meaning to hide, hence "the Hidden Science." In fact, a book of secrets was written in the time of the ancient Arabians called "Kemi." Probably no one will ever know definitely which one of these possible derivations is the correct one.

ORIGIN OF CHEMISTRY AS A SCIENCE

According to some historians, the origin of chemistry as a science dates back to the time of Tubal Cain, the father of workers in metal. Credit is also given to Hermas, the Egyptian god of art and sciences. His son is said to have colonized Egypt, which was foremost in the knowledge of chemistry in those ancient days for they had developed the arts of making glass, pottery, colors, embalming fluids and other practical products to a high degree, and the early Egyptians can really be said, therefore, to have had an advanced knowledge of applied chemistry. Then Paracelsus, the Greek physician, carried the study along and discovered the influence of chemistry upon medicine in the treatment of human ills, and it was through him that the action of several inorganic salts upon the human system became known. Following this period a long time elapsed, hundreds of years, during which time contributions were spasmodically made by unknown workers in science, but which really had little influence upon the development of modern chemistry.

Chemistry, as we know it today, is one of the newest of our sciences, and yet it is one which offers the greatest opportunities of advancement, research and fame for those today who are interested in the fuller things of life. Centuries ago there was no such thing as chemistry. Chemistry was preceded by alchemy. Alchemists were superstitious men and were very often dishonest men. He was a groper for mysteries, and if it had not been for this interest in the mysteries of energy and matter, modern science would never have been born. We can now visualize the old alchemist working over his pots and retorts in crude laboratories and in dark caves. Shrouded in mysticism, and his activities kept secret, his imagination fired with zeal and exercising patience, and with the purpose of a religious fanatic, he sought to make or find the philosopher's stone.

It was not until the early part of the eighteenth century that the scientist of the central European countries and the English Empire began to contribute fundamental knowledge which laid the foundation and paved the way for the development of this wonderful science. The Frenchman, Lavoisier (1743-94) may really be credited with being the father of modern chemistry.

There is hardly a science today that has greater economic influence, or holds more fascinating interest to scientists throughout the world than chemistry. If we are to unravel the secrets of our wonderful world and life, there is no science that will enable us to understand and correctly interpret these hidden things of nature that most of us think are magical and mysterious, like a knowledge of chemistry.

No large and progressive manufacturing industry can cope with its competitors today without a trained chemist to advise and assist in its development and the analysis of the raw materials which it buys. The present-day physician without a knowledge of chemistry would be incompetent and unable to maintain an acceptable professional standing as a practitioner of medicine.

The great problems involved in the manufacture of synthetic drugs, dyes, perfumes, essential oils, of soil fertilization, and of the many substituted and artificial productions influencing modern civilization are every-day problems of chemistry. The regulation of our food supply calls for the services of thousands of experienced technicians who are employed as chemists by industry, municipalities and both our State and National governments. If we would have our country today improve its standards of living and at the same time accommodate itself to an increasing population, we must hereafter maintain on an even more liberal scale than ever before great laboratories of science devoted to the study of chemistry. The men and women working in these laboratories are among our priceless possessions. There is no sum that the world could not afford to pay these men who have that originality of mind and devotion and industry to carry forward in scientific advancement until its influence spreads to the comfort of every home. It was former President Coolidge who wrote as follows: "Wherever we look, the work of the chemist has raised the level of our civilization, and has increased the productive capacity of the nation."

Probably most boys are interested in science because they just naturally think they will like science. This is a perfectly good and sufficient reason in itself. At the same time, a boy of intelligence who becomes interested in science would like to be reassured, no doubt, that science offers a really important field for service in the interests of human welfare. From the far-sighted point of view, the public is better off today than it was before science was developed, and so it always will be. Every boy and girl should be impressed with this fact and be made to realize that science creates jobs, and that its application makes life more comfortable and more interesting.

In order to illustrate this point of view, emphasis has been laid on experiments in this little manual which show the relationship between chemistry and its application to our chemical industries and to everyday life. There was a time when chemistry was regarded as being related to witchery and sorcery. Chemicals were formerly looked upon as deadly poisons and chemical reactions were associated with explosions. The men who practiced the science of chemistry had to do so in secret because they were regarded by the people with superstition and dread and as related to the devil.

Today conditions are entirely different. There is now no need for secrecy. A chemist is looked upon today as a professional man to be treated with respect, and there is a growing desire to know more about this science. To satisfy to some degree the youthful thirst for chemical knowledge, and to afford the pleasure to boys to be derived from the intelligent performance of simple experiments, is one of the aims of this manual. The second aim is to develop the power of scientific reasoning and to give to the boy an elementary knowledge of the fundamental principles upon which modern chemistry is based.

The experiments in this manual must be carried out with accuracy in order to obtain satisfactory results. Remember that nature is exacting in her methods of operation, and it is the problem of the scientist to seek the truth and operate according to the "rules of the game," so to speak, by careful experimentation. The author would therefore urge that you think out for yourself, when you are performing experiments, first as to what you are doing the experiment for, second, weigh carefully the results obtained, and third, draw some conclusions as to what the results really mean to you. It is by so doing that you will develop your imagination, and an investigative mind. The performance of your experiments will prove a pleasure to you, and at the same time you will contribute to your knowledge and also advance and develop the science of chemistry.

WARNING!!

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

Gilbert Chemistry Sets do not contain dangerous poisons and the chemicals mentioned in this manual are not embraced under the term "poisons." They are perfectly safe to use if handled carefully and intelligently. They are not intended to be taken by mouth or swallowed, and no intelligent person would be expected to use them for such purposes. It is necessary, however, to emphasize the fact that carelessness on the part of the experimenter can always lead to trouble. The author suggests, therefore, that all experimentation be carried out cautiously and according to the directions, especially when manipulations like heating is involved, or when gases are evolved in the reactions.

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.

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

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.

DEFINITIONS OF SOME COMMON CHEMICAL TERMS

ACIDS
Chemical compounds which have a sour taste. They turn blue litmus red. They unite with bases to form salts. They all contain hydrogen, which is a gas.

ATOM
The smallest particle of an element which enters into chemical combination. Atoms are extraordinarily small. We can never hope to see one, even with powerful magnifying glasses.

ATOMIC WEIGHT
Relative weight of an atom compared with an atom of hydrogen as a standard. Since hydrogen is the lightest known element, the weight of its atom is taken as 1. When we say that the atomic weight of oxygen is 16 we mean that the atoms of oxygen are sixteen times heavier than those of hydrogen.

BASE
A base is water in which half of the hydrogen has been replaced by a metal. For example, water is H/OH. A base, sodium hydroxide is Na/OH. Bases are also known as alkalies. They combine with acids to form a salt of the metal and water.

CHEMISTRY
The science of chemistry has for its object the accurate investigation of all changes in the identity of substances and the laws, causes and effects of such changes.

CHEMICAL CHANGE
A change which destroys the identity of the substance or substances acted upon.

CHEMICAL COMPOUND
A union of two or more substances in definite quantities, combined so as to form a new and distinct substance which is unlike either of the substances which formed it.

CHEMICAL EQUATION
When chemical substances react upon or unite with one another, definite transformations take place which can be expressed in the form of a chemical equation. Thus we may express the action of hydrochloric acid on calcium carbonate to form calcium chloride, water and carbon dioxide as follows:

$$2\,HCl + CaCO_3 = CaCl_2 + H_2O + CO_2$$

An equation is an abbreviated form of what takes place in a chemical reaction.

CHEMICAL AFFINITY
Property which elements have for uniting with one another.

DECOLORIZE
To bleach or whiten—to remove the color from a liquid or solid.

DECOMPOSE
The process by which a compound breaks up into simpler parts—usually through the action of heat.

DEODORIZE
To remove an odor or smell—especially the odor which results from impurities.

DISSOCIATE
The process by which a compound breaks up into ions when dissolved in water.

ELECTROLYSIS
The decomposition or breaking up of a chemical compound by means of an electric current.

ELEMENT
A substance which cannot be separated into simpler parts.

EVAPORATE
To change a liquid or solid into a vapor or gas. This is usually done with hea Minerals, salts or ash often remain behind. Many liquids will evaporate on simpl exposure to the air.

IMMERSE
To dip or plunge into anything that surrounds or covers—especially a liquid.

ION
An atom or group of atoms which carries a certain amount of electricity.

LAW OF CONSERVATION OF MATTER
Matter can neither be created nor destroyed. For example, if we burn a piece o coal, the weight of ashes and gases formed after burning is exactly equal to the weigh of the coal before burning. This is true with every chemical reaction that takes place.

LAW OF DEFINITE PROPORTIONS
Atoms unite with one another in definite though frequently in two or more differe proportions. For example, carbon, sulphur and arsenic form two distinct oxides, C and CO_2,SO_2 and SO_3 and As_2O_3 and As_2O_5.

MIXTURE
A mass of two or more ingredients, the particles of which are separate, independe and uncompounded with each other, no matter how thoroughly and finely they a mixed. There is no chemical union as there is in a compound.

MOLECULE
The smallest particle of a chemical compound which is capable of existence.

PHYSICAL CHANGE
A change which does not affect the identity of the substance or substances acte upon.

PRECIPITATE
An insoluble substance separated from a solution by the action of some substan which is added to the solution. The precipitate may fall to the bottom (hence t name which means to throw down) or it may float in the liquid.

SALTS
Compounds formed by the combination of acids and bases, and resulting in t replacement of part or all of the hydrogen atoms of the acid by metals.

SOLUTION
The art or process by which a body, whether solid, liquid or gaseous, is absorb in a liquid and diffused or spread throughout the liquid. The liquid is called t solvent.

SYMBOL
For convenience, elements are designated by symbols. Each symbol stands for o atom of an element; as S for sulphur, Pb for lead (Latin plumbum). NaCl is t chemical formula of and represents a molecule of sodium chloride or common tab salt.

VALENCE
The combining power of an element. Chlorine is univalent and oxygen is bivale because they unite with hydrogen to form the molecules, HCL (hydrochloric acid) a H_2O (water), respectively.

CHEMISTRY CLASSIFICATION

Inorganic Chemistry

Metals, minerals, ores, etc., which are found in nature occurring in the crust of the earth, are classified as inorganic materials. They are not combustible in the sense that they can be burned like carbon to gaseous products. They represent a classification which was originally spoken of as mineral substances and are distinguished from those products or substances which originate directly or indirectly from living organisms. Iron, copper, glass and the ore pyrite, for example, are typical inorganic substances, and all materials of this nature are treated under a specific classification which we designate as inorganic chemistry.

Organic Chemistry

It was the French chemist, Lavoisier (1743-94) who showed that in spite of their great number, nearly all vegetable products occurring in nature are composed of three elements—carbon, hydrogen, and oxygen—whereas animal substances, which also consist, for the most part, of these same three elements, contain nitrogen, and in some cases phosphorus, sulphur and iodine. All such products were shown to be not only peculiar in their composition, but also were combustible. This discovery of Lavoisier and later workers led to the belief that all animal and vegetable substances in nature were produced under the influence of a *vital force,* and that their formation in nature was regulated by laws which were different from those which governed the formation of mineral substances. For this reason, therefore, compounds obtained from animals and plants, either directly or indirectly, were called organic compounds and a study of the products of this type was classified under the designation "Organic Chemistry." This distinction between organic chemistry and inorganic chemistry was generally accepted until the year 1828, when the German chemist, Wohler, succeeded in preparing urea (an excretion product of animal organisms) by heating the inorganic salt, ammonium cyanate, a substance which might be considered to be inorganic, or mineral. This classic synthesis showed that the influence of a living organism was not necessary for the production of an organic substance—urea. As the science of chemistry was developed, it was soon found that a great many other so-called organic substances could be prepared in the laboratory by artificial methods and from materials of inorganic origin, and ultimately it came to be generally acknowledged that many of the processes which occur in animals and plants could very probably be carried out in the laboratory, and that the formation of an organic compound is probably not dependent at all on the help of any vital force than is that of an organic compound. Today this difference between the two classes of compounds has been recognized as an imaginary one, and the terms "organic chemistry" and "inorganic chemistry," have, to a large degree, lost their original meanings. They do, however, serve to sub-divide the fields of chemistry into two groups which are characterized by their own special technique, and whose exploitation has led to products which have satisfied many human needs and produced a basis for important and basic chemical industries. The compounds of carbon compounds also are all related to one another and they differ widely in their general behavior from those of all other elements. Carbon compounds, therefore, form, in fact, a very distinct group of compounds, and it is therefore convenient to class them separately and to distinguish them by the term "organic." Organic chemistry, therefore, is, according to modern interpretation, the chemistry of the carbon compounds.

METRIC SYSTEM TABLES

Length

1 kilometer (km) = 1000 meters
1 hectometer (hm) = 100 meters
1 dekameter (dkm) = 10 meters
1 decimeter (dm) = 0.1 meter
1 centimeter (cm) = 0.01 meter
1 millimeter (mm) = 0.001 meter

Weight

1 metric ton (t) = 1000 kilograms
1 kilogram (kg) = 1000 grams
1 hectogram (hg) = 100 grams
1 dekagram (dkg) = 10 grams
1 decigram (dg) = 0.1 gram (g)
1 centigram (cg) = 0.01 gram
1 milligram (mg) = 0.001 gram

Area

1 square kilometer (sq. km) = 1,000,000 square meters
1 square hectometer (sq. hm) or 1 hectare (ha) = 10,000 square meters
1 square dekameter (sq. dkm) or 1 are (a) = 100 square meters
1 centare (ca) = 1 square meter
1 square decimeter (sq. dm) = 0.01 square meter
1 square centimeter (sq. cm) = 0.0001 square meter
1 square millimeter (sq. mm) = 0.000001 square meter or 0.01 square centimeter

Volume

1 cubic kilometer (cu. kl.) = 1,000,000,000 cubic meters
1 cubic hectometer (cu. hm) = 1,000,000 cubic meters
1 cubic dekameter (cu. dkm) = 1,000 cubic meters
1 cubic meter (cu. m) = 1 stere (s)
1 cubic decimeter (cu. dm) = 0.001 cubic meter or 1 liter
1 cubic centimeter (cu. cm) or (cc) = 0.000001 cubic meter or 1 milliter (ml)
1 cubic millimeter (cu. mm) = 0.00000001 cubic meter or 0.001 cubic centimeter

CONVERSION TABLES

Weight

10 grams = about one-third ounce
50 grams = about 2 ounces
250 grams-= about one-half pound

Capacity

30 cubic centimeters (cc) = about 1 fluid ounce
60 cubic centimeters (cc) = about 2 fluid ounces
125 cubic centimeters (cc) = about 4 fluid ounces
250 cubic centimeters (cc) = about 8 fluid ounces
360 cubic centimeters (cc) = about 12 fluid ounces
500 cubic centimeters (cc) = about 16 fluid ounces
1000 cubic centimeters (cc) = about 32 fluid ounces

Length

1 millimeter (mm) = about one twenty-fifth of an inch
1 centimeter (cm) = 10 millimeters = about two-fifths of an inch
1 inch = about 2½ centimeters

METRIC CONVERSION TABLE

millimeters ÷ 25.4 = inches
centimeters ÷ 2.54 = inches
meters x 39.37 = inches
meters x 1.094 = yards
square centimeters x .155 = square inches
square meters x 10.764 = square feet
square kilometers x 247.1 = acres
cubic centimeters ÷ 16.383 = cubic inches
cubic centimeters ÷ 3.69 = fluid drams
cubic centimeters ÷ 29.57 = fluid ounces

cubic meters x 35.315 = cubic feet
cubic meters x 1.308 = cubic yards
cubic meters x 264.2 = gallons (231 cubic inches)
liters x 61.022 = cubic inches
liters x 33.84 = fluid ounces
grams ÷ 981 = dynes
grams (water) ÷ 29.57 = fluid ounces
grams ÷ 28.35 = ounces avoirdupois
grams per cubic centimeter ÷ 27.7 = pounds per cubic inches
joule x .7373 = foot pounds
kilograms x 2.2046 = pounds

U. S. WEIGHTS AND MEASURES

Apothecaries' Weight

20 grains = 1 scruple
60 grains = 3 scruples = 1 drachm
480 grains = 24 scruples = 8 drachm = 1 oz.
5760 grains = 288 scruples = 96 drachm = 12 oz. = 1 lb.

Avoirdupois Weight

27.343 grains = 1 drachm
437.5 grains = 16 drachm = 1 oz.
7000 grains = 256 drachm = 16 oz. = 1 lb.

Troy Weight

24 grains = 1 dwt.
480 grains = 20 dwt. = 1 oz.
5760 grains = 240 dwt. = 12 oz. = 1 lb.

Imperial Fluid Measure

16 fluid drams = 1 fluid oz.
128 fluid drams = 16 fluid oz. = 1 pint
1024 fluid drams = 128 fluid oz. = 8 pints = 1 gallon
1 gallon = 58328.886 grains of water at 16.7 dg. C. = 62.06 dg. F.
1 fluid oz. = 455.694 grains of water at 16.7 dg. C. = 62.06 dg. F.
1 gallon = 231.000 cubic inches.
1 fluid oz. = 1.8047 cubic inches.
1 cubic foot of water = 1000 oz. Avoir.

PART I

The Chemists' Laboratory
and
How the Chemist Uses His Equipment

The chemist's work-room or laboratory has several special requirements if it is be fully satisfactory. A room somewhat isolated to avoid interruption is desirabl especially if small children are around to stick inquisitive fingers into things. Goo ventilation is necessary, and at least enough heat at all times to keep water solutio from freezing. While a capable chemist seldom spills anything, and, in spite of pop lar opinion, almost never has an explosion, it is better to have the laboratory plain and simply furnished so that an accidental splash will do no damage. A plain wood floor is better than a carpet, and concrete or linoleum are still better. The work tab may be of plain lumber, with the top waxed frequently to protect it. A sink and supply of running water are quite essential, but if he lacks these the ingenious b chemist will find a way to provide himself with running water from a pail fitted wi a siphon and hose. And you never will get too many shelves, cabinets and drawers f storage.

Now in picturing to you this ideal laboratory, we realize that few boys can have this at once. In fact, your Gilbert Chemistry Set has been designed to be as far possible a complete laboratory in itself. But we feel sure you will enjoy it more if y can at least select for it a secluded corner in den or kitchen, or even in the woodshe cellar, or attic, where your apparatus may be left set up undisturbed and where the will be room to expand as you build or buy new equipment and supplies.

THE EQUIPMENT AND ITS USE

Good technique can only be acquired by careful self-training. Learn what use ea piece of apparatus is intended for, and the best way to handle or use it. Begin at t start by having a place to keep each and every piece, and keep it clean and in its pla Be extremely careful not to contaminate your chemical supplies by getting even trac of one into the bottle with another. And watch to keep your chemicals replaced as so as the supply runs low.

While you have not been furnished with dangerous and poisonous chemicals, neve theless they are not intended to be taken into the mouth, and you should begin n to train yourself, not only never to taste anything in the laboratory, but to use cauti in smelling.

THE BALANCE

The balance is one of the most prized possessions of the chemist and for v accurate weighing he may have a balance costing several hundred dollars and sensit to one ten-thousandth of a gram or less.

Supplied with the balance are several weights weighing ½ gram each. Since chemists use the metric system to express weights and measures you should familiar yourself with the simplest units. The gram is the unit of weight, and is taken as weight of 1 cubic centimeter of water at a temperature of 4° Centigrade.

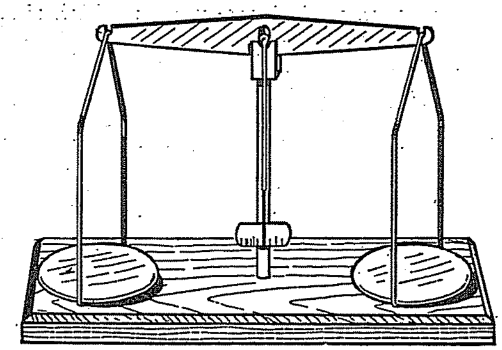


FIG. 1

$$1000 \text{ grams} = 1 \text{ kilogram} = 2.2 \text{ pounds (approximately)}$$

$$\frac{1}{1000} \text{ gram} = 1 \text{ milligram}$$

These are the units of weight you will use most commonly. You may also find it nvenient to know that

1 pound = 454 grams (approximately)
1 ounce = 28½ grams (approximately)

Abbreviations:
- Kilogram—kg.
- Gram—gm.
- Milligram—mg.
- Pound—lb.
- Ounce—oz.

XPERIMENT 1—To weigh solids on your balance

First protect the balance by covering both pans with squares of paper of the same ze. Be sure the beam is swinging freely without friction and observe the center point f the swing of the pointer on the scale. It should swing an equal distance each side f the center of the scale and if it does not you should look to see that the papers are ual in weight.

Now place the required weights on the paper on the right pan, and carefully pile e substance to be weighed on the left pan until the pointer again swings just the me distance each side of the center of the scale. You now have the required weight f substance ready for your experiment. Always use a fresh, clean piece of paper for ch weighing.

XPERIMENT 2—To weigh a liquid on your balance

First place a small dish or a beaker on the left pan of the balance. On the right pan lace a dish or bottle which is slightly lighter and carefully add sand to this dish until just balances the other. We call this a counter-balance. You may want to make up ermanent counter-balances, using small stoppered bottles with sand, for the beakers ou use most often. Finally place the required weights on the right pan beside the ounter-balance and slowly pour the liquid to be weighed into the beaker until the balance pointer again swings an equal distance to right and left of the center of t scale. With practice you will learn to recognize when you have nearly the requir quantity of liquid and can add the remaining portion drop by drop to avoid getti too much. In case a little too much liquid has been poured into the beaker on the b ance, you will find a medicine dropper very convenient for removing just the rig amount.

Always clean the balance pans immediately if you spill either solids or liquids them.

EXPERIMENT 3—To make an additional 10 gram weight for the balance

Since your balance is rugged enough to weigh far more than 10 grams, you m wish to make up additional weights to use with it. First make an additional 10 gr weight. Get a thin walled glass vial which, with a cork stopper, weighs less than grams. Place the vial and stopper on the right pan of the balance and your origi 10 gram weight on the left pan. Pour grains of sand into the vial until the pans balance. Stopper the vial and you have a practical 10 gram weight. If you wish label it, the label should be stuck on to the vial before you bring it to the exact wei with sand.

Notice that in this experiment you have reversed the usual procedure and placed vial on the right pan of the balance and the weights on the left. This is to correct any inequality in the lengths of the balance arms. Ordinarily in using the balance weighing, the weights are *always* placed on the right hand pan. You can now see the vial of sand when placed on the right pan will always balance 10 grams of material on the left hand pan. Make two of these 10 gram weights.

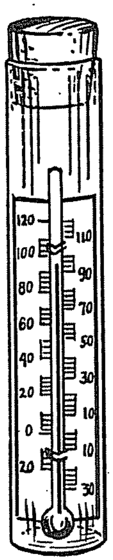


FIG. 2

EXPERIMENT 4—To make a 20 gram weight

Obtain a glass vial with a stopper weighing less than 20 grams. P these on the right hand pan of the balance and on the left place the 10 gram weights you have just made. Proceed as in the previous exp ment to put sand in the vial until the balance pointer swings freely equal distance each side of the center of the scale, then stopper the tightly.

EXPERIMENT 5—To make a 50 gram weight

Proceed as above, but place on the left hand pan the two 10-gram the 20-gram weights you have made, together with the original grams that came with your set. You may find it better to use small or iron filings instead of sand to give the necessary weight to the via

If you have made all these weights, you will find that you are abl choose combinations to weigh any article up to 100 grams.

EXPERIMENT 6—To make a 1-ounce weight

While you will usually use grams instead of ounces in chemical periments, you may wish to make up a set of weights in ounces (av dupois). To do this place on the left pan of the balance a combina of weights totalling 28½ grams and proceed as before.

THE THERMOMETER

The Thermometer is one of the chemists most useful instrument can be dipped into corrosive liquids without damaging it. Care shoul used in handling the thermometer as too sudden changes in tempera sometimes break the glass.

THE SPATULA AND MEASURE

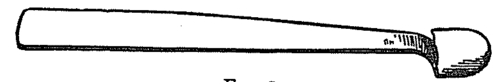


FIG. 3

One measure of a dry chemical means as much as can be held in the spoon-shaped easure, Fig. 3. For transferring solid materials and for rough measuring the chem- uses a flat blade called a spatula. Your set has been equipped with an improved atula having the flat blade at one end and a small spoon-shaped measure at the her. Even when made of corrosion-resistant metals, a spatula is soon corroded by emicals unless you wash and dry it immediately after use. A roll of inexpensive per toweling is invaluable for this and similar purposes in your laboratory.

THE MEASURING SPOON

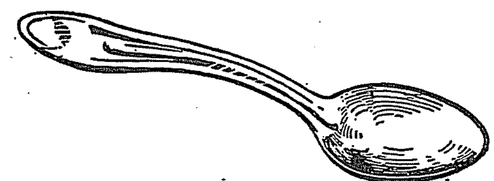


FIG. 4

One teaspoonful of a dry chemical means as much as the spoon will hold after tap- ng it lightly. The teaspoon is also used for heating solids. Fig. 4.

BEAKER

The beaker is a straight sided glass container generally used for mixing and heating antities of material too large for a test tube. It should be of a quality of glass cap- le of standing sudden temperature anges without breaking. Even with the st of glass a wire gauze or an asbestos it should be placed between the free me and the bottom of the beaker.

Although the beaker is provided with lip for pouring, liquid sometimes runs wn the outside of the beaker unless a ss rod is held across the lip of the aker in the position shown in the etch.

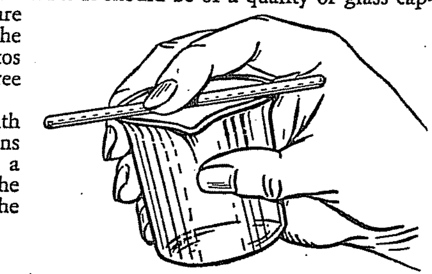


FIG. 5

EXPERIMENT 7—To pour liquid from a beaker

Fill a beaker quite full with a liquid (water, for practice) and place a stirring ro across the top so that it rests on the lip of the beaker and the end extends a litt beyond the lip. Now pick up the beaker with the rod held in position by the first finger as shown in the sketch and tip it slowly to pour. Notice that the liquid follows the glass rod and is much less likely to run down the side of the beaker than when no rod is used in this way.

FLASK

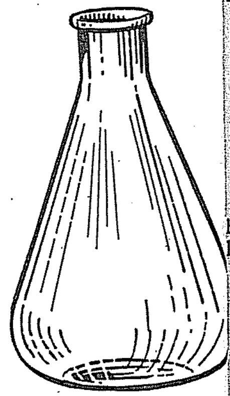


FIG. 6

When chemical mixtures are to be heated in such a way as to avoid the loss of vapors, a flask replaces the beaker. The same good quality of glass is needed as in the beaker, and the same precaution to avoid heating over a free flame. By suitable fittings the flask can be converted into a distilling flask, gas generating bottle, wash bottle, and many other useful combinations. Never heat anything in a stoppered flask for it may develop pressure enough either to blow out the stopper or to burst the flask. In either case the contents of the flask may be splashed around the room with bad results.

TEST TUBES

The test tubes in your set are not the miniature toy affairs sometimes put into che istry sets, but practical test tubes made of especially strong, heat-resisting glass. So skill is needed when heating liquids in a test tube to avoid sudden explosive forn tion of steam which may throw some of the liquid out of the tube.

THE TEST TUBE HOLDER

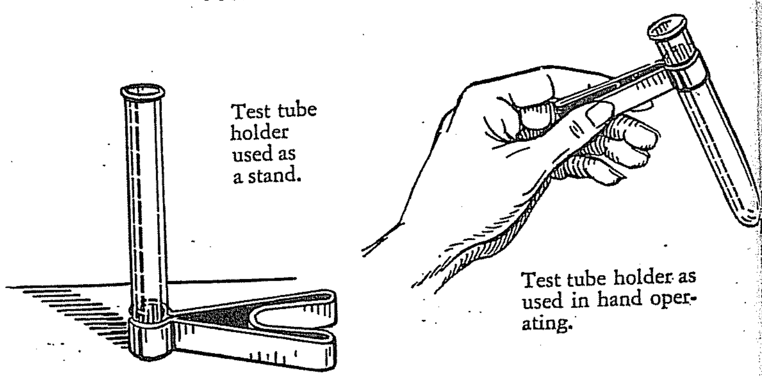


FIG. 7

The Test Tube Holder can be used for two purposes: when heating mixtures in a st tube it sometimes becomes too hot to hold with the fingers, and it is recomended to always use the test tube holder. The Test Tube Holder can also be used as stand. (See illustration, Fig. 7.)

THE STIRRING ROD

FIG. 8

A stirring rod, Fig. 8, is a very convenient piece of apparatus for mixing a solution hen dissolving a solid in a liquid. It is a solid glass rod, round at both ends. lways clean the rod with water before using it in different solutions.

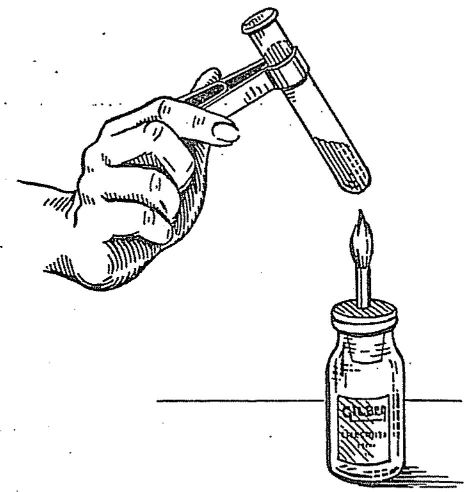


FIG. 9

PERIMENT 8—Heating a liquid in a test tube

Fill a test tube about one-third full with water and attach the test tube holder ır the top of the tube. Hold the tube over the flame of the alcohol lamp, keeping n a slanting position as shown in the illustration so that the heat strikes the side of tube. Maintain a gentle shaking motion to promote smooth and steady boiling. en with this precaution, do not point the open end of the tube toward yourself or other person while you are heating it.

f a test tube has been heated empty or with dry solid materials inside, do not ır water or any other liquid into the tube until it has cooled.

TEST TUBE BRUSH

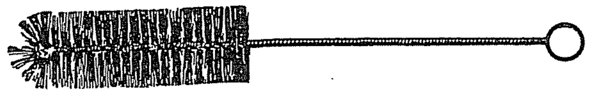


FIG. 10

A test tube brush has been furnished to help clean the test tubes. You will [cut off] that a little of an ordinary kitchen scouring powder on the brush will help gre[cut off] in cleaning them. Always clean the test tubes immediately after you are through us[cut off] them so they will be clean and dry next time. Clean test tubes are very convenie[cut off] stored upside down on the pegs of your test tube rack.

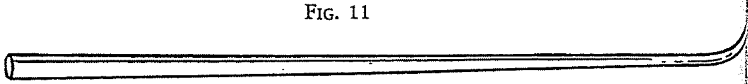
ALCOHOL LAMP

Although chemists usually use a gas burner, we have supplied an alcohol lam[cut off] accommodate the many boys in homes where gas is not available.

The alcohol lamp supplies enough heat for most laboratory purposes, and prov[cut off] a clean flame with less attention to adjustment than the gas burner. Use a good g[cut off] of denatured alcohol. If the alcohol has been mixed with water, the alcohol will [cut off] to evaporate first, gradually accumulating water in the lamp until it does not burn [cut off]

BLOW PIPE

FIG. 11



A more intense flame can be obtained by supplying a jet of air with the b[cut off] pipe as shown in the sketch. This is frequently done in fusing small lumps of m[cut off] compounds on a charcoal block to identify them, but for longer operations suc[cut off] glass blowing this method is awkward and tiresome. Most boys will be tempte[cut off] connect the blow-pipe to some mechanical air compressor such as the vacuum cle[cut off]

GAS DELIVERY TUBE

The gas delivery tube (Figure 12) is used whenever a gas is [cut off] conducted from a test tube, in which it is formed, into another test[cut off] or vessel.

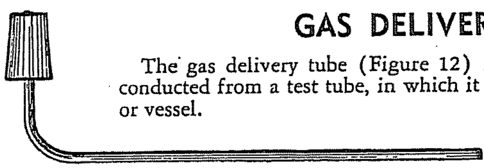


FIG. 12

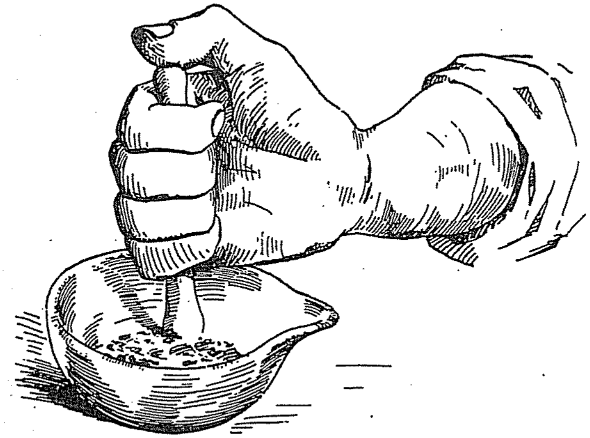


FIG. 13

MORTAR AND PESTLE

The mortar and pestle is used both for grinding lumps of solids to a powder and [cut off]r mixing substances in solid or paste form.

[cut off]KPERIMENT 9—To pulverize a coarse solid to a fine powder

Place one or two pieces of loaf sugar in your mortar. Now, holding the mortar in [cut off]ur left hand, take the pestle in the fingers of the right about as you would hold a [cut off]ncil in writing. Gently tap the lumps of sugar a few times until they have crumbled [cut off] a loose mass of small crystals. Never pound hard with the pestle. Next change your [cut off]ip on the pestle, *holding it firmly as shown in the picture,* and rub the pestle around [cut off]d around inside the mortar while pressing fairly hard. See how the crystals of sugar [cut off]ange to a fine white powder.

THE FUNNEL AND FILTERING

The glass funnel may be used in the usual way to assist in pouring liquids into [cut off]ttles, but it is especially designed for filtering.

[cut off]PERIMENT 10—To filter solid particles from a liquid

For this operation the funnel must first be lined with filter paper. The filter paper [cut off]mes in circles which are to be folded twice as shown in the drawing, then opened [cut off]t into the cone-shaped cup which will fit into the funnel. When a liquid containing [cut off]rticles of solids is poured into this filter, only the liquid runs through and all the [cut off]lid matter is retained on the paper.

You can prepare a suspension of solid particles in water by dissolving a measure of [cut off]lium carbonate in a test tube one-third full of water and a measure of calcium [cut off]loride in the same quantity of water in another test tube. Now pour the contents of one tube into the other and, covering the open end of the tube with your thu mix the contents well. The white solid which forms is calcium carbonate. Pour mixture into the filter paper cup which you have fitted into the funnel. A perfe clear liquid will run through the filter, leaving the white solid on the paper.

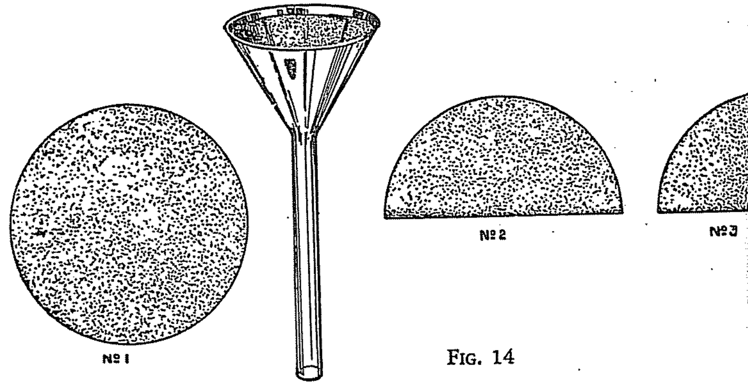


FIG. 14

This liquid, although clear, is not pure water for it contains substances in solu which cannot be removed by filtering.

THE GAS GENERATOR

This is a very convenient piece of apparatus for generating and delivering gases. It is set up as shown in Figure 15.

The end of the funnel in the generator bottle must always be below the surface of the liquid in the generator bottle, otherwise some of the gas will go out through the funnel and be lost.

The solid from which the gas is to be obtained is placed in the bottle and enough water added so that the stem of the funnel will come just below the surface of the liquid in the bottle. The other reacting substance, usually an acid, is then added in portions through the funnel in order to keep up a steady flow of gas.

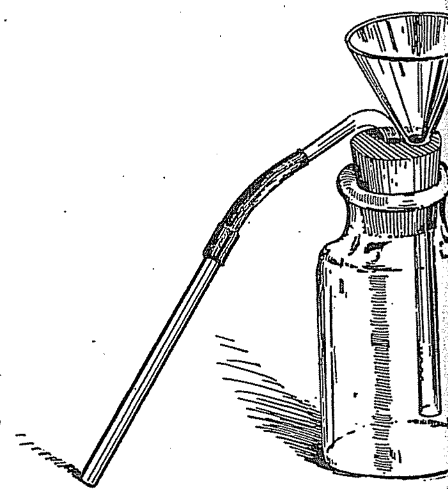


FIG. 15

MEASURING LIQUIDS OR SOLUTIONS

The medicine dropper (Figure 16) is a very useful piece of apparatus for measur- g out several drops of a liquid or solution. The dropper is filled by pressing on the lb and inserting the open end of the dropper into the solution. On relieving the essure, the dropper is filled with the solution.

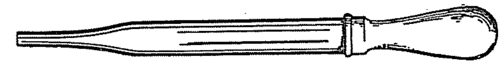


FIG. 16

Always wash out the dropper with water several times before using it with dif- ent solutions.

GLASS BLOWING

Only a few simple operations can be undertaken in glass blowing unless you have ecial equipment. You should know how to cut glass tubing and rods, how to fire lish the cut ends, and how to make very simple bends.

PERIMENT 11—To cut small glass tubing and rods

To cut a rod or tube, make a scratch by one (and only one) stroke of a sharp angular file at the place where it is to be cut. Now hold the tube in both hands th the thumbs together and pressing gently on the glass on the opposite side from scratch. It should break very easily if the scratch was properly made.

PERIMENT 12—Fire polishing glass

The edges will be very sharp after a fresh cut, but by holding the glass over the me of the alcohol lamp so that only the sharp edge is in the hot part of the flame will be able to soften the glass until a smooth round edge forms. This is called polishing.

PERIMENT 13—To bend glass

Cautiously heat the glass in the flame of the alcohol lamp, turning it continously as to be sure you heat it evenly all the way around. When it has softened, remove glass from the flame and bend it a little. Return it to the flame and soften another tion of the glass just beyond the part you softened first. Bend the glass a little re. Repeat, if necessary, until the glass has been bent to the desired angle.

If you have a gas burner you can heat a larger portion of the glass at once and you y be able to make the complete bend with only one heating.

You will find that you can often devise useful apparatus from materials that you l around the house. For instance, tumblers and jelly glasses are just as useful as kers, *provided you never try to heat them.* You can make larger jars by cutting off necks of bottles or jugs.

PERIMENT 14—To cut a glass jug in two

First make a short file scratch at the right height and tie around the jug at this ce a string soaked in alcohol. Light the string with a match and rotate the jug wly in a horizontal position while it burns. The glass usually cracks around under string. If it does not, you may help it by touching the hot glass with a drop of l water.