PLAY BOOKS OF SCIENCE

CHEMISTRY AND CHEMICAL MAGIC

Uniform with this Volume

MECHANICS AND SOME OF ITS MYSTERIES.

FLYING AND SOME OF ITS MYSTERIES.

PLAYBOOKS OF SCIENCE

CHEMISTRY AND CHEMICAL MAGIC

BY

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"THE THEORY AND PRACTICE OF MODEL AEROPLANING"
ETC.

OVER ONE HUNDRED AND FIFTY EXPERIMENTS
AND NUMEROUS ILLUSTRATIONS

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PREFACE

THIS is one of a series of little volumes dealing with the lighter and more amusing sides of science, and therefore properly termed "playbooks." In each the author's aim has been the same: to provide boys with material for intelligent amusement, in the course of which they will bring into play qualities that will serve them well in matters of greater importance. Every endeavour has been made to render the volumes up-to-date. Of the various experiments described a large number are original; and where selected they have generally been presented in a novel form. They have almost without exception been personally performed by the author, and every one is quite practicable if due care and a little patience be exercised.

Different volumes will naturally appeal to different readers. The amateur conjurer will naturally find most to interest him in the volume on Chemistry and Chemical Magic; the budding airman will turn with more zest to the volume on Aeronautics; the future engineer to that on Mechanics and Mechanical Appliances. What is important is that each boy should be encouraged in his proper bent. Every boy, like my Uncle Toby, should ride a hobby-horse of some kind; and an acquaintance with some branch of science, even if sought at first with no other end than recreation, will be a delight in itself, and may prove a stepping-stone to higher things.

In conclusion, if a word of advice may be addressed directly to the boy reader, it is this: Never be content merely to read about an experiment; that is, to see it only through the mind of the writer and the artist. Always perform it yourself, even if at first in a manner more or less crude: *that* is to see it with your own mind—the only real way to see it at all; *you* have made it *your* experiment and *your* knowledge. No man can take it from you; it is yours for all time.

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INTRODUCTORY

FROM the earliest times the science of chemistry has not failed to exercise a powerful attraction and influence on the minds of men. It has also never ceased to be a veritable storehouse of wonder and mystery, which has increased rather than diminished as more and more of its mysteries have been explored and made known. Much has been discovered; much is now clear that was once obscure or unknown; but still more remains hidden. In these pages we propose to peep into some of its mysteries. We shall not deal with chemistry as a science, but rather as a pastime and an amusement—an amusement which, if used properly, cannot fail to be one of a profitable character.

Nor are we concerned so much with the cause of such and such extraordinary effects, as with the effects themselves; although the former is a matter which has not been altogether neglected. Hints and suggestions are given from time to time which, if followed up by reference to standard text-books on chemistry, will supply the greatest of all desiderata—"The reason why."

Probably no science lends itself so readily to producing so-called magical effects as chemistry, yet (save in a very limited sense) its use for such purposes is of quite recent date. New chemical effects are constantly being discovered which are startling and unexpected in their results even to the initiated, and much more so to those who have made no special study of the subject.

We have stated that we are not directly concerned with the scientific explanation of cause and effect; but the experiments herein detailed must be carried out with a carefulness and a precision absolutely scientific if they are to succeed. Haphazard methods are useless and success by such means can only be in the character of a "fluke." The reason why chemical tricks are not so popular as they should be is because they have been too often prepared by unscientific people and treated in an unscientific manner. No illusion is more startling or puzzling than a chemical effect properly manipulated and presented; none a bigger failure or more biting frost than such an experiment performed in a careless, slovenly manner.

CHAPTER I

GENERAL PRECAUTIONS AND SUGG[redacted]

In order that success may attend the following experiments, none but pure chemicals should be used—this is absolutely essential. All chemicals should be kept in bottles (stoppered for preference) and properly and clearly labelled. If solutions or acids become at all discoloured, throw them away at once. Use distilled water not only when absolutely necessary but whenever advisable.

Clear glass jugs and decanters should be used whenever possible. Everything must be kept scrupulously clean, and thoroughly washed and carefully dried before using again.

Never present a new experiment to your friends or in public until you have thoroughly mastered it in private in every detail. Careful attention to small points will save endless trouble—the writer speaks from experience. However good an experiment may appear to you to be, always try to improve it. Nothing is perfect. Always present the experiment in your own way—it has thus become yours and you have set your mark upon it.

In chemical magic all changes must be sudden, startling, confounding—the less time given your audience to think, the less chance of your secret being discovered or your *modus operandi* grasped and understood. For example, if a coloured liquid is to be decolourized, the bleaching or reagent must be instantaneous—in the twinkling of an eye. Your agents[1] and reagents must, therefore, be delicate and of a highly sensitive nature to chemical influences. Also all quantities and proportions must be exact, for haphazard mixing and preparing cannot possibly lead to successful results. The actual apparatus required is, generally speaking, neither expensive nor difficult to make; but in studying and preparing the experiments a fairly good pair of ordinary scales—such as are used by amateur photographers—and a graduated measure are essential.

Carefully note in writing the effect of varying the relative proportions of the chemicals used in any experiment.

Do not begin by using large quantities. Commence with ordinary test-tubes or half-filled wine-glasses, and you can always increase the amount if you use your balance and graduated measure.

Having ascertained by experiment the exact proportions and quantities required to produce the best effect, make a careful note of the particulars and keep it for future reference.

The exact amount of the ingredients to be used in the following experiments is not always stated: this varies slightly with the nature and manufacture of the chemicals used, and much more with their purity and the care with which they have been kept. On changing the

[1] A chemical *agent* is one of the substances used in compounding two or more, in order to produce a desired result. A *reagent* is a substance which *reacts* upon a compound, reversing or upsetting the former result, thereby forming a new chemical compound. An *indicator* is a substance employed in chemistry to show the termination of a chemical reaction.

chemist from whom you purchase drugs, or on repeating an experiment after an interval, say, of several months, it is advisable to make a preliminary trial before commencing a public exhibition, as otherwise *you* may have a surprise as well as your audience.

CHAPTER II

LIQUID COLOUR EFFECTS

THE startling and instantaneous changing of liquids such as ink to water, water to beer, beer to milk, etc., is a favourite trick with magicians, and for more than two thousand years the apparent turning of water into wine and *vice versâ* has been one of their chief accomplishments. The methods of the ancients, who employed opaque vessels capable of concealing hidden partitions, may be left out of consideration, their results being due to mechanical and not to chemical agency.

EXPERIMENT 1

Wine and Water

Apparatus.—Two claret (or wine) glasses and two perfectly transparent decanters, one containing red wine the other water.

Chemicals.—Permanganate of potash, pure sulphuric acid, hyposulphite of soda.

If one gramme of permanganate of potash and two grammes of sulphuric acid be dissolved in a quart of (distilled) water a red liquid resembling wine is produced. This liquid can be instantaneously decolourized by pouring it into a glass containing a few drops of a concentrated solution of hyposulphite of soda. A little pinch of aniline dye, mixed into a paste with glycerine, and stuck to the bottom of a second glass—(this device permits of the glass being inverted or accidentally upset without the contents being lost)—is sufficient to change water to the colour of wine.

Decanter No. 1 contains clear water, decanter No. 2 the permanganate and acid solution. One glass is unprepared and one prepared as stated with the dye. The actual presentation of any experiment will in general be left to the taste of the reader. The usual method of procedure in such cases as the above is as follows. One of the guests or audience is asked to join the performer in some refreshment. The guest is asked to select one of the two decanters, and he will generally take the one containing wine. On his pouring the contents into the tumbler containing the hyposulphite of soda, it instantly becomes colourless, and the water in the other decanter is apparently turned into red wine on being poured into the second glass prepared with the aniline dye. The glasses etc. should be immediately removed on the conclusion of the experiment, owing to the turbid appearance that the red liquid will assume after a few minutes.

The mixtures are poisonous and must not on any account be drunk.

Experiment 2

Claret and Water (non-poisonous)

Apparatus.—Clear glass decanter and two clear glass tumblers.

Chemicals.—Phenolthalein, carbonate of soda,[1] tartaric acid.

Mix a spoonful or less of phenolthalein in a small decanter of water. One glass contains a little fairly strong solution of carbonate of soda, the other a little concentrated solution of tartaric acid. The clear liquid contained in the decanter is at once coloured by pouring it into glass No. 1; and the coloured solution decolourized by pouring it into glass No. 2.

The colour effect in this case is produced by what is known as a *sensitive indicator*, viz., the phenolthalein. When this chemical is dissolved in an acid or neutral medium it is colourless, but in an alkaline medium it turns red.

Other indicators than the above can obviously be employed with varied effect. Hundreds of such indicators are known, but only a few are of practical use for this purpose.

A very common indicator, *litmus*, is red in an acid, violet in a neutral, and blue in an alkaline solution. *methyl orange* is yellow in an alkaline and red in an acid. *Cochineal* is violet in an alkaline and yellow-red in an acid.

As regards alkaline and acid solutions generally, sodium and potassium carbonate usually serve to make such fluids alkaline, while tartaric acid is about the best to use to render a liquid acid, it being non-poisonous. Sulphuric, hydrochloric, oxalic, and acetic acids can also be used.

The most suitable chemicals to use for any combination can only be worked out by actual experiment.

[1] Caustic soda is preferable. Too much phenolthalein gives a violet colour.

Experiment 3

Water to Sherry and Sherry to Water

Apparatus.—Same as in Experiment 2.

Chemicals.—Tincture of iodine and potassium cyanide or sodium sulphite.

Alternative Method.—Methyl orange, chlorine water.[1]

No detailed account of this experiment is necessary. The colourizer is the iodine or methyl orange—the decolourizer the potassium cyanide (poisonous) or sodium sulphite; and in the alternative method the chlorine water.

Experiment 4

Water to Sherry, Sherry to Port, Port to Water

Apparatus.—Decanter and three glasses.

Chemicals.—Methyl orange, tartaric acid, chlorine water.

The decanter contains clear water, glass No. 1 a little methyl orange, glass No. 2 a few drops of strong tartaric acid, glass No. 3 a little chlorine water. The only difficulty likely to be experienced is in the bleaching action of the chlorine water, owing to the small quantity permissible if it is to escape observation. This may, however, be overcome by using two decanters (similar in appearance) and two glasses, the second decanter containing *a glass less* of chlorine water than the first. The *modus operandi* should be such that the audience are unaware of the existence of *two* decanters, and are led to think, when the contents of the second glass is being emptied back into the decanter, that this

[1] For method of preparing chlorine water, see Experiment 62.

is the original one. Pour from the first decanter into glass one, empty glass one into glass two, and glass two into glass three, or glass two into the chlorine water decanter.

Experiment 5

Water to Ink, Ink to Port, Port to Water

Apparatus.—A decanter of about a pint capacity filled (as before) with distilled water; seven wine-glasses alike in shape.

Fig. 1.

Chemicals.—Tannin, perchloride of iron, oxalic acid.

About as much tannin as will lie on a sixpence is dissolved in the distilled water in the decanter. Of the glasses, numbers one and three are unprepared; numbers two and four contain two drops of perchloride of iron; number five about ten drops of a saturated solution of oxalic acid; number six the same quantity of liquid ammonia; and number seven a small tea-spoonful of sulphuric acid. On pouring from the decanter, the first glass (unprepared) gives clear water, the second gives ink, the third clear water, the fourth ink once more (Fig. 1). The contents of all four glasses are then returned to the decanter—the whole then appearing as ink. The first four glasses are then filled from the decanter, the contents still appearing as ink. A wave of the magic wand over the fifth glass changes the ink when poured in from the decanter to clear water, and a wave in the reverse direction changes the same fluid to port, or more strictly speaking to claret, in the case of the sixth glass. The contents of all six glasses are then emptied back into the decanter, the whole being claret coloured. Once more six glasses are filled with claret coloured liquid; another wave of the wand or suitable action as the performer fills glass seven produces clear water once more.

The effect is much heightened if the glasses are not arranged in a row but apparently haphazard, and the final and semi-final changes not seemingly made in any particular glass.

On no account should the contents be tasted.

This experiment is one of many that can be performed with quite ordinary chemicals, such as iron (salts), tannic and gallic acids, salicylates, and such like chemicals. By dissolving a few drops of ferric chloride or perchloride of iron in water, the result is a colourless liquid; but on introducing a few drops of a tannate or gallate, the liquid is at once darkened, ferric gallate or tannic gallate being formed. To restore the liquid to its original colour a suitable reagent must evidently be used. Any acid which forms a colourless soluble salt when added to the tannate would answer the purpose. Oxalic acid is nearly always used, being the least corrosive, easy to handle, and portable in a crystalline form.

If we use a salicylate, such as sodium salicylate, in place of a tannate, a beautiful purple colour is the result, which can be reacted upon or cleared as before.

Experiment 6

Water to Ink, Ink to Port, Port to Sherry, Sherry to Water (many gradations)

Apparatus.—Large decanter of distilled water in which a small quantity of tannin has been dissolved as in Experiment 5, and a number of similar glasses.

Chemicals.—Tannin, perchloride of iron, bichloride of mercury, oxalic acid, sulphocyanide of potassium.

The exact number of glasses used and *modus operandi* are left to the taste of the operator. It will be sufficient to state here the effects of the new chemicals introduced.

The effects of tannin, perchloride of iron and oxalic acid have been already discussed in Experiment 5.

The order in which the chemicals are used is as follows: tannin, perchloride of iron, oxalic acid, sulphocyanide of potassium, bichloride of mercury, and more bichloride of mercury.

The oxalic acid changes the ink to water. The sulphocyanide of potassium changes the latter to port; the bichloride of mercury gives us sherry; and still more bichloride of mercury, clear water. The experiment is original.

EXPERIMENT 7

To stir a glass of water first to yellow, then (by gradations) to scarlet, and finally to clear water again

Apparatus.—Specially made tumbler, glass rod.

Chemicals.—Bichloride of mercury, iodide of potassium.

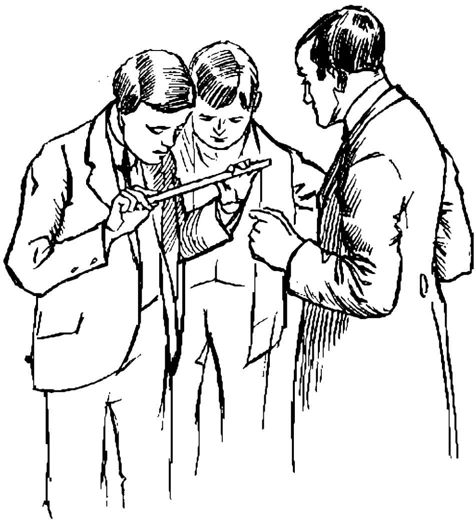

FIG. 2.

The old way of performing this experiment was by means of a hollow glass rod used as the stirrer; and it was very difficult to accomplish and often went wrong. The following way (the invention of the writer) is absolutely to be relied on if ordinary care be used. The glass rod is solid and genuine, and can be passed round for examination—a proceeding that quite nonplusses anyone knowing the ordinary manner of performing the experiment.

The glass previously inverted and shown empty is filled from a decanter or jug of clear water. This decanter or jug contains a solution of bichloride of mercury, which, as it is highly poisonous, must on no account be tasted or be left standing about.

Now, when a strong solution of iodide of potassium is mixed with it little by little, it gradually turns it yellow, brownish-red, red, scarlet, and finally, when still more is added, colourless.

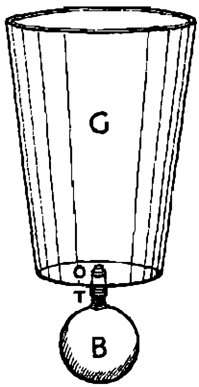

Fig. 3.

This experiment if properly shown can be made a very effective one. The manner in which the iodide of potassium is introduced by the writer is by means of a specially prepared tumbler, shown in Fig. 3. *G* is an ordinary glass, through the centre of the bottom of which a small hole has been drilled. This can be done at a china shop or wherever china is rivetted. *B* is a small indiarubber ball about an inch in diameter, and *O T* a piece of fine stiff rubber or glass tubing with a piece of valve tubing over it to make it watertight where it passes through the bottom of the glass. The tube and ball can be obtained in one at any chemist's. It is necessary that there should be a hole in the table or box on which the tumbler stands in order to allow the ball *B* to pass through, and a little care and practice are necessary in picking up the glass to hide the ball; but a few trials soon show the best way to do this. On no account squeeze the ball when inverting the glass. It is hardly necessary to add that the glass must be picked up and held with the back of the hand towards the audience and the ball in the palm of the hand. The glass is grasped close to the bottom by the *thumb* and first finger (or first or second fingers) with the ball *B* resting against the ball of the thumb, as shown in Fig. 4.

The ball is squeezed by pressing on it with the second or third finger. Any movement of the fingers of the one hand is sufficiently masked by the stirring of the liquid with the glass rod held in the other hand not to be observed by the audience.[1]

As more *liquid* is pressed up from the ball into the glass, the latter naturally gets fuller; and to avoid any too apparent increase, a quantity should from time to time be spilt or poured out on the excuse of showing that it is the liquid that is really changing colour.

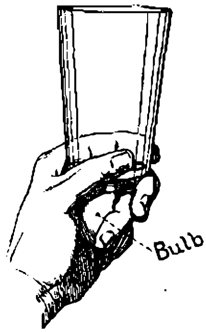

Fig. 4.

Another very interesting experiment with the same chemicals can be performed in the following manner. When the liquid has become scarlet, it is collected on a filter, and washed and drained. The residue (iodide of mercury) is of a beautiful scarlet colour, and when some of this substance is rubbed across a sheet of paper, a bright scarlet effect is produced, which may be rapidly changed to a lemon-yellow by warming the paper, and brought back to scarlet by rubbing down the crystals

[1] For method of filling ball see Experiment 15.

with the finger. The experiment can be repeated over and over again with like result. If some of the scarlet iodide of mercury is sublimed from one bit of glass to another, it forms crystals (rhombic prism form). When these are scratched with a pin they change again to the scarlet state, the latter when crystallized being of square base octohedron form. In these experiments the solution of chloride of mercury is carefully precipitated with one of iodide of potassium—just enough of the latter being added to precipitate the metal, for if more than this is used the iodide of mercury is redissolved in excess of the precipitant.

Experiment 8

To produce five or six differently coloured solutions from a glass jug full of clear water; to pour them all back into the jug and have still a clear solution; the original water to be drunk. More familiarly known as Rainbow or Chameleon Water.

The following original and very effective method of performing this experiment is accomplished by using vegetable dyes and sensitive indicators. Use two exactly similar glass jugs and secretly substitute the second jug for the first after filling the glasses. The second jug contains chlorine water equal in amount to the water left in the first jug after all the glasses have been filled.

Aniline dyes may be used, care being taken to introduce only just sufficient for the desired coloration; but these are not bleached so quickly and easily, and require a stronger solution of the chlorine water: and the stronger the solution the more it becomes tinged.

The water in the original jug may be slightly alkaline; then for the red use phenolphthalein; for yellow, methyl orange; for blue, litmus solution; for green, chlorophyll; for violet, a dye. Put only just sufficient of each for the desired effect in the bottom of the respective glasses.

Experiment 9

Chameleon or Rainbow Water (another method)

Apparatus.—Two decanters (clear glass) and tray, and half a dozen wine-glasses.

Chemicals.—Six aniline dyes (say) scarlet, blue, violet, orange, green, and purple. Glycerine.

The following is the original method of presenting this experiment. The magical idea contained in it is (1) that a chameleon has been dissolved or spiritualized in the original solution in the decanter, and that on pouring it out into separate glasses different colours can be produced at will; or (2) that the decanter contains a piece broken off a rainbow and dissolved in the water. If the latter idea be made use of, the dyes employed must be red, orange, yellow, green, blue and violet, to correspond to the colours of the rainbow. In the old way of performing the experiment, the different glasses were filled up with liquids of different colours and there was the end.

To make the experiment complete, the contents of the glasses should evidently be *poured back again* into the decanter and turned to clear water. This can be accomplished by using two similar decanters as described in Experiment 8.

Mix a little glycerine and water in equal proportions. Procure six little pots (such as chemists use for cold cream), and mix each dye powder with the glycerine and water until it attains the consistency of a paste or cream, and place in its respective pot.

The great feature of this experiment, considered as a magical illusion, lies in the fact that one of the decanters and some of the glasses are prepared. Calling the decanters A and B and the glasses 1, 2, 3, 4, 5, 6, the bottoms of glasses 1, 2, 3 have each a tiny dab of the dye paste, red, blue, and orange respectively. The lip of decanter A has three little dabs on it as shown (Fig. 5), say yellow at *a*, green at *b*, violet at *c*. The dabs may be placed a little lower down in the neck of the decanter if preferred. In filling glasses 1, 2, 3, the decanter must be held so that the water (this is all the decanter contains) shall run over the place marked *d*. The three glasses are filled in this manner. Having arrived thus far, the performer pretends he has forgotten something and made a mistake in not asking his audience in what order they would like to have the colours, and also in not handing the glasses round for examination. This is done; and the three remaining colours are poured out to order—by holding the decanter in the proper position so that the water runs over the correct dye. Decanter B contains a strong solution of chlorine water equal in amount to the water left in decanter A. Decanter B should be substituted for decanter A whilst the performer pretends to search

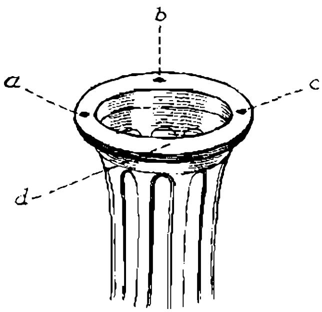

FIG. 5.

for a funnel with which to pour the liquids back again.

Some colours and dyes bleach more quickly and easily in chlorine water than others. If they do not change instantaneously it does not greatly matter. It is naturally more difficult to make a broken or disintegrated thing whole than to break it. In a room chlorine water, if very strong, can be smelt, and in such a case its smell must be overpowered by a stronger scent of a more pleasant kind.

Experiment 10

To have two glassfuls of liquid, one yellow and one blue; to mix them by pouring them into a third glass and obtain clear water

Apparatus.—Three tumblers.

Chemicals.—Methyl orange, litmus solution, chlorine water or tincture of iodine, sulphate of indigo, caustic soda.

In the one case methyl orange and litmus are cleared (bleached) by chlorine water. In the other a spoonful of concentrated solution of caustic soda is the clearer. Methyl orange and litmus mixed do not give a green, but indigo instead of litmus solution does. Tincture of iodine and indigo mixed in the proportion of two indigo to one iodine give a green if the colours are not too deep, weak solutions being the best.

As a chemical trick its entire success depends on the manner in which it is presented. It should be preceded by the mixture of blue and yellow pigments and blue and yellow dyes, and the fact that a mixture of blue and yellow produces *green* should be duly accentuated.

Experiment 11

To separate two wines that have been mixed

Apparatus.—Three decanters, two tumblers.

Chemicals.—Sulphocyanide of potassium, sulphocyanide of mercury, bichloride of mercury.

In decanter one is a solution of sulphocyanide of potassium (port); in decanter two, sulphocyanide of mercury, turned to sherry by bichloride of mercury. These are mixed in decanter three. In glass one is a little bichloride of mercury to turn the mixture to sherry, and in glass two is a dab of red dye to turn it to port.

Of over fifty experiments tried by the writer with various chemicals the above was found to give the best result.

The ingredients, being very poisonous, must on no account be tasted or left standing about.

Experiment 12

To turn Water to Milk and back again

White fluids representing milk, etc., may be formed by mixing soluble salts (in solution) with suitable agents, so that the final result shall give a white precipitate in suspension; but the results differ much in appearance and only a few salts are suitable. Soluble calcium salts, as calcium chloride, are rendered insoluble, forming white deposits with sulphates or carbonates, as sodium carbonate or sodium sulphate. Soluble silver salts act in the same way with chlorides, such as sodium chloride; as do also the soluble salts of lead. Mercury salts and ammonia give like results, and magnesium hydrate and sodium or potassium hydroxide give heavy curdy precipitates.

To take one or two of the best :—

(1) To form a fluid resembling milk, mix strong solutions of calcium carbonate and sodium carbonate; to clear it, use hydrochloric acid.

(2) Use nitrate of silver and a saturated solution of *pure* chloride of sodium; this is cleared by ammonia. Avoid shaking, or the milk goes into curds at once. The chloride of sodium must be pure—common salt is no good.

(3) Sulphurous acid and acetate of lead, which is cleared by strong nitric acid.

Experiment 13

To turn Milk into Wine

To do this, it is only necessary to clear the milk and add a little red dye.

Experiment 14

To turn Wine into Milk

This is achieved by clearing the wine and adding a milk producer. The wine is cleared by phenolphthalein plus an alkali (sodium carbonate) *in excess*; to turn to milk, add calcium chloride plus acid (tartaric).

Experiment 15

To turn a glass of water any primary colour asked for —red, green, or blue violet

Apparatus.—Specially prepared glass.

Chemicals.—The three required colours in dyes.

In this experiment, which is more mechanical than chemical, everything depends on a specially constructed glass similar to that described in Experiment 7, but with three small indiarubber balls or bulbs instead of one, for the three separate dyes or colour producers. This can be made in a cheap form by using a short incandescent lamp glass and closing one end with a bung. The rubber balls or receptacles are filled as follows. The glass is filled to a depth say of a quarter or half an inch with fluid of one colour; one ball is squeezed and allowed to expand and the process repeated until the ball is nearly full. Wash and dry the glass carefully, and proceed to fill ball number two by the same method. Again wash and dry the glass before filling the third ball, and again after all three balls are full.

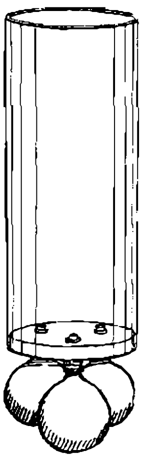

FIG. 6.

When presenting the experiment a circling movement must be given to the arm and glass, and thereby to the water in the glass, and the rubber bulbs should be pressed fairly hard to conceal the modus operandi. The glass can be safely inverted.

EXPERIMENT 16

The Obedient Colours: four different coloured liquids each of which changes to any colour asked for

Apparatus. Four glass tumblers and decanter.

Chemicals. Four aniline dyes not easily bleached, and four other colours easy to bleach (sensitive indicators) or easily bleached vegetable dyes.

Let the four tumblers (not more than two-thirds full) contain say, the following coloured liquids: yellow, red, blue, green or violet. The colours can be changed as desired from say yellow to blue, red to violet, violet to green, blue to red. The change is brought about by using a decanter containing a not too strong solution of chlorine water with its lip prepared as in Experiment 9. The chlorine water in the decanter is poured over the dab of dye of the desired colour.

The chlorine bleaches the coloured liquid in the glass but the dye gives it the colour demanded. It is advisable to remove the glasses, etc. as soon as the experiment is ended.

A little alcohol or eau-de-cologne should be added to the chlorine water in the decanter as aniline dyes are very soluble in it.

Further examples of liquid colour effects might be given, but enough should have been said to convey an idea how such changes are produced. Other experiments, as well as variations of those described, will no doubt readily occur to many readers; and the following are a few notes and suggestions which may be useful to those desiring to devise further original experiments for themselves.

Notes on Chapter I

When an oxide of manganese is fused in air with a caustic alkali, a bright green mass is formed which yields a dark green solution containing potassium manganate. If this green solution be allowed to stand it slowly changes to a bright purple colour.

Copper sulphate and ammonium hydrate produce a blue solution; also potassium ferrocyanide and weak solution of iron sulphate; also ferrocyanide of potassium and ferrous sulphate (protosulphate of iron)—the last named being a deep blue.

Iron perchloride and potassium sulphocyanide give a blood-red, decolourized by mercuric chloride; potassium sulphocyanide and sulphuric acid a fine old port colour, cleared by the same agent. Litmus solution and an acid produce red, also permanganate of potash and sulphuric acid, cleared by hyposulphite of soda. Potassium ferrocyanide and the double sulphate of uranium and potassium give an old port-like colour—washing soda clears it.

Mercury perchloride and sodium hydrate give a yellow solution, also lead acetate and potassium iodide; or better still potassium chromate.

Iron sulphate and pyrogallic, tannic or gallic acids produce black (ink); also tannin, and perchloride of iron; cleared by oxalic acid.

A solution of gold chloride added to a dilute solution of tin (stannous) chloride produces purple. Madder root and ferric oxide produce a very deep purple.

For colour change effects in green the writer uses chlorophyll—it being very easily bleached. Chlorophyll is the green colouring matter of plants.

A strong solution of indigo sulphate mixed with an equal quantity of potassium carbonate solution is said to make a piece of white cloth dipped into it blue; a piece of red, violet; a piece of yellow, green; and a piece of vegetable, yellow.

If boiling water be poured on a few slices of purple cabbage, thereby making a solution of the same, then an alum solution turns this green; a potash, purple; and hydrochloric acid, crimson.

To produce ink from sherry, coffee from ink, and turn the coffee back again to sherry, use fresh made tea, perchloride of iron, oxalic acid, and ammonia.

To produce foaming beer from sherry use tea and lithia tablet. Cover them for a time.

To pour milk, sherry, port, champagne, and blue ink from one bottle: in the bottle—a pint one—put two teaspoonfuls of a strong solution of perchloride of iron and one of oil of vitriol (sulphuric acid). In the first glass, for sherry, put one drop of a strong solution of sulphocyanide of potassium. In the second glass, for port, three or four drops of the same ; in the third glass, for blue ink, put two drops of a ferro-prussiate solution ; in the fourth glass, for champagne, a few crystals of bicarbonate of soda ; in the fifth glass, for milk, a few drops of a strong solution of acetate of lead.

Aniline Dyes are generally only used in magic when a single liquid colour change is desired or for a final effect in solutions where other agents or re-agents have previously been used. The reason is that the products sold under the name aniline (the aniline by-products) are so numerous and varied that years of experiment would be necessary before determining the exact re-agent to use in each case. The use of strong chlorine water for the purpose has already been dealt with.

A solution of tartaric acid added to one of syrup of violets turns the blue colour of the latter to red ; a solution of caustic soda turns it green ; and a solution of alum turns it purple.

Take a few chips of logwood and boil in a little water, thereby making a red solution. If this solution be poured into a glass which has been rinsed with vinegar the resulting liquid will be straw coloured ; and if it be poured into one which has been rinsed with a solution of alum the liquid is bluish black.

Experiment 17

A Colour Developer

Apparatus. A wooden frame (such as a slate or picture frame) on which is tightly stretched a piece of "unbleached" muslin.

Chemicals. Sulphate of iron, nitrate of bismuth, sulphate of copper, prussiate of potash.

Dissolve a small quantity of each of the chemicals in warm water. The first three named are your painting solutions, the last your "developer," as it were. Using a separate brush for each colour, paint on the muslin some (outlined) picture or design. It is not advisable to attempt much detail. Allow each colour to dry before painting the next. When dry all are quite invisible. To develop or bring out the picture all that is necessary is to spray on to the muslin a solution of prussiate of potash; the effect is hastened if the muslin is very slightly damp. When sprayed on with this chemical the sulphate of iron comes up blue, the nitrate of bismuth yellow, and the sulphate of copper brown.

If the prepared frame be hung in such a manner that the developer can be sprayed on from behind without the knowledge of the audience the effect in a magical sense is much heightened.

An ordinary scent spray or atomizer can be used, the sound being hidden by a little music.

Experiment 18

The Shifty Photograph

Print a photograph on chloride of silver paper; and, without toning, fix the print in a 9 per cent. solution of hypo (sodium hyposulphite). Wash thoroughly to eliminate all trace of the salt. Now take the print and float it on a 5 per cent. bath of chloride of mercury. The image rapidly fades and finally disappears altogether. Thoroughly wash in water and allow to dry. The latent image can be caused to reappear by immersing the print in a 5 per cent. solution of hypo; or a weak solution of ammonia might be tried, it having the property of colouring black the chloride of mercury.

Experiment 19

The Magical Drawing

It is a well-known scientific fact that the vapours of mercury are very diffuse in their action, the salts of silver, the chlorides of gold, platinum, iridium, and palladium being strongly affected by mercurial vapours.

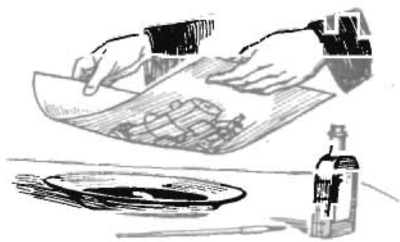

Fig. 7.

Suppose for instance a design (see Fig. 7) be drawn on white paper with platinum chloride, such a drawing would be quite invisible. If, however, the sheet of paper be held over some mercury contained in a dish, the metal will be brought out on the paper in dark tints. If the drawing be now placed in contact with a sheet of paper previously sensitised with a solution of platinum chloride the drawing will be reproduced line by line on the paper. Drawings made in this way are very distinct and clear and the half tones very soft.

Numerous chemical reactions give results such as those indicated above, the experiment being to write a letter, or execute a drawing or picture, with some chemical which will leave no apparent trace, and then develop the characters or design by means of a suitable re-agent. Here are a number of such experiments. A clean quill pen should be used.

Experiment 20

Write or draw with a solution of cobalt chloride; the writing or drawing (*green in colour*) disappears when breathed upon, to reappear when heated.

Experiment 21

For a *Blue* use potassium ferrocyanide, and sponge or spray with a dilute solution of iron sulphate;[1] or use copper sulphate, and sponge with ammonium hydrate.

Experiment 22

For a *Brown* use copper sulphate and develop with potassium ferrocyanide.[2]

[1] Acetate of cobalt, or muriate of cobalt, heated, give a similar result.

[2] Or milk, and heat.

Experiment 23

For a *Red* use chloride of mercury and develop with potassium iodide.

Experiment 24

Fluorescent Writing

If a design be written or drawn on white paper, using a solution of sulphate of quinine as the ink, such design or writing when dry will be quite invisible. But if it be exposed in a dark room to the light of an ordinary Geissler tube or *similar* electric light the writing or design will appear in blue (Fig. 8).

Fig. 8.

Similarly, if tungstate of calcium were used on a brownish or darkish paper, and the design exposed to the action of the X Rays (the X Ray bulb could itself be wrapped in black paper or placed in a cardboard or even a wooden box), it would appear in phosphorescent white.

If the (much dearer) chemical, barium platinocyanide be used, the phosphorescence is much stronger and of a greenish tinge. It is with this chemical that X Ray screens are coated. Another chemical almost equally brilliant (phosphorescing blue) is potassium platinocyanide; it is also equally dear.

For a further development of experiments of this nature see Chapter XV.

Experiment 25

For a *Yellow* use (1) chloride of mercury, and develop with sodium hydrate or caustic soda; or (2) acetate of lead, and develop with potassium chromate; or (3) dissolve equal parts of sulphate of copper and chloride of ammonia in water and develop by heat. The image disappears on cooling.

Experiment 26

For *Black* use (1) a solution of iron sulphate, and develop with pyrogallic, tannic or gallic acids; or (2) a very dilute solution of sulphuric acid, and develop with heat.

Experiment 27

For a *pale Rose colour* dissolve a little oxide of cobalt in acetic acid and a little potassium nitrate; develop with heat. The image disappears on cooling.

Experiment 28

A Zoological Transformation

Hydrogen sulphide if allowed to act upon a surface painted with chloride of antimony (itself invisible) has the effect of giving it an orange tint, and of imparting to a surface coated with a basic acetate of lead solution (also invisible) a black tint.

If we take a white cardboard model, say of a cat, and treat it with these solutions in the form of an antimony chloride groundwork, crossed by transverse stripes of acetate of lead, then, on subjecting it to the fumes of hydrogen sulphide, our cat becomes a tiger (Fig. 9).

The cat is best enclosed in a glass jar in which the gas can be secretly generated.

A little pulverised iron sulphide should be folded in a piece of blotting or filtering paper and placed behind the cat. A little dilute sulphuric acid is placed on the other side of the jar, which is slightly depressed on this side. On pushing the jar forward and moving it in such a way that the front becomes elevated, the sulphuric acid at once comes in contact with the iron sulphide—the gas is generated and the required transformation takes place.

FIG. 9.

EXPERIMENT 29

Flowers, figures, or other designs, may be drawn upon silk with a solution of nitrate of silver, when they are invisible. If they are moistened and exposed to the action of hydrogen gas, the latter removes the oxygen from the silver and reduces it to the metallic (visible) state. Designs drawn with a solution of chloride of gold may be similarly reduced; other chlorides, as chorides of tin, etc., can also be dealt with, due care being taken to keep the material damp whilst exposed to the hydrogen.

EXPERIMENT 30

Chameleon Pictures

On a piece of drawing paper sketch a scene with a solution of copper bromide. Paint in the trees, grass, etc. (in fact anything which it is desired should become green), with a solution of cobalt chloride. The sky and any water effects should be painted with a solution of cobalt acetate.

If the picture be heated the scene will be developed in its natural colours. The sketches should be prepared beforehand and allowed to dry.

In connection with this subject of chameleon pictures, it may be useful to note (1) that a solution of sulphate of copper and chloride of ammonia (blue) turns green when heated. (2) Oxide of cobalt dissolved in acetic acid and a little potassium nitrate added, under the action of heat, develops a pale rose. (3) The original colour of tourmeric paper is affected by ammonia and restored on the application of heat.

Experiment 31

The Blushing Picture

If any plain print or drawing be taken—preferably of a young lady—and the face, hands and neck be painted with a solution of equal parts of water and methylated spirits to which a few grains of phenolphthalein have been added, on subjecting the picture to the influence of ammonia vapour it will "blush" most vividly, especially if it be damp. Use a camel's hair brush. To damp it, hold it over steam and allow it to cool, or use clean water and a scent spray. A small sponge dipped in strong ammonia solution and concealed in the hand acts admirably as a blush producer. The picture resumes its original colour when withdrawn from the influence of the ammonia vapour.

Experiment 32

Magical Portraits on Glass

This most effective experiment consists in showing a square of plain transparent glass in or on which nothing can be seen even on the closest inspection, but if the glass be breathed upon so as to cover its surface with moisture, a portrait at once makes its appearance. As soon as the moisture leaves the glass the image disappears (Fig. 10).

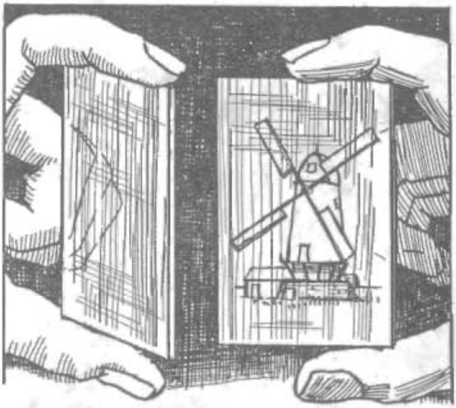
Fig. 10.

To produce this novel effect a piece of mirror (plate) glass is procured. A small quantity of fluorspar is placed on a tiny leaden dish and a little sulphuric acid added. The resulting chemical is hydrofluoric acid, with which too much care cannot be exercised. On no account should it be allowed to come in contact with the fingers, and it is best thrown away down the sink as soon as used. With this liquid and a quill pen the desired writing or drawing is executed on the glass, which must previously have been most carefully cleaned. In about five minutes, or ten at the most, the glass must be well washed in running water and carefully dried with a cloth. It is then ready for use, and it is only necessary to breathe upon it to bring out the design. A little experimenting is necessary to find out exactly how long to leave the acid on. Too long a biting of the acid would leave a perceptible drawing when dry, which is just what is not required.

The above interesting result is owing to the fact that fluorine possesses the remarkable property of attacking glass and other silicious bodies. Consequently hydrofluoric acid has to be kept in an indiarubber bottle. The above experiment is really one in glass etching.

EXPERIMENT 33

Another Experiment in Glass Etching

The glass plate is first coated with wax and the portrait, design, or drawing traced upon it. The plate is then subjected to the fumes of hydrofluoric acid as shown in Fig. 11. The wax plate must not remain too long over the leaden tray, as the heat is apt to melt the wax, when the acid not only attacks those parts of the glass from which the wax has been removed by the etching needle, but also the surface generally, thereby spoiling the clearness of the resulting image. To coat the plate with wax, heat it before the fire, and a sufficient quantity of wax is soon melted on to it by merely rubbing the wax against the plate. Any excess must be carefully avoided if a well-executed drawing is to be etched.

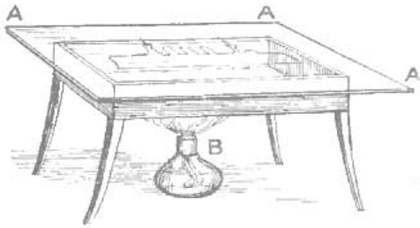

FIG. 11.

After exposure, the wax is quickly removed by rubbing and washing with oil of turpentine, and the design (which should be beautifully etched into the glass) is then apparent.

A solution of hydrofluoric acid in water is also used for the purpose of etching glass.

On no account must the fumes of the gas be inhaled and the experiment should be performed in the open air or in an airy place—not in a small shut-up room.

Fig. 12.

Experiment 34

The Magic Rosebush

Aniline possesses the property of being extremely soluable in alcohol or eau-de-cologne. This is usually shown in the laboratory by dusting some of the dye over a sheet of white paper and then shaking the surplus off until none apparently remains. If eau-de-cologne or alcohol be sprayed on to the paper it immediately becomes red.

If instead of scattering the dye on to paper, a white rose-bush be chosen, and the flowers so shaken as to render any remaining dust invisible, then when sprayed or watered with alcohol or eau-de-cologne the white roses immediately become red (Fig. 12).

Notes on Chapter III

If a dilute solution of nitrate of silver be used for the experiments in sympathetic writing or drawing, designs will be invisible till exposed to the light or the fire, when they will turn permanently black.

If a weak solution of sulphate of copper be used, this is invisible until held over ammonia fumes. The colour can be driven out by heat.

The juice of onion may be used—the writing is invisible until warmed.

Write with sulphate of iron—develop with camel's hair brush or feather dipped in prussiate of potash.

CHAPTER IV

MYSTERIES OF FIRE AND WATER

Experiment 35

Fire Burning under Water [1]

A mixture of nitrate of potash, powdered charcoal, sulphur, and strontium nitrate driven into a strong paper case about two inches long, well closed at the end and varnished so as to be quite waterproof, may be set on fire and will continue to burn under water until the whole is consumed, provided that the cartridge be burnt mouth downwards (Fig. 13). The best effect is produced when burnt in a deep glass jar.

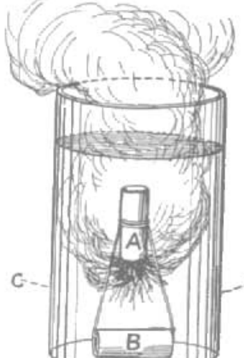

Fig. 13.

A, Case ; B, Leaden weight : C, Jar containing water.

The combustible (red fire) is made by mixing by weight: strontium nitrate 40 parts, flower of sulphur 13 parts, chlorate of potash 5 parts, sulphuret of antimony 4 parts. Powder the ingredients separately, and then mix carefully on a sheet of paper with a paper knife. *On no account must sulphur and chlorate of potash be rubbed together in a mortar,*

[1] See also Experiment 54.

being very liable to explode. The composition should not be kept for any length of time before using, as it is liable to spontaneous combustion.

Experiment 36

Burning Water

Apparatus. A brass bowl, a clear glass decanter and a tumbler.

Chemicals. Ether (pure). Potassium (the metal).

In the decanter is clean water, which may be poured into the tumbler and drunk. On pouring this same water into the bowl (of brass or iron) it at once catches fire and burns, producing a flame a foot or so in height.

This effect is produced as follows. The bowl contains a little ether—two or three teaspoonfuls—on which is placed a small piece of potassium not larger than a pea. If the ether be pure there will be no action; but when water is poured into the bowl the potassium at once sets free the hydrogen contained in the water; and the action is so vigorous that the hydrogen is ignited and thereby the ether as well—it being of course the ether that burns and not the water.

Experiment 37

A Piece of Ice used as a Match

This is nothing but an extension or modification of the last experiment depending on the watery character of the surface of the ice, which instantly ignites a piece of potassium when the latter is brought into contact with it. The writer has often amused himself by lighting a cigarette in this way.

Certain precautions must however be taken to insure success. The substances—tobacco, candle wick, etc.—in which the potassium is concealed (a tiny piece only projecting) must be *absolutely dry*: it should even be dried in the oven if necessary. And the piece of potassium should partake of the nature of a stick, as thick as a darning needle and about one quarter of an inch long. The exact amount can only be determined by experiment.

If the substance which it is desired to ignite be moistened (at the spot where the potassium is placed) with mineral naphtha, success is more certain.

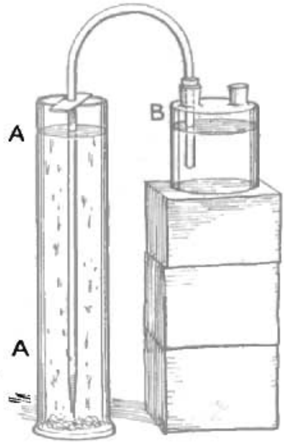

FIG. 14.
A, Glass jar; B, Wolfe's bottle.

EXPERIMENT 38

Fire Stars Burning in Water

Apparatus. Tall glass jar; Wolfe's bottle; some blocks of wood; glass siphon.

Chemicals. Phosphorus, chlorate of potash, sulphuric acid (oil of vitriol).

Phosphorus burns and emits beautiful flashes of light in the presence of a gas called chlorine peroxide. This gas has to be very carefully generated under the surface of water by first placing some cut phosphorus and chlorate of potash at the bottom of a long and stout glass jar nearly full of water; sulphuric acid is then conveyed to the chlorate of potash by means of the siphon BAA., as shown in Fig. 14. The bottom end of this glass tube must be drawn out to a small opening or else the sulphuric acid will descend too rapidly and the glass may be cracked with the heat. As soon as the iron peroxide comes in contact with the phosphorus it explodes and passes again to its original elements, oxygen and chlorine. These bubbles develop minute particles of phosphorus, which rapidly ascend like water-spiders to the surface, and burn as they pass upwards, producing a continual series of sparks of fire, the effect being extremely pretty. The siphon is first filled with water, which is gradually displaced by the sulphuric acid.

Experiment 39

Naked Fire Burning under Water

Phosphorus will burn under boiling water if oxygen gas play upon it. Take a piece of ordinary stick phosphorus (the kind that has to be kept under water in order to prevent spontaneous combustion in air), place it in a little metallic cup (see Fig. 15), and plunge it rapidly under the surface of the boiling water contained in a finger bowl of hardened glass. If a jet of oxygen gas be directed on the now liquid phosphorus, it will burn with great brilliancy. If the oxygen escape too rapidly from the jet some small particles may be thrown out of the water, consequently it is advisable to protect the

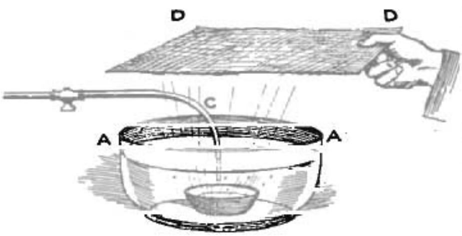

Fig. 15.
A A, Glass bowl; D D, Wire gauze; C, Jet of hydrogen.

face with a sheet of wire gauze held a few inches above the glass bowl whilst the experiment is being conducted. The effect is much heightened if a hole be drilled in the bottom of the bowl and the oxygen be introduced in a suitable jet through this in a secret manner.

EXPERIMENT 40

Will-o'-the-Wisp (1st method)[1]

If some phosphorus be placed in a retort with a fairly strong solution of potash and some ether, and heated

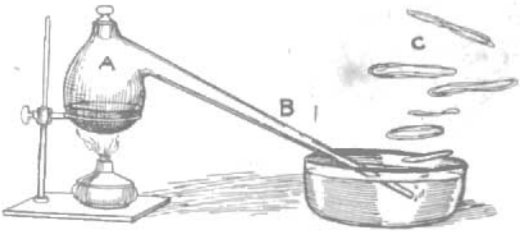

FIG. 16.

A, Retort; B, Neck dipping into basin of water; C, Gas burning and producing smoke rings.

over a lamp, a very considerable amount of a gas called phosphuretted hydrogen can be produced. This gas takes fire spontaneously on being exposed to the air. The neck of the retort must dip into a basin of water. The object of the ether is to prevent the combustion of the first bubbles inside the retort, which by their explosion would probably break the glass.

[1] That curious appearance of light, called "will-o'-the-wisp," after which these experiments are named, is supposed to be due to the escape from decomposing matter of bubbles of certain gases, through which phosphuretted hydrogen is diffused.

It is best to dissolve some potash in the water in the basin. On emerging from the water the gas at once burns, producing beautiful rings of smoke (Fig. 16).

EXPERIMENT 41

Will-o'-the-Wisp (*2nd method*)

If a few drops of phosphorized ether be poured on to a piece of lump sugar and the sugar be dropped into a glass of warm water, the surface of the water will become luminous; and, if it be blown upon, beautiful and brilliant surface undulations will be produced.

EXPERIMENT 42

Will-o'-the-Wisp (*3rd method*)

If phosphide of calcium be dropped into a glass jar two thirds full of water, phosphuretted hydrogen will be produced, which will rise in bubbles through the water and behave as in Experiment 40.

NOTES ON CHAPTER IV

Phosphide of calcium is obtained by heating together lime and phosphorus in a closed crucible.

In Experiment 40 a solution of caustic soda and coal-gas can be used instead of potash and ether, the coal-gas previous to heating being made to displace the air in the flask.

Phosphuretted hydrogen has an unpleasant odour, is poisonous, and must not be inhaled.

If a jar of oxygen be held over the neck of the retort described in Experiment 40, a bright flash of light and an explosion occurs; and if the experiment be performed in a darkened room the effect is similar to that of a sudden flash of lightning. A bottle of chlorine gas held over the neck of the retort, and dipping of course into the water in the basin, produces a green flame every time a bubble passes through it.

Phosphuretted hydrogen or phosphine is best prepared as follows: Fit to an 8 oz. flask a cork and rather large delivery tube, with its end leading into a pneumatic trough nearly full of water; and arrange on a retort stand. Place in the flask a few pieces of caustic potash, together with some small pieces of phosphorus and a little water. Pass coal-gas into the upper part of the flask so as completely to displace the whole of the air; then cork tightly and seal. Gently heat the flask; and bubbles of gas arise and displace the coal-gas. Soon each bubble as it rises to the surface of the water in the pneumatic trough bursts into flame and generates a beautiful vortex smoke ring.

Lime water may be used instead of potash water if desired. The odour of phosphine is that of putrid fish. The gas on standing in the light loses its will-o'-the-wisp properties.

Instead of coal-gas to displace the air in the flask carbon dioxide may be used, and in the hands of the inexperienced the latter is easier to experiment with than the former. A lighted taper plunged in carbon dioxide at once goes out, thus showing when the flask is full and ready. When the experiment is at an end, allow the liquid in the flask to cool until water is drawn up into it from the trough; and finally remove the cork from the flask—*with the flask under water*. If these directions are followed the experiment is a perfectly safe one.

The experiment with phosphuretted hydrogen and the jar of oxygen is one which should not be attempted by the inexperienced.

Stick phosphorus must always be kept and cut under water. On no account pick a piece up in the fingers, as the heat of the hands is almost sure to ignite it and the result will be a nasty burn.

CHAPTER V

SPONTANEOUS COMBUSTION AND MAGICAL EXPLOSIVES

Generally speaking experiments of this kind are safely performed only by an expert. There are, however, two which the careful beginner may venture upon without danger, and with which some very startling, effective, and even amusing results may be obtained.

Experiment 43

Spontaneous Combustion

A mixture of perchlorate of potash and powdered lump sugar at once takes fire on being touched with a drop of sulphuric acid.

Experiment 44

A Safe Magical Explosive

Take a few flakes of iodine, *but no more*; grind them to a powder in a pestle and mortar; place in a clean glass flask or vessel, and pour about a teaspoonful of strong liquid ammonia on them. Allow the mixture to stand for at least half an hour, and then carefully filter through white blotting paper. The dark brown substance left behind must be carefully divided into minute portions whilst still wet and then partially dried, but conveyed whilst still damp to the article on which it is proposed to use it.

It is a powerful fulminate and explodes spontaneously if dried in too warm a place. Even a pellet the size of a small pin's head will produce a quite audible explosion; but if used in minute quantities there is absolutely no danger.

Experiment 45

To set Fire to a Newspaper by Breathing on it

Apparatus.—An ordinary newspaper; a china plate; some perchlorate of potash and sugar (mixed); sulphuric acid.

The newspaper (or any easily inflammable article) is quite unprepared. On one side of the plate is placed a little of the chlorate of potash and sugar (one part of loaf sugar to two of potassium chlorate), and on the other side a little sulphuric acid. The plate rests on a table or suitable stand in such a manner that the sulphuric acid side is slightly lower than the other. The newspaper, being more or less crumpled up, is placed lightly on the plate, and the latter lifted off the table still in its inclined position. Someone is invited (with suitable remarks) to come and blow upon it. When the time is thought ripe the plate is slightly tilted over to the other side, the sulphuric acid and sugared chlorate are thus brought into contact, and the fiery deed is done.

Experiment 46

A Fulminating Powder—an Experiment in Fusion

Take three parts by weight of nitre, two of dry carbonate of potash, and one of sulphur. Dry carefully and grind them *separately* to a fine powder, then mix carefully with a bone spatula. Take a pinch of this powder, *but no more*, place in a small iron dish or ladle, and apply a gentle heat. The mixture at first fuses and becomes brown, and then explodes with a deafening report. The face should not be held near the substance when being heated. In a solid or powdered state this mixed powder keeps indefinitely, but combustion immediately follows fusion.

Experiment 47

Instantaneous Flame

Potassium and sulphur if heated together on a metal plate or in a ladle burst instanteously into flame and burn vividly.

A little potassium nitrate and a little sulphur sprinkled on it will also produce instantaneous fire.

Iron filings thrown upon potassium nitrate (heated) will detonate and burn.

Another fire-producing combination consists of a few grains of sugared chlorate of potash placed in a tablespoonful of spirit, and a drop of sulphuric acid added.

Experiment 48

The Spontaneous Combustion of Three Metals

In a *perfectly dry* ladle place a small piece of sodium with an equal quantity of potassium. If a little mercury be added, and the whole well shaken, it will take fire and burn vividly.

The ladle or containing vessel must be quite dry, as any dampness might fire the potassium.

Experiment 49[1]

Greek Fire

It is related as a matter of history that the Saracens, by the introduction of a terrible and then diabolically regarded liquid known as Greek fire, spread terror amongst their foes. The composition of this liquid has given rise to much discussion amongst learned men of many countries. One of the latest suppositions is that it consisted of "saltpetre, sulphur, and petroleum or pitch." Whatever Greek fire was, it certainly was not this. The nearest approach to it that the writer knows of is made by dissolving phosphorus in carbon disulphide; the carbon disulphide will dissolve from nine to ten parts of phosphorus. If a little of this liquid be poured on to blotting or filtering paper the carbon disulphide rapidly evaporates and the phosphorus takes fire. It does not follow, however, that it will ignite the substance on which it is poured, for the following reason. Phosphorus in burning forms phosphoric acid, a non-combustible substance, which coats the surface of the paper round the spot where the combustion occurs, and being a non-conductor of heat, prevents the fire spreading. If, however, wax be dissolved with the phosphorus, then the case is entirely different and a very dangerous fluid is produced, which will ignite anything combustible on which it may be poured. Even without the addition of the wax, of course, the burning

[1] This experiment should only be made by those who are experienced in the use of chemicals.

phosphorus is quite capable of igniting anything combustible just above it.

EXPERIMENT 50

Artificial Lightning

If lycopodium powder be sprinkled slowly in the flame of a candle, miniature but vivid flashes of lightning are produced (Fig. 17); and if a bunsen burner and blow-pipe be used the effect is much increased. A blow-pipe can be made from a piece of glass tubing or the stem of a churchwarden pipe. If magnesium instead of lycopodium powder be used a still better result is obtained. It can be blown up the tube of the bunsen burner, no blow-pipe being necessary.

FIG. 17.

EXPERIMENT 51

How to Prepare Flash or Lightning Paper of Various Colours

These papers can now be bought at conjuring depots quite cheaply and of quite safe manufacture, and it is not wise to attempt to make them. The following information is given merely in order that the reader may know "how it is done."

Any thin, unsized paper may be used. A suitable flat dish must be procured just large enough to hold the sheet, say a quarter size, this being handy to work with, Fill the dish three parts full with a solution of four parts sulphuric acid and five parts (both by measure) of strong nitric acid. Mix the two acids well with a glass rod. Take one of the sheets, immerse it in the solution and let it soak for ten minutes. Remove it by the aid of a glass rod, and place it in a pan full of warm, soft or distilled water. Let it remain for one hour; then pour off the water, and refill the bowl afresh. This operation must be repeated several times. Or, what is much better, place the sheet (or sheets, for more than one can be put in the washing basin at the same time) in running warm water until every trace of the acid is removed. If this be not done thoroughly, the paper will not only be liable to spontaneous combustion, but will explode in a violent manner if struck. After washing, the sheets of paper must be carefully dried in a gentle heat. If, after drying, a small pellet of the paper be lighted at one point, and then thrown into the air, a flame of intense light is produced, the combustiou being so perfect that no perceptible ash is left.

To give the paper its colour effect, after drying, take the sheets and steep them for five minutes in a warm saturated solution of strontium chlorate, or, better still, a lithium salt (for crimson); copper chlorate (for blue); barium chlorate (for green); potassium nitrate (for violet); and afterwards hang them up to dry.

Experiment 52

Silver Fire

If a few grains of silver nitrate be sprinkled on a piece of glowing charcoal, beautiful stars will be thrown off and the surface of the charcoal will be coated with silver.

Experiment 53

Golden Fire

This can be produced by blowing finely powdered charcoal up the tube of a bunsen burner. Iron filings or finely powdered and perfectly dry sodium nitrate may be employed with similar effect.

Experiment 54[1]

Fire Burning under Water

Take one part of nitrate of potash, three parts of gunpowder, and the same quantity of sulphur; mix them carefully and put them in a varnished pasteboard case. Quickly kindle at the mouth, and immerse it under water. It will continue to burn until consumed.

[1] See also Experiment 35.

CHAPTER VI

CHEMICAL PYROTECHNICS AND PARLOUR FIREWORKS

THIS branch of the subject has been partially dealt with in Chapters IV and V. As already stated, cold water when acted on by potassium is decomposed, forming potassium hydroxide, and liberating hydrogen. This last-named gas ignites spontaneously when set free; and by being brought into contact with benzine, alcohol or ether a flame is at once produced. We now pass on to consider the production of coloured fires.

If it be desired to carry out the following experiments in a room instead of out of doors, an equal amount of shellac should be used instead of sulphur in each case, the former giving off but little smoke and that not of an objectionable character.

If the experiments be performed in a room, the various mixtures can be ignited in a pill box standing on a plate or saucer. All the ingredients must be carefully powdered *separately* in a pestle and mortar. As already stated, on no account must sulphur and chlorate of potash be powdered or ground together. It is essential that the ingredients should be thoroughly mixed, as otherwise successful coloured fire cannot be produced.

Before giving detailed particulars, let us briefly consider the chief ingredients. Coloured fires generally are made of various mixtures of potassium chlorate and nitrate, sulphur, sugar, shellac, charcoal, etc., with other chemicals to impart the desired colour effect. Sodium salts give a yellow flame; barium salts a green; potassium salts a blue violet; strontium, lithium and calcium a red or purple. White silver stars or rain are produced by adding to these compounds such substances as iron filings, black antimony (powdered); and for golden rain or stars, brass filings. Copper filings give a *green* rain, whilst copper salts give a *blue* flame.

Experiment 55

Blue Fire

Potassium nitrate, 27 parts; potassium sulphate, 15 parts; sulphur, 15 parts; potassium chlorate, 28 parts; cuprammonium sulphate, 15 parts; *or*

Prunella powder, 12 parts; sulphur, 4 parts; Regulus of antimony, 3 parts; *or*

Nitre, 18 parts; sulphur, 4 parts; antimony sulphide, 4 parts. The two last-named combinations are especially suitable for blue candles.

For blue stars:—

Potassium chlorate, 8 parts; copper sulphide, 2 parts; copper oxide, 1 part; sulphur, 4 parts; mercurous chloride, 2 parts.

Experiment 56

Red Fire

Precipitated strontium carbonate, 4 parts; potassium chlorate, 12 parts; mercurous chloride, 4 parts; powdered sulphur (pure) 2 to 3 parts; powdered shellac, 1 part; powdered charcoal, ½ a part.

The strontium carbonate here used is not a deliquescent salt like the nitrate, which latter must always be carefully spread out on a dish or plate and dried in an oven before mixing.

The red tint given by the carbonate is not, however, of so deep a tinge as that produced by the nitrate, but if the latter be employed it should only be for immediate use.

Experiment 57

Green Fire

Barium nitrate, 12 parts; potassium chlorate, 6 parts; sulphur, 3 parts; powdered shellac, 1 part; powdered charcoal, ½ a part; mercurous chloride, 2 parts.

It is essential that the barium salt should be quite pure; and if the ingredients be well mixed the resulting colour will be a lovely emerald green.

Experiment 58

Yellow Fire

This can be made in any of the following ways:—

(1) Sulphur, 1 part; carbonate of soda 1½ parts; potassium chlorate, 4 parts.

The carbonate of soda must be carefully dried before mixing.

(2) Potassium chlorate, 6 parts; sodium oxalate, 2 parts; sulphur, 2 parts; powdered shellac, 1 part.

If made for immediate use the sodium nitrate salt can be used with advantage—this salt giving a deeper tint. It is, however, unfortunately most deliquescent (liable to absorb moisture), and must be most carefully dried in an oven before using; and the mixture will not keep, but will deteriorate from damp.

(3) Sulphur, 1 part; chalk, $2\frac{1}{2}$ parts; potassium chlorate, 4 parts. Result, orange red.

As already stated, when it is desired to burn these coloured fires—in small quantities—indoors, shellac should be used instead of sulphur. It is best to heat the colour ingredient in a suitable dish till it glows, then add the shellac unpowdered. It will melt at once, and can be intimately mixed with the strontium, sodium, barium, or potassium by means of a spatula or broad thin knife. After cooling, the mass must be thoroughly pulverized in a pestle and mortar. Take about one part of shellac to three or four parts of the salt.

For a purple colour, lithium salts can be used with advantage. For a brilliant white fire use magnesium powder or ribbon, though both are very expensive. Aluminium can be used, but does not give nearly so good a result.

Experiment 59

Japanese Matches

Take five parts by weight of lamp black, eleven of sulphur, and twenty-five of meal powder, and thoroughly mix. Then add a weak solution of gum water, sufficient only to make the mixture into the consistency of a stiff paste. Roll or flatten this out and cut it up into cubes of one quarter-inch sides. Place these on a dish, in a warm place, and allow them to dry *gradually*. The more gradually they are dried the better, and a week is not too long to allow for the process. When perfectly dry, fix the cubes separately on straw-like fibres similar to those used in carpet brooms. The Japanese themselves use a thin bamboo splinter. To fire them, hold them stem downwards, and light in a candle. They first of all blaze up, and then a molten mass forms, from which curious coruscations soon appear.

Remember (1) to use as little fluid as possible in the mixing; (2) to allow the mixture to become thoroughly hard; and (3) to see that the completed matches are perfectly dry before they are used. If these precautions are not observed, only failure will attend the experiment.

EXPERIMENT 60

Pharaoh's Serpents

This "parlour firework" or magical chemical illusion has probably caused more amusement and astonishment to both young and old than any other similar kind of experiment. The manufacture of the "serpents" is quite simple. In their best form they are nothing more or less than small masses of mercuric sulphocyanide formed into the desired shape, which, when ignited, produce an ash resembling a serpent, the ash forming in such a way as to give apparent movement and life to the reptile (Fig. 18).

FIG. 18.

The sulphocyanide of mercury must be made into a paste by adding a little mucilage of tragacanth, with about 5 per cent. nitrate of potash. Unfortunately the sulphocyanide of mercury is a deadly poison; the fumes given off during combustion are also injurious, and the residue poisonous. Pharaoh's serpents, with these ingredients, can, therefore, only be made under proper supervision.

Happily a non-poisonous though less effective "serpent" can be made by using: bichromate of potash 2 parts; nitrate of potash, 1 part; powdered sugar, 1 part. These ingredients must be powdered separately and then thoroughly mixed. Small paper cones are made about the size of a pastile and the mixture pressed into them.

Remember always to light these "eggs" at the top, from which the serpent unrolls itself to an astonishing extent.

Experiment 61

To draw a Design on a Piece of Paper by setting Fire to it

Take a sheet of paper, and draw upon it a design with a concentrated solution of potassium nitrate, and allow it to dry. If the glowing end of a piece of string be applied to any point of the design, the curious effect is produced of its burning itself out without injury to the other parts of the paper. The design must obviously be a fairly simple one without too much detail.

Experiment 62

To draw a Design on a Piece of Paper, burn the Paper, and leave the Design

This experiment may be regarded as the opposite to the foregoing. It is accomplished as follows: take half a pint of asbestos paint and add a *few* drops of nitric acid. This gives a fireproof solution, with which the design should be painted on the paper. This is best done by making a stencil of the design you wish to experiment with, and using a stencil brush. After painting, the paper must be allowed to dry thoroughly; and on setting light to it, all will be consumed except the painted design.

Another incombustible solution or paint can be made from white of egg and alum.

CHAPTER VII

STRANGE ACTING ALLOYS

Experiment 63

An Alloy which fuses at Low Temperature

Take bismuth,[1] 8 parts; lead, 5 parts; tin, 2 parts, and form them into an alloy in the following manner. First melt the lead in a crucible (it melts at 334°); then add the tin and bismuth (in tiny pieces), and stir well. This "fusible" alloy, not unlike lead in appearance, melts in boiling or even very hot water. By first melting the alloy and then adding mercury, a solid is produced which melts in water considerably below boiling-point.

The two [illegible] alloys for this purpose are, however, the following.

Experiment 64

Wood's Fusible Alloy

Tin	. .	2 parts.
Lead	. .	2 parts.
Bismuth	. .	4 to 8 parts.
Cadmium	. .	1 to 2 parts.

The melting-point of this is 66°-71°.[2]

[1] The melting-point of lead is 334°; bismuth, 264°; tin, 235°; cadmium, 315°; mercury, 350°.

[2] Centigrade boiling-point, 100°.

Experiment 65

Liponitz's Alloy

Tin	4 parts.
Lead	8 parts.
Bismuth	15 parts.
Cadmium	3 parts.

Melting-point, 60°. Perfectly fluid at 65°.

In both cases the ingredients should be ground to a fine powder before mixing.

The melting-point of iron can be lowered by adding sulphur, the metal becoming molten at red heat if this substance be applied; and the resulting compound is iron sulphide.

Experiment 66

Sodium Amalgam

This curious acting alloy is [illegible] by adding small pieces of the metal sodium[1] [illegible]cury, warmed under a layer of heavy paraffin [illegible] It is liquid when it contains 1·5 per cent of so[illegible]n, and solid when it contains more. On adding this alloy to a concentrated solution of ammonium chloride a remarkable phenomenon takes place, the amalgam swelling up enormously while retaining its metallic appearance.

The resultant product is of a soft buttery consistency. The sodium should be clean cut.

[1] Potassium and sodium (two soft solids—metals) unite to form an alloy liquid at ordinary temperature.

CHAPTER VIII

QUICK BLEACHING AGENTS—THEIR ACTIONS AND RESTORERS

THIS subject has already been referred to under Liquid Colour Changes, and some examples of the bleaching or discolouring action of chlorine water on coloured solutions given.

Sulphurous acid, another evil-smelling reducing agent, furnishes some exceedingly interesting and novel effects, more especially on natural flowers. Roses, dahlias and iolets are particularly susceptible. It must not be gotten that we are experimenting with an acid, and t it acts as such on indicators, etc.

Both chlorine a. lphurous acid can be used in either their gaseous o. solution form.

It must be carefully e in mind that, when using the gases, the articles ich it is required to bleach must be *damp*. The m gical use of the gases is unpleasant, owing to their smell. Neither gases should be inhaled.

We will now consider the production of these gases and their solutions.

EXPERIMENT 67

How to prepare Chlorine Gas

A very expeditious way to prepare a little of this gas is by placing a small glass jar, containing say half an ounce of chloride of lime (bleaching powder) at the bottom of a deep and larger glass jar, as shown in Fig. 19; then, by means of a glass tube and funnel, pouring quietly on to the chloride of lime dilute sulphuric acid (half water, half acid). Effervescence at once begins owing to the escape of chlorine gas; and as it is given off it falls over the sides of the small glass or jar into the larger one, when (if the glass be clear and not of a greenish tinge) it may be distinguished by its green colour. The larger jar should be covered at the top with a piece of thick paper or cardboard with a hole through the centre, to prevent to some extent the escape of the gas.

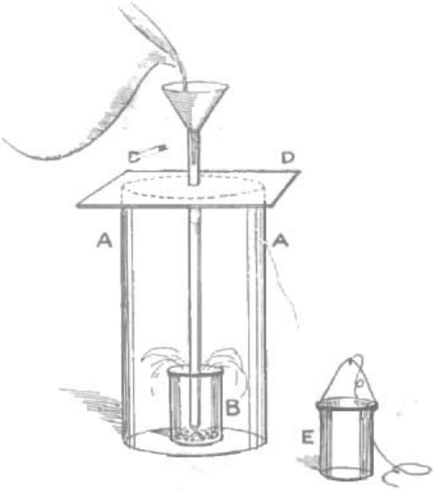

FIG. 19.

A A, Glass beaker; B, Small beaker, used as a bucket containing chloride of lime; D, Sheet of cardboard with hole in the centre to admit the tube.

In diluting sulphuric acid, always add the acid to the water slowly and gradually—*never pour the water on to the acid.* If care be not exercised, great heat is produced, and the containing vessel may be cracked or broken. A very common occurrence is for the bottom to come clean out. To pour the water on to the acid is to run the risk of losing your eyesight owing to the "spitting" action which is likely to be set up.

Experiment 68

Another Way to prepare Chlorine Gas

The apparatus required in this experiment is a little more complicated owing to heat being required to produce the gas.

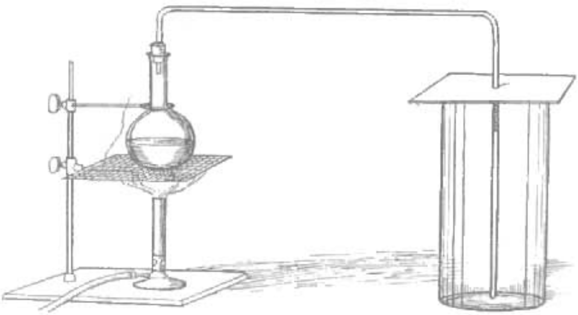

Fig. 20.

Fig. 20 shows a flask fitted with a cork with a hole bored through it; a longish piece of bent glass tubing; a piece of wire gauze; a retort stand and ring: a bunsen burner; a tall glass jar as before; and a piece of cardboard to cover the mouth of the latter. The glass tubing and cork must fit tightly, and sealing wax can be used to effect this.

The chemicals are black oxide of manganese, and strong hydrochloric acid ("spirit of salts").

Put about a tablespoonful of the oxide of manganese in the flask, one fourth this quantity of water, and sufficient hydrochloric acid to cover the manganese.

Care must be taken that the whole is thoroughly wet and that none clings to the bottom of the flask in a dry state; otherwise the flask may crack. The wire gauze is an additional safeguard against this. The cork and glass tubing are now fitted, and the whole arranged as shown. If heat is applied to the flask, the chlorine gas is given off and passes through the tubing into the large jar. It is important that the longer limb of the tubing should descend to within an eighth of an inch of the bottom of the collecting jar. Do not heat the flask too strongly or the contents will boil over and make a mess in the collecting jar.

Experiment 69

How to prepare Chlorine Water

This is made by passing chlorine gas into water; all that we require to do then is to let the delivery tube as described in the preceding experiment pass into a bottle filled with water, and allow the gas to bubble through the water for some time. The chlorine water so formed is merely water which has absorbed or dissolved a large quantity of the gas. Instead of only one bottle, it is better to use several connected by means of tubing, and allow the gas to bubble through them in succession as shown in Fig. 21. By this means much less gas is lost, and several bottles of chlorine water are obtained differing in strength.

All the bottles should be kept well corked, or better still well stoppered—greasing the stoppers to make them more gas-tight. Indiarubber tubing should not be used when making chlorine, as the gas rapidly destroys its substance.

The method by which the writer has generally prepared chlorine water is by using chloride of lime and dilute sulphuric acid as described in Experiment 67.

FIG. 21.

These experiments are best carried out in the open air.

EXPERIMENT 70

Chlorine as a Supporter of Combustion

Dutch metal, powdered antimony, or a bit of phosphorus immediately takes fire when introduced into a jar or bottle of chlorine gas, and forms one of a series of compounds termed chlorides, thereby demonstrating the energetic action of chlorine and proving that oxygen is not the only supporter of combustion. The phosphorus as a matter of fact ignites more quickly in chlorine than in oxygen gas. A piece of paper moistened in oil of turpentine takes fire and burns in chlorine gas.

EXPERIMENT 71

To illustrate the Weight and Quick Bleaching Action of Chlorine

In a tall cylindrical glass jar place a solution of indigo, not much more than half filling the glass. Invert a bottle of chlorine gas over the mouth of the cylindrical jar, and it will pour out like water, being about two and a half times heavier than atmospheric air. Close the top of the jar with a bung and shake. The solution is immediately bleached.

A magical effect can be given to this experiment by introducing the gas secretly, when the colour is apparently *shaken out of the liquid.*

Experiment 72

Chlorine as a Colour Producer

The following experiment affords a striking contrast to the foregoing one. Another similar cylindrical glass jar should be provided, containing a solution of iodide of potassium and starch. This is made by boiling a teaspoonful of arrowroot with some water. On inverting a bottle of chlorine over the jar as in the last experiment and shaking, the mixture becomes a beautiful purple-blue colour in consequence of the liberation of the iodine by the chlorine. The colour is caused by the union of the iodine and the starch, which together form this beautiful blue compound: and thus the apparent anomaly of both producing and destroying colour with the same agent is explained.

Experiment 73

The Preparation of Sulphurous Acid

When sulphur burns in oxygen or air, a gas known as sulphur dioxide is formed. This may be prepared under a bell jar; and, when it is required for experiments in which admixture with nitrogen does not matter, the gas so produced answers quite well. When, however, it is required in a fairly pure condition, the following method should be employed. Take about half an ounce of metallic copper (copper filings); place it in an 8-oz. flask provided with a thistle funnel and delivery-tube leading into a jar of water (see Fig. 22); and pour about 3 oz. of concentrated pure sulphuric acid down the funnel. The flask is then carefully heated, usually in a sand bath, the heat being moderated as soon as the action commences.

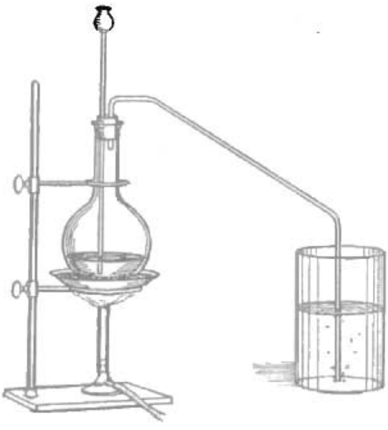

Fig. 22.

The same result can be obtained if sulphur be substituted for copper. All sulphites when treated with a mineral acid yield sulphur dioxide. The gas is allowed to pass into the water until a saturated solution is obtained. This is sulphurous acid.

The gas is extremely soluble in water, so much so that it cannot be collected over water; but being twice as heavy as air, it may conveniently be collected by displacement of air. At normal pressure water dissolves eighty times its volume of the gas.

Sulphur dioxide condenses to a liquid under ordinary atmospheric pressure at about $-10°$ C., and under $1\frac{1}{2}$ to 2 atmospheres pressure at 0° C. It can be obtained in a liquid form by passing the gas into a vessel surrounded by a freezing mixture of ice and salt. Two parts of ice to one of common salt should be used, by which means a temperature of $-18°$ can be obtained. Fig. 23 shows the necessary apparatus. The gas (after passing through the glass worm-tube) condenses into a liquid, which is collected in a small flask, also surrounded by freezing mixture. Liquid sulphur dioxide boils at $-8°$; and if cooled below $-75°$, it freezes into a transparent solid.

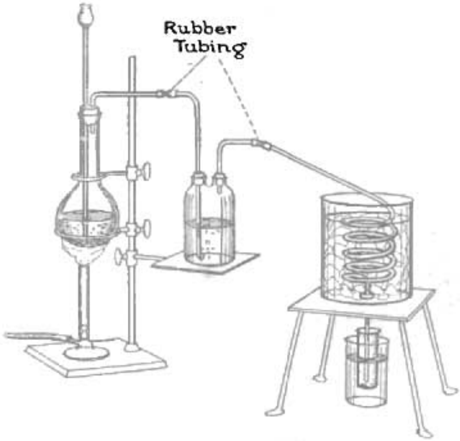

FIG. 23.

The liquid solution of sulphurous acid possesses the characteristic odour of the gas.

EXPERIMENT 74

The Bleaching Action of Sulphurous Acid

Rose leaves thrown into a concentrated solution of sulphurous acid are at once bleached, also violets and many other flowers. The colouring matter is not, however, destroyed as when chlorine is used, and the colour may even be restored again by adding a few drops of strong sulphuric acid, or by exposure of the flowers to the air for some time. The best way, however, is to immerse them in an alkaline solution. Ammonia by itself has very little effect, but when mixed with ether its action is rapid.

Silk, straw, and wool may also be bleached by sulphurous acid.

It may be as well to draw attention here to the difference in the bleaching action of this agent and chlorine. The latter bleaches in consequence of its bringing about the oxidation of the colouring matter; sulphur dioxide bleaches owing to its great affinity for oxygen. The one liberates *oxygen* from water, the other *hydrogen*.

Experiment 75

Chlorine Monoxide

Chlorine monoxide, obtained by the action of chlorine on mercuric oxide, is a yellowish gas, very soluble in water. It is twice as powerful in its bleaching action as chlorine. The gas is obtained by passing over dry mercuric oxide (prepared by precipitation from mercuric chloride with caustic soda) dry chlorine gas. The tube containing the oxide must be cooled by being surrounded by freezing mixture. It is a very volatile liquid, boiling at 6°.

It is better not to attempt its preparation save in a properly equipped laboratory. If, however, the mercuric oxide be made into an emulsion with water, and chlorine gas be passed through it, then it is produced in aqueous solution—a pale greenish liquid, with a not unpleasant smell, recalling that of chlorine.

CHAPTER IX

THE MAGICAL PRODUCTION AND USES OF CERTAIN GASES, SMOKES AND VAPOURS

EXPERIMENT 76

How to prepare Carbon Dioxide

THIS is the simplest and easiest gas to produce, it being effected by the action of an acid upon a carbonate or bicarbonate. The amount of gas produced by this means and its freer solubility in a small quantity of water render it especially suitable for magical experiments.

To inflate an ordinary toy balloon some 4 cubic centimetres of sulphuric acid, and 8 grammes of sodium bicarbonate only are needed.

In the laboratory, carbon dioxide is usually prepared by the action of hydrochloric acid on marble, some lumps of the latter being placed in a flask and hydrochloric acid poured down a thistle funnel. Carbon dioxide being half as heavy again as air, the gas can be collected like chlorine in Experiment 67. It is a colourless gas, without smell and with a very faint acid taste, but slightly soluble in water. It should be allowed to bubble through water before it is collected in order to remove all traces of hydrochloric acid.

EXPERIMENT 77

An Experiment in Weighing Nothing

We have already stated that carbon dioxide is one and a half times as heavy as ordinary air. Fig. 24 shows us how with this gas we may perform a little experiment by apparently weighing nothing.

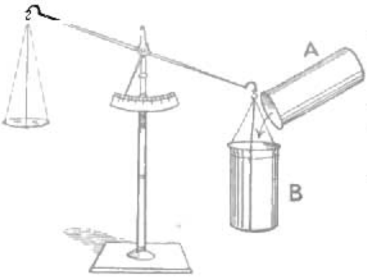

FIG. 24.

The vessel A contains carbon dioxide, and when it is inverted above another vessel B, containing only air, the gas descends from the one to the other, displacing the air, and causing B to upset the even balance of the scale.

EXPERIMENT 78

A Novel Candle Extinguisher

If a bottle or jar full of carbon dioxide be inverted over a series of lighted candles set in a row, the jar sweeping over them from end to end, they will all be extinguished in succession (see Fig. 25).

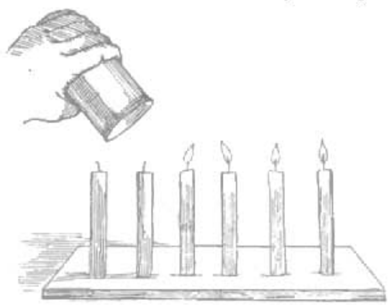

FIG. 25.

EXPERIMENT 79[1]

Half-and-Half, or the Mysterious Taper

This is a very interesting and astonishing experiment if carefully carried out, and shows in a most striking manner the action of carbon dioxide

[1] See also experiment 135.

in extinguishing flame, and of oxygen in supporting it.

The apparatus required is a tall cylindrical jar of clear glass.

The jar is first filled with oxygen, the lower half of which is subsequently displaced by water being passed into it. A large cork, perforated with holes, may be introduced, so as to float upon the surface of the water (now half filling the jar) and break the violence of the carbon dioxide as it is passed in to fill up the remaining half volume of the jar, which now contains oxygen at the top and carbon dioxide below. Plunge a lighted taper into the jar; it burns fiercely in the oxygen, but is immediately extinguished in the carbon dioxide, and is alternately lighted and put out as it is quickly raised and depressed in the jar. We say "quickly" because the taper will probably not rekindle in the oxygen if it has ceased to glow. It will only relight so long as the oxygen lasts.

Experiment 80

To produce Milk from Water

If carbon dioxide gas be passed into a solution of a soluble calcium salt, a liquid having the appearance of milk is produced. (Compare the experiment of breathing into clear lime water and rendering it milky.) Add a little hydrochloric acid, and it at once clears.

Experiment 81

Soap Bubbles floating on Carbon Dioxide

Fill by downward displacement a bowl some 8 inches deep and 12 or 15 inches in diameter with carbon dioxide.

Make a soap solution,[1] and blow some bubbles; detach them from the pipe over the vessel of carbon dioxide. They will descend and float on the surface of the gas.

EXPERIMENT 82

Soap Bubble floating on Ether and afterwards exploding

A soap bubble blown in the ordinary way and allowed to fall into a bowl of vapour of ether will float on it as on carbon dioxide, and if afterwards picked up on a wire ring and taken to a light, will burst into flame and vanish.

Great care is necessary is using ether. A bottle of ether must never be brought near a naked light, especially if the light be low down. If a large quantity is spilled the heavy vapour is liable to run along the floor and ignite at a fire, even on the other side of the room. To fill any vessel with ether vapour, pour the liquid upon a piece of blotting-paper reaching from top to bottom of one side. Only a little is required, not more than a wineglassful for a gallon vessel. The bubbles should be removed from the vapour after a few seconds by means of a small light ring provided with a handle. The ring must be first dipped in the soap solution, but should have *no film across it.*

Soap bubbles blown with hydrogen gas (or even coal gas) will float and rise, and on a light being brought to them, explode.

[1] Bubbles made of soap and water do not last very long. To make the experiments more effective, glycerine should be added. Use common yellow soap, or better still Castille soap, and distilled water, adding glycerine in the proportion of one part to four of water.

Experiment 83

The Precipitation of Smoke

If a glassful of hydrochloric acid gas be inverted over a jar containing ammonia, a dense white cloud of ammonium chloride is formed. the jar getting sensibly warm to the hand. If we take an ordinary tumbler, in the bottom of which are a few drops of ammonium hydrate (commonly called ammonia, although ammonia strictly speaking is a gas), and place over it a plate or saucer on the *bottom* of which is a little hydrochloric acid, then the glass becomes filled with smoke. As a trick this is usually shown by the performer throwing a handkerchief over the plate and glass, walking to the other side of the stage, and puffing smoke from a cigarette. After a time the handkerchief is removed and the smoke apparently found in the glass.

Another method is for the performer to produce two clay pipes, both empty, and apparently unprepared; but on his putting one of them in his mouth, and covering it with the bowl of the other, smoke at once begins to issue from between them. In trying this experiment be careful to *exhale* (blow) and not *inhale* (draw

Experiment 84

The Instantaneous Production of a Beautifully Coloured Vapour

If a few flakes of iodine be dropped into a hot glass flask or jar, it instantly becomes filled with a magnificent violet vapour. If the flakes be dropped on a hot brick or plate at the back of which is a sheet of white paper or cardboard, the splendid violet colour of the vapour is seen to great advantage. On cooling in the jar the vapour condenses in the form of minute and brilliant crystals.

EXPERIMENT 85

The Production of Inflated Balloons from a Hat

The balloons or bladders used for this experiment are of special manufacture and should be obtained from a reliable conjuring depot. They are of two sizes, the larger being bought for a few pence each, and the smaller so many a penny. The smaller balloon is made from a thinner and weaker material; the larger is extra strong and has a wide neck. The inflating agents are bicarbonate of soda and tartaric acid, about a quarter of a pound of each being sufficient to inflate half a dozen balloons. The tartaric acid should be emptied in a jam jar, just covered with water, and allowed to stand. With the assistance of a syringe, pump this solution into one of the smaller balloons until it attains the size of a small egg. The mouth is then tied up, and it is inserted through the wide neck of one of the larger balloons. In the latter is placed a tablespoonful of bicarbonate of potash, and the neck tied up.

FIG. 26.

To inflate the big balloon, you simply squeeze and squash the little one from the outside; and the action of the tartaric acid on the bicarbonate of soda does the rest. As many as twenty-five balloons have been produced from a hat in this manner (Fig. 26).

The weight of the gas-producing ingredients—which are left inside the balloon—to say nothing of the gas itself (carbon dioxide), which is heavy, make the balloon a decidedly "heavier than air machine." Consequently, when performed in this way, the experiment is not so telling as it would be if the balloon floated in the air. But carbon dioxide is the easiest gas to produce, being formed by the action of an acid upon a carbonate or bicarbonate (see Experiment 76). A much more effective gas to use—provided certain mechanical difficulties of production be overcome—is obviously hydrogen, the lightest substance known; or failing this, coal gas, which possesses about half the buoyancy of hydrogen.

Supposing, however, that even hydrogen be used, the ingredients producing the gas must obviously not be contained in the balloon as the latter will certainly not float under such conditions. It might be mentioned *en passant* that the following method of carrying out this experiment was proposed to the writer. Put a teaspoonful of ether in the smaller balloon; tie the mouth up tightly, and put it in the larger balloon. Pour hot water on the latter and cause the ether to vapourize. Even supposing this practicable, ether vapour is heavier, not lighter than air. And what about the hat?

CHAPTER X

CHEMICAL VEGETATION

Experiment 86

To make Trees of Lead

Dissolve an ounce of acetate of lead in a twenty-ounce bottle of water, filtering the water if necessary to render clear; pour the solution in a wide-mouthed jar or bottle fitted with a cork or bung, from which are suspended thin strips of zinc so twisted and shaped as to resemble as much as possible the branches of a tree. The jar should be securely corked and stood on one side. It should not be shaken. After some hours a beautiful metallic tree-like growth will be formed, owing to the deposit of crystals of metallic lead upon the zinc (Fig. 27).

Experiment 87

Tin Trees

Place 3 drachms of muriate of tin in 3 ounces of water contained in a small bottle; add 10 or 12 drops of nitric acid, and shake well till fully dissolved. Suspend a piece of zinc in the centre as in the previous experiment, and a similar result will ensue. In both cases, if the zinc is roughly cut, and given a spiral or leaf-like form, the tree or flower-like effect is much enhanced.

EXPERIMENT 88

Silver Trees

Dissolve 4 drachms of nitrate of silver in half a pint of distilled water, and set the containing vessel on one side, where it will not be disturbed; then pour in 2 drachms

FIG. 27.

of mercury (quicksilver). In a short time an extremely beautiful growth will be apparent, resembling real vegetation.

EXPERIMENT 89

Gold Tree

This is produced as in the previous experiment, using a solution of chloride of gold and mercury.

Experiment 90

Chemical Vegetation of Variegated Colours

In a 20-ounce bottle put 7 ounces of silicate of soda, fill up the bottle with water, and stir and shake well until a thoroughly homogeneous fluid is produced. This will take time and patience, but is absolutely necessary if the experiment is to be a success. Having done this, next put sand into the bottle or jar until it forms a layer at the bottom nearly half an inch thick. The sand must be deposited quietly, and is best poured down a tube reaching to the bottom of the jar. Take a number of crystals of various substances such as alum, sulphates of iron, copper, chromium, etc., and with a glass rod firmly embed them in the sand, about half covering them but no more. The bottle or jar must then be set aside and left absolutely undisturbed. In course of time the crystals will spout cut in filaments, etc., of varying colours.

Experiment 91

The Crystallized Grotto

In a watertight box (of wood or metal) with apertures in the top, bottom and ends (Fig. 28), place a number of jagged points covered with canton flannel, attached by means of brass wire nails. Stop up the apertures with corks, and fill the box with a warm solution of alum.

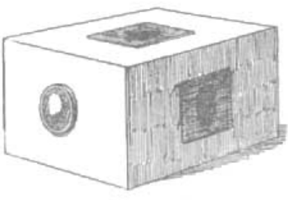

Fig. 28.

When cooled, the points or rocks will be found to be covered with bright crystals. Remove the corks after crystallization is complete, and cover all the apertures save one with coloured glass. To what is desired to be the front aperture fix a convex lens with a focus about equal to half the length of the box. When the interior of the box is illuminated by a strong light passing through the coloured windows, the effect is very pretty. After pouring out the solution prior to closing up the box, allow the interior to dry thoroughly but naturally.

Experiment 92

Chemical Snow

This is a fine example of what is known as sublimation. Place in a tasteful manner under a bottomless glass vessel or bell jar, as shown in the illustration (Fig. 29), some sprigs of holly or other evergreen, or imitation paper snowdrops, crocuses, etc. Place the vessel on a non-inflammable stand with a hole in the centre. In this is placed a little porcelain evaporating dish containing a little benzoic acid (prepared by heating gum benzoin, when the acid sublimes in pearly white plates, melting at 120° and boiling at 250°). By heating this and subliming it over the sprigs or artificial flowers, a very elegant imitation of snow is produced. The stopper or cork in the top of the jar should be left open at first, to be closed

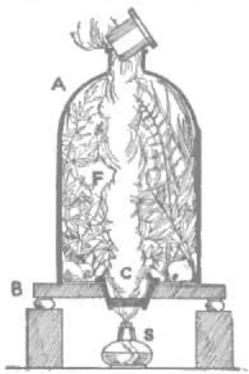

Fig. 29.

A, Glass-jar, with stopper open at first, to be shut when the lamp is withdrawn; B, Wooden stand with a hole for the cup C, containing the benzoic acid; S, the spirit lamp; F, Foliage sprigs, etc.

when the spirit lamp (used for heating the benzoic acid) is withdrawn.

Experiment 93

Instantaneous Crystallization

A very singular and almost instantaneous crystallization can be brought about by saturating water with Glauber's salts (sodium sulphate). One and a half ounces of water will dissolve about two ounces of salt. Having done this, pour the solution, boiling hot, into flasks or bottles of any kind, *previously made hot in the oven,* and immediately cork them tightly up; or pour gently into the neck a small quantity of olive oil; or tie a strip of whetted bladder or rubber tightly over the neck, to keep out any atmospheric air. When cold, no crystallization takes place until atmospheric air is admitted. It was formerly thought that the pressure of the air set up the crystallization until the oil in the neck method was tried. Now crystallization is supposed to occur owing to the water dissolving some air which causes the minute deposit of a crystal, and thus the whole becomes solid. Should the liquid refuse to crystallize on the admission of the air—and this should take place immediately—a minute crystal of sodium sulphate should be dropped into the flask.

Experiment 94

Camphor Trees

Dissolve some camphor in warm spirits of wine, until the spirit will dissolve no more. Pour some of the solution into a cold glass, or, better still, over a sheet of glass, and the camphor will instantly crystallize in beautiful tree-like forms.

Experiment 95

Visible Crystallization in the Lantern

The following beautiful experiment should be tried by those possessing a magic lantern and microscope. Make a piece of glass perfectly clean and place on it a coating or film of a solution of ammonium chloride and sal ammoniac. Place the glass slide in a microscope and let the electric light of the lantern pass through it and be concentrated on a white disc. The heat causes the film to evaporate, and brings the molecules of the salts sufficiently near to one another for them to exercise the crystallizing force. The result is that a lovely crystalline structure is built up with marvellous rapidity.

Note on Chapter X

For obtaining large and perfect crystals in general we have to thank M. Le Blanc. His method was, first, to produce small and perfect crystals, say octohedra of alum. Then placing them in a broad, flat-bottomed dish, he poured over them a quantity of saturated solution of the substance he was crystallizing—in this case alum. This warm solution was considered as saturated when a drop of alum solution, on being taken out, crystallized on cooling. The position of the crystals was altered at least once a day, and as they continued to grow, the best and most symmetrical were picked out and placed in other vessels containing the same saturated solution of alum. Being constantly turned, they were at length obtained of almost any size desired.

Unless the crystals are removed to fresh solutions, a reaction takes place owing to the withdrawal of the alum from the water, and the crystals are attacked and dissolved. To make them grow in length, place them on their side; in breadth, stand them on their bases.

On this principle, beautiful crystal baskets, ornaments, etc., can be built of alum, sulphate of copper, and bichromate of potash. The baskets are made of covered copper wire, and when the salts crystallize on them as a nucleus or centre, they are constantly removed to fresh solutions, in which they must be completely covered, until red, white, and blue sparkling crystal structures are formed. They will retain their brilliancy for an indefinite period by being put under a glass shade in which is placed a cup containing a little water.

CHAPTER XI

FREEZING MIXTURES AND THEIR WONDERS

If we mix together snow and salt, they will liquefy, and the temperature of the solution will be considerably reduced. Leslie was the first to freeze water by its own evaporation. He took a vessel containing strong sulphuric acid (Fig. 30), which has a great attraction for water, and placed it beneath a thin metallic vessel containing water in the receiver of an air-pump. On pumping out the air, the water very quickly evaporated, and the aqueous vapour was absorbed by the sulphuric acid. The temperature of the water continually diminished, until at length it froze.

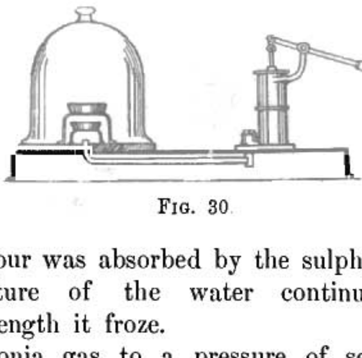

Fig. 30

On exposing ammonia gas to a pressure of seven atmospheres at ordinary air temperature, it condenses to a colourless liquid, boiling at about $-33°$; if cooled below $-75°$, it freezes to a transparent solid.

M. Carré's freezing-machine (see Fig. 31) consists essentially of two strong iron vessels connected in a perfectly air-tight manner by a bent pipe. One of these vessels contains an aqueous solution of ammonia saturated with the gas at 0°. When it is desired to produce ice, the vessel A containing the ammonia (generally termed the retort) is gradually heated over a large gas-burner, the other vessel B (the receiver) being placed in a vessel containing cold water. Owing to the increase in temperature the gas cannot remain dissolved in the water, and passes into the receiver, where, as soon as the pressure amounts to about ten atmospheres, it condenses in the liquid form. When the greater part of the ammonia gas has thus been driven out of the water, the apparatus is reversed—the retort A being cooled in a current of cold water, whilst the liquid it is desired to freeze is placed in the interior of the receiver B. A re-absorption of the ammonia by the water now takes place, and a quick evaporation of the liquefied ammonia in the receiver, this evaporation being accompanied by an absorption of heat necessary for the existence of the gas. The receiver B is thus soon cooled below the freezing-point, and ice produced around it.

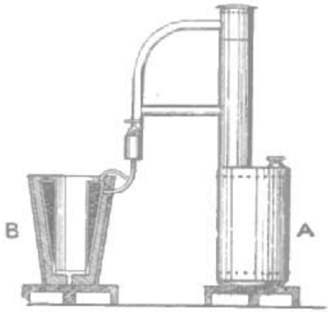

FIG. 31.

An excellent arrangement of Leslie's experiment, devised by M. Carré, is one in which the vapour arising from the water in the receiver (Fig. 31) is forced by the action of the bell-jar pump through a vessel containing sulphuric acid. In this case the water actually boils until the cold caused by its rapid evaporation causes it to become a solid block of ice.

Experiment 96

Cover the bulb of a thermometer with a piece of cambric or tiny wrapping of cotton wool; drop a little ether upon it, and notice the marked and rapid fall of the mercury owing to the cold produced by the evaporation of the ether.

Pour a *little* on the upturned palm of the hand and note the effect.

Experiment 97

Interesting Low-Temperature Chemical Mixtures

If the following ingredients are mixed in the proportions given, very low temperatures are produced. Dissolve 500 grammes of potassium sulphocyanide in 400 grammes of cold water; this gives a temperature as low as $-20°$.

Crystallized calcium, 4 parts, and snow, 3 parts (ice), mixed, produce a temperature from 0° to $-45°$.

Sodium sulphate, 8 parts, and hydrochloric acid, 5 parts, also produce a low temperature.

When we desire to produce a temperature sufficiently low for extremely interesting, not to say very striking, experiments, we must employ carbon dioxide gas in a liquid or even solid form.

In a liquid form it is now a commercial product, sold at one shilling the pound, stored in steel cylinders.

At a pressure of about 38 atmospheres this gas condenses to a liquid at 0° C.; or it may be liquefied at ordinary atmospheric pressure by a temperature of $-78°$ C. The liquefaction of the gas can be effected either by evolving it in a strong closed vessel, so that it is condensed by its own pressure—as is the case with ammonia as described above (Carré's freezing-machine), or by pumping the gas by means of an ordinary forcing pump into a strong wrought-iron or steel receiver, kept during the process at a temperature of 0°.

FIG. 32.

As soon as the volume of gas pumped in amounts to about 37 the volume of the receiver, each stroke of the pump produces a further condensation of the gas which is pumped in, and the vessel is easily filled with liquid carbon dioxide, which is colourless and transparent. On being allowed to escape into the air, especially if it emerge through a fine nozzle attached to the vessel, part of the liquid at once evaporates, and assumes the gaseous state, so much heat being thereby lost that the remainder has no longer the necessary heat to maintain it in a liquid state. It therefore promptly freezes, thus producing a white snow-like mass (known popularly as carbonic acid snow), which evaporates comparatively slowly.

To collect this snow, a brass box provided with holes is attached to the nozzle of the steel cylinder; and this box, after the liquid has been allowed to enter, is filled with the snow-like solid.

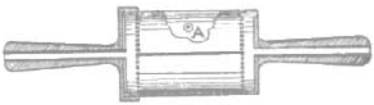

FIG. 33.

When ordering a cylinder of liquid carbon dioxide, it is necessary to state that it is to furnish a stream of liquid CO_2, and not the gas. For the liquid, the valve must have a long siphon tube running to the bottom of the cylinder.

A very suitable collector for the solid is the following, which permits of its being easily manipulated—for on no account should the "snow" be touched with the fingers.

Fig. 32 shows the outside appearance of this collector, Fig. 33 a vertical section of the same, a cross section being shown in Fig. 34.

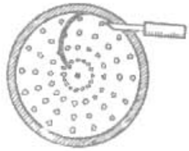

FIG. 34.

The little piece of apparatus is made of metal (brass preferable), with wooden handles driven on to the brass tubes leading into the interior. The ends of these brass tubes must be left open. The inside ends of the tubes are covered with perforated brass discs, to allow the gas to escape, but to catch the snow-like solid. The point marked A (Fig. 32) is where the nozzle of the steel cylinder containing the liquid is placed. Opposite this—shown more clearly in Fig. 34—is a curved brass plate to deflect the stream as it enters the cylinder. The screw valve of the cylinder should be opened very gently. It will be noticed that the collector is made with one end and handle fitting like a cap (see Fig. 32), so that it can easily be removed, and the solid snow shaken out when desired. It should be then put into a wooden form or mould with a rammer (see Fig. 35). After being tightly packed, the bottom of the mould should be pushed out (it is made in this form on purpose), and the cylinder of close packed solid carbon dioxide should then be placed in a glass beaker

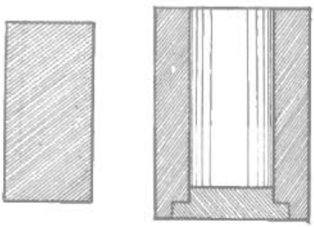

FIG. 35.

of the same diameter as the cylindrical mould, but a little taller. This beaker should be supported on a wooden ring within what is known as a muff box (see Fig. 36). A watch glass or something of that nature should be placed over the beaker. On no account try to keep the solid in any confined space, such as a corked-up flask or bottle, but simply in a lightly covered beaker. It is the very evaporation of the solid which keeps it below its melting-point; and if kept confined, the gas is still generated, and will soon create a dangerous pressure.

FIG. 36.

If the carbonic acid snow be thus stored it can be kept in the solid state for several hours.

Carbonic acid snow even is now an article of commerce, being sent into the market in this form to avoid the cost of carriage of the heavy steel bottles containing the liquid. It is, however, best procured in the liquid form (which can be kept indefinitely in a cool place) and dealt with as described above.

A very large number of most interesting experiments can be made with carbonic acid snow and ether, by the use of which a temperature of $-110°$ may be obtained.

EXPERIMENT 98

How to Freeze Mercury

To freeze a pound (by weight) of mercury, procure a little cylindrical wooden box top (mercury is very heavy, more than thirteen times as heavy as water, and so a pound of mercury is not much in size), and pour the mercury in. Now cover the mercury by pouring in some ether, and put (by means of a bone spoon) several small pieces of the solid carbon dioxide in. By the intensely rapid evaporation of the carbon dioxide in the ether, the mercury is soon frozen in a solid cake.

A wooden box top is recommended for this experiment, owing to the fact that mercury must not be allowed to come into contact with metals, as it attacks so many of them, forming amalgams. This difficulty, however, is successfully overcome if the metal be first dipped in melted paraffin wax.

A coating of shellac is also said to answer, but upon this point the writer cannot speak from personal experience. Any metallic moulds can then be employed, and are much better than wooden ones, the latter being bad conductors of heat.

With practice and a little experimenting, almost anv shape may be cast in frozen mercury.

The same caution must be exercised in handling frozen mercury as in dealing with carbonic acid snow. It must not be up picked by the fingers, but lifted by means of strings or nippers.

We give below a temperature table which may be very useful to those experimenting with this substance and ether.

Temperature Table

Centigrade Scale

Water freezes and becomes solid ice at . .	0°
Liquid sulphurous acid boils at about . . .	−10°
Liquid methyl chloride boils at about . . .	−23°
Liquid ammonia boils at about	−36°

Liquid mercury freezes (becomes solid) at about	−40°
Liquid carbonic acid boils at about	−80°
Greatest recorded natural cold about	−60°
Liquid ammonia becomes solid[1] at about . .	−75°

Experiment 99

Make a dilute solution of purple coloured permanganate of potash and place it in a glass bottle. Surround it for some time with a mixture of carbonic acid snow and ether. On removing the bottle, it will be found that the solution has solidified into a transparent block of clear, transparent, and perfectly colourless ice, with the exception of an intense coloured cylinder of permanganate of potash concentrated along the axis of the entire mass.

Experiment 100

Immerse balls of iron, lead, tin, ivory, and indiarubber into a freezing-mixture of this character, and it will be found that with the exception of rubber, their elasticity has been increased. In the case of rubber, if the temperature be low enough, on dropping it on to the ground it will break into fragments, having become as brittle as glass.

Experiment 101

Immerse seeds of barley, peas, etc., in this mixture, and afterwards sow them. It will be found that they have not been harmed. On the other hand, immerse them in boiling water and all life is destroyed. In fact, a temperature slightly above that of boiling water is sufficient to kill all known forms of living organisms,

[1] Quite transparent.

which, however, remain unaffected even by the temperature of liquid hydrogen over 253° below freezing point.

Experiment 102

An Extraordinary Disappearance

The following striking experiment is an excellent application of scientific knowledge to magic. The experiment consists in first exhibiting a stand as depicted in Fig. 37, special attention being directed to the slimness of the central column and the impossibility of concealing anything of any size in such a stand. This stand is placed upon a sheet of glass. A shade is then shown of opaque glass. A metal covering can be used, but is not so effective. A pair of scales are then shown, and permission given to examine them freely.[1] Lastly, a silver ornament, animal or bird, is exhibited and *weighed* in order to prove its solidity. It is then quickly picked up, by means of ribbons or tapes passed round it, placed on the top of the stand, and the cover put over it. After a time (which can only be judged from previous experiments) the cover is removed, and the silver object has disappeared. As the reader will already have guessed,

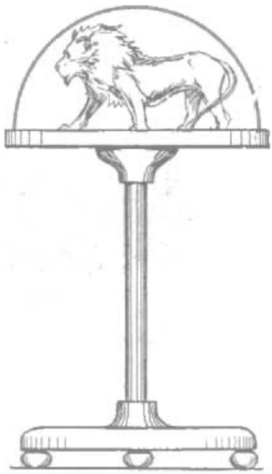

Fig. 37.

[1] What is perhaps better is to pass them round after the silver object is placed on the stand, the examination helping to fill up the time which must elapse before the cover can be removed.

the "silver" object is nothing more than frozen mercury. The stand, of course, is hollow (Fig. 38), and the melted mercury passes down the stem into the base. The top must be of decided saucer-like form or there is a danger of the mercury splashing over. The stand can be of wood, but is much better made of light brass, which must be coated inside with melted paraffin wax as already stated. If made in metal, it can be given a much slimmer appearance than if in wood.

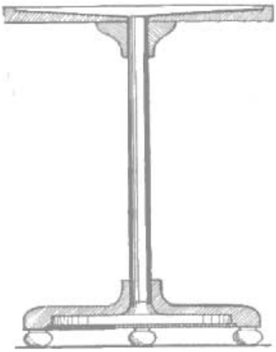

FIG. 38.

EXPERIMENT 103

The Kettle that Boils on Ice

Place in a kettle a quantity of liquid carbon dioxide, which boils at $-78°$. Bearing in mind the fact that the temperature of ice is $0°$, the latter compared with the contents of the kettle is obviously *hot*, and will cause the liquid carbon dioxide to vaporize in steam. Instead of liquid carbon dioxide, ether and carbonic acid snow can be used. To drop pieces of ice into the kettle is but to make it boil the faster (Fig. 39).

EXPERIMENT 104

Liquids that do not Wet

Liquids are popularly supposed to make whatever they come in contact with wet. Molten lead, however, and carbon dioxide in the state in which we have just been considering it, are both liquids, but they do not make wet, for neither contains a drop of moisture. In both cases it is possible to plunge in the hand and quickly withdraw it without getting it wet, provided certain precautions be adopted. In the case of liquid carbon dioxide, the natural heat of the hand forms for a moment a thin non-conducting cushion of air, preventing actual contact and acting like a protecting glove. There is no need, however, to run the risk of accident to the hand: the demonstration can be made by means of a handkerchief immersed in liquefied carbonic acid snow, which comes ont of the washing quite dry.

FIG. 39.

EXPERIMENT 105

To make Grapes like Marbles and Flowers like Glass

Immerse flowers and grapes in liquid carbon dioxide, or a mixture of carbonic acid snow and ether; allow them to remain a short time, and on their removal they will be found to have become quite brittle—the grapes breaking to pieces on being thrown against a hard substance, and the flowers being as easily broken as thin glass. If allowed to regain their normal temperature, they will be found none the worse for their experience. When in this state of intense cold, all may be easily pulverized to dust. A piece of beefsteak or a small dead animal, such as a mouse, becomes as hard as the proverbial brick under such conditions, and is just as easily pulverized to absolute dust, if allowed to remain long enough in the liquid to become thoroughly frozen.

EXPERIMENT 106

To make Ice Cream in a Chafing Dish heated over a Spirit Lamp

To do this it is merely necessary to pour the above intensely cold liquid over the ice-cream ingredients (what-

FIG. 40.

ever *they* may be) contained in the dish (Fig. 40); and in spite of the flame underneath, ice immediately forms. The more rapid the evaporation the more intense the cold produced. The heat of the chafing dish of course assists this. In other words, the harder the liquid boils the lower the actual temperature produced.

EXPERIMENT 107

The Mercury-Headed Hammer

To use a mobile liquid like mercury or quicksilver only for the actual head of a hammer and to drive in big nails by means of it, is another of the little wonders that carbon dioxide snow can easily accomplish. All that is necessary is to run mercury into a suitable mould, in which is held upright the wooden handle and freeze the mercury as before.

EXPERIMENT 108

Liquid Air

If instead of liquid carbon dioxide, or carbon dioxide snow and ether, we employ liquid air, which boils at a much lower temperature,[1] all the previous experiments can be carried out, and others as well; for it must be remembered that liquid air is very rich in oxygen—the great supporter of combustion—while carbon dioxide is just the opposite.

Freeze a test-tube of oil by means of liquid air; apply a light and it burns like a candle. Pour liquid air on a cigar almost out, and it immediately burns furiously on coming in contact with the vaporized liquid, *i.e.* the oxygen. Similarly with other experiments of a like nature.

[1] Boiling point of liquid air $-192°$ to $-182°$ C.

CHAPTER XII

OXYGEN AND HYDROGEN—THE EFFECTS OF HIGH TEMPERATURE

EXPERIMENT 109

How to make Oxygen Gas

WHEN required in small quantities, oxygen is best prepared as follows. Mix together chlorate of potash and manganese dioxide in the proportion of nearly four to one; grind the mixture to a fine powder in a pestle and mortar, then place in a hard glass flask, fitted with a cork (air tight), through which a bent delivery tube passes (see Fig. 41). The end of the delivery tube should dip under water contained in a basin or trough. Heat the flask with a bunsen burner. If the glass flask be not a hardened one place a piece of wire gauze between it and the flame of the burner. On lighting the burner and heating the flask, air will at first be driven out of the

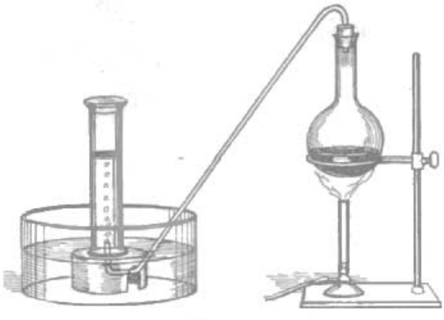

FIG. 41.

flask and bubble up through the water in the basin. Soon the production of gas becomes brisker, and oxygen is given off. Now fill a jar with water, put a greased glass plate over the mouth, invert it, and put it in the dish with its mouth downwards under water. Care must be taken not to let any of the water escape. Withdraw the greased plate and bring the jar, still full of water, with its mouth over the delivery tube. The oxygen will now bubble up and displace the water. When quite full of oxygen, replace the glass plate and withdraw the jar. Place it in a large saucer or soup plate nearly full of water, mouth still downwards and greased plate still on. In this way some half-dozen jars may be collected in succession and the gas retained for some time.

Experiment 110

Cut *under water* a small piece from an ordinary stick of phosphorus, dry it properly with blotting paper, and place it in a deflagrating spoon. Turn one of the jars of oxygen right way up and remove the greased plate (the gas will not escape being slightly heavier than atmospheric air). Place the spoon with the phosphorus in the neck of the jar, touch the phosphorus with a hot wire to ignite it, and at once plunge into the jar. The phosphorus will burn in the oxygen with a most brilliant light and the jar will be filled with a white smoke (phosphoric acid).

Experiment 111

Set fire to a piece of bark-charcoal bound round with wire by holding it in the flame of a spirit lamp; then plunge it into another jar of oxygen. The most brilliant scintillations will take place.

Experiment 112

Place in a deflagrating spoon, such as used in Experiment 110, a small piece of the metal potassium; set this on fire by holding it in the flame of a spirit lamp and rapidly plunge the burning metal into another jar of oxygen. A brilliant ignition is the result. Try the same experiment with a piece of sodium.

Experiment 113

Steel Burning in Oxygen

Take a piece of watch spring, softened at one end by making it red hot and allowing it to cool slowly. Wrap round the softened end a small piece of string, hemp or lampwick dipped in spirit. Light the same and plunge it into a large jar of oxygen. The cotton or wick first burns away, and finally the steel, which when ignited continues to burn with amazing rapidity and bright scintillations, forming an oxide which falls in globules to the bottom of the jar. The latter should be protected with a layer of sand to prevent breakage.

Experiment 114

The Preparation of Hydrogen Gas

As a general rule acids when acted upon by metals generate hydrogen. When required in quantity and of moderate purity sulphuric acid and zinc are as good reagents as any for the purpose. Place about 4 oz. of granulated zinc in a glass flask (of about 5 in. diam.)

and fit with thistle funnel and delivery tube (as shown in Fig. 42), with a basin of water or pneumatic trough for the collection of the gas.

Pour in about 4 oz. of water through the thistle funnel. Next pour in gently a little strong sulphuric acid, and give the flask a shake. (In order to be able to do this it is best to use a piece of rubber for part of the delivery tube (see Fig. 23, p. 75).) There is at once a brisk effervescence, the gas being now readily given off. More sulphuric acid (about a teaspoonful at a time) may be added from time to time as the action slackens. The first jar collected will not be all hydrogen, but partly hydrogen and partly air; and this, being liable to explode if a light be applied to it, *must be rejected.*[1] The second jar may contain a little air. The third and subsequent jars should be pure hydrogen. Be sure and see the cork fits tightly in the flask; and in order to ensure that it is air tight, paraffin wax or sealing wax can be melted over it. Ordinary commercial impure zinc should be used. The pure metal is without action on dilute sulphuric acid.

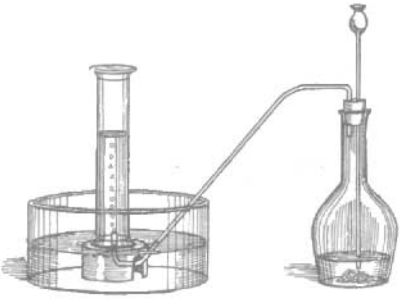

FIG. 42.

A much purer hydrogen may be obtained by boiling zinc with caustic potash.

It is most important to see that the jars in which the hydrogen is collected are full of water and contain no air

[1] Or the gas may be allowed to escape for a few minutes into the air.

(see Experiment 109, preparing oxygen). Hydrogen is the lightest substance known, being more than fourteen times lighter than air, and is the best gas to use for filling balloons where expense is not a consideration.

Experiment 115

Soap Bubble Balloons

This has already been referred to in Experiment 81. We give here another method and a somewhat better soap bubble solution. Pass the hydrogen gas through a U-shaped tube filled with cotton wool, and connect the delivery tube (by means of a piece of rubber tubing) to a thistle funnel, which is placed in a soap solution. The bubbles on breaking away will ascend to the ceiling, where they burst. Very interesting experiments can be made with light collodion balloons filled with this gas. For the soap bubble solution dissolve 20 grammes of sodium oleate in 800 cubic centimetres of cold and distilled water; add 200 cubic centimetres of *pure* (*i.e.* redistilled) glycerine, and well shake the mixture. Allow it to stand *in the dark* for a few days; siphon the clear solution off and add two drops of strong ammonia. Keep it well corked and in the dark when not in use.

Experiment 116

An Experiment in Squeaking

Hydrogen gas being so much lighter than air may be contained for a time in a bell jar open at the bottom as in Fig. 43. If a little squeaking toy be sounded first in air and then in hydrogen, we note an interesting and curious effect of hydrogen on sound. The experiment can be extended and the toy squeaked in carbon dioxide. Further experiments of an interesting and amusing nature may be made by passing light and heavy gases through wind instruments. In these experiments bags or bladders filled with the different gases should be made use of, and the gases driven through at exactly the same pressure.

FIG. 43.

An accordion playing some popular air, first in air and then in, say, hydrogen, demonstrates still more clearly what would be the effect of an orchestra playing in such a gas—or even in a room where a *considerable* quantity of this gas was present.

EXPERIMENT 117

The Oxyhydrogen Blow-pipe

When hydrogen (or the more generally employed coal-gas) is burnt in a specially constructed burner (see Fig. 44), an intensely hot but very feeble luminous flame is produced. Some idea of the intensity of the heat developed may be gauged from the fact that even platinum fuses or melts in it—and this does not take place until a temperature of 1800° centigrade is reached.

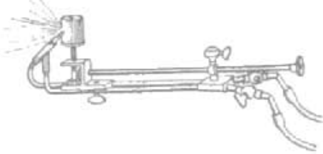

FIG. 44.

To obtain the best results pure hydrogen and oxygen (both in cylinders under great pressure) are made use of.

To show what the oxyhydrogen flame is capable of, we give below a table of the melting-points of various well-known substances which can be fused in it.

Substance.	Melting-Point. Centigrade.
Phosphorus	44°
Spermaceti	49°
Stearine	55°
Potassium	58°
Sodium	90°
Sulphur	111°
Tin	235°
Bismuth	264°
Lead	334°
Zinc	412°
Silver	1000°
Gold	1250°
Iron	1500°

If this flame be directed on various metals contained in a small hole made in a fire-brick, a most intense light is obtained from the combustion, which is variously coloured according to the nature of the metals used (see Chap. VI.).

With cast iron the most vivid scintillations are obtained, especially if, after having fused and boiled the cast-iron with the mixed jet, one of them, viz. the hydrogen, be turned off and the oxygen only directed on the fused ball of iron. Then the carbon of the iron burns with great rapidity, and the little globule is enveloped in a shower of sparks. Other metals may be similarly dealt with.

High as is the temperature of the oxyhydrogen flame and gas flames of like nature, none can compare with the temperature of the electric furnace, which rises to 3000° or even to 4000° centigrade.

CHAPTER XIII

FIRE-EATING AND FIRE-EATERS

It is credibly recorded of King Edward VII that when once on a visit to some works in one of our industrial centres, he had the courage to dip his hand into a vessel of molten lead without experiencing any ill effect. Whether the story be true or not, this is an experiment which has frequently been performed without the slightest injury. If the hand were dipped for only a moment into boiling water at 100° centigrade (212° Fahr.) the result would be disastrous; yet lead melts at 334° cent. or 633° Fahr., which is just 400° hotter. Why can one be done without injury and the other not? One explanation is that one is a wet or moist heat and the other a dry. The hand can be passed in safety through a jet of live steam, *i.e.* steam so hot as to be approaching the nature of a true steam. To pass the hand through the *visible* steam from a kettle spout scalds. The steam is then partly condensed and therefore moist.

Returning for a moment to the plunging of the hand into molten lead, the skin has a certain amount of moisture, and the experiment should not be made with a hot dry hand. The heat of the molten metal turns this moisture into a kind of glove of protecting steam-gas, a powerful non-conductor of heat. If, therefore, the hand be withdrawn before this protecting glove has had time to conduct the heat through, no unpleasant results will follow. No greasy matter must be on the hand: it must be scrupulously clean and moist. The outer surface of the skin is peculiarly insensitive to heat. Early experimenters in fire tricks, as long ago as the seventeenth century, relied for their success on that hardening of the epidermis which may be acquired by its frequent subjection to great heat, as well as on the deadening effect of a special chemical preparation which they used. An Italian chemist named Sementini having subjected certain portions of his skin to the oft-repeated action of sulphurous acid, found that he could apply a red-hot iron to that part of his skin with impunity. Continuing his experiments, he found the same result to follow from the action of a strong solution of alum. Having one day accidentally rubbed soap on a hand impregnated with alum, he found that the hand was still further proof against fire. He then discovered that a layer of powdered sugar covered with soap sufficed to render his tongue entirely insensible to heat.

At the present day, however, performers with fire rely mostly on the extremely volatile nature of the oils that they use, such as alcohol, ether, gasolene, etc.

Experiments of this nature must, however, be left to the professional performer. The method used in (apparently) eating burning coals is said to be as follows. A good charcoal fire is made, and just before the experiment is performed three or four pieces of soft pine are thrown on. When burnt, this cannot be distinguished from the charcoal save by sticking a fork into it. The fork will enter the pine wood easily but not the charcoal, the latter being hard and brittle. The charcoal would burn anyone who touched it; the pine wood does not.

Similarly, raisins can be plucked out of burning brandy and alcohol by means of a pickle fork and eaten straight away, provided the mouth be shut tightly the moment they are placed therein so as to exclude all air.

Experiment 118

Eating Lighted Wax Vestas

This is quite a safe and easy experiment provided the following directions be carefully followed. The vesta is struck and lighted in the ordinary way and allowed to burn for a short time. The glowing "head" of the vesta is then plucked off with the finger and thumb—this is quite easy if done quickly; the vesta is placed in the mouth and the mouth tightly closed so as *instantly* to extinguish the flame. Care should be taken at the same time to *exhale* the breath through the nose. It is hardly necessary to add that the mouth should be moist at the time; and the vesta can be heard to go out with a faint hiss.

The experiment must be done boldly or not at all; if the mouth be half closed and the breath *inhaled,* then you will probably burn yourself. Place the vesta well in the mouth—not on the lips. Always remember to exhale the breath. We inhale oxygen gas, a supporter of combustion; we exhale carbonic acid gas, a non-supporter. The vesta should not, of course, be swallowed.

Experiment 119

A Lighted Candle as Dessert

The candle itself is not made of wax but fashioned from a large turnip or, if preferred, an apple; its wick is made from a piece of sweet almond or Brazil nut—all of which can of course be eaten.

Experiment 120

Chinese Fire Eating

Take pieces of soft string about as thick as an ordinary clothes line; soak them for ten or twelve hours in a saturated solution of potassium nitrate. Remove them and thoroughly dry, and cut up into lengths of an inch or so. Light one of these and place it in a ball of tow. This can safely be placed in the mouth, and clouds of smoke and even sparks, etc., may be ejected. Once the string is in the mouth it is only necessary to blow to do this. If the heat becomes uncomfortable, simply close the mouth tightly and breathe through the nose. Never *inhale* the breath through the mouth in any of these experiments, or you will be sure to swallow smoke and have a fit of coughing, which will most certainly spoil the effect.

CHAPTER XIV

MISCELLANEOUS EXPERIMENTS

Experiment 121

The Sinking and Floating Egg

Fill a tall, cylindrical, clear glass jar with dilute hydrochloric acid and place in it an egg, which will sink. It will, however, in a short time rise to the surface and slowly rotate. This curious effect is owing to the fact that the surface of the shell becomes covered with bubbles of carbonic acid gas.

Experiment 122

Chameleon Powder

Take some mercuric oxide (an orange-coloured powder) and put it on a white enamelled iron plate or dish ; place the plate on the top of a specially contrived table or stand, so that the plate can be secretly heated by a bunsen burner or spirit lamp concealed underneath. A bunsen burner is best because the gas can be turned off.

On being heated, this powder changes first to a bright red, then dull red, purple, and so on, and eventually to black. On cooling it returns to its original colour.

Experiment 123

The Magical Scent Spray

Six white feathers are shown; and by merely spraying on them from an atomizer, they become any colour desired.

The feathers are previously dusted with six different aniline dye powders, and then shaken so that apparently none remains. If, however, alcohol or eau de cologne (in which these dyes are very soluble) be sprayed over them, the feathers immediately become coloured. A private mark must be made on each feather to enable the experimenter to produce the desired effect.

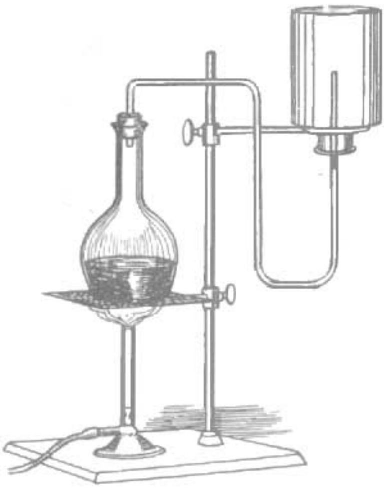

Fig. 4[?].

Experiment 124

A Colour-changing Fountain—Red to Blue

The two following experiments are extremely pretty and effective, especially if carried out on a somewhat large scale.

Fill a large round-bottomed flask with ammonia gas by upward displacement.[1] Insert a cork through which passes a piece of glass tubing, drawn to a rather fine point, and fitted with a stop-cock or tap as shown (see Fig. 46). The bottom end dips into a beaker of water coloured red with a little litmus solution.[2] A little ether is sprayed on the outside of the flask. The gas is thereby cooled and contracts, allowing a little water to enter. This dissolves so much gas that the pressure inside the flask is greatly reduced, and the water rushes in in the form of a fountain, changing in colour as it does so from red to blue owing to the alkaline character of the solution. A substitute for a stop-cock can be made by joining two pieces of glass tubing by means of a piece of rubber tubing and nipping the rubber with a spring clip.

FIG. 46.

EXPERIMENT 125

A Colour-changing Fountain—Blue to Red

This experiment is very similar to the foregoing, but here the change is from blue to red, owing to an acid reaction. Instead of ammonia, the gas in the flask is

[1] Ammonia gas is generated by putting in the flask two parts of powdered quicklime and one of sal ammoniac, and heating as shown in Fig. 45. Both ingredients must be finely powdered and quite dry. To be sure the lime is "quick," a new "lime," such as is used in magic lanterns, should be used. Those hermetically sealed in glass tubes are the best, in fact the only ones you can be sure of.

[2] Red litmus solution is made by adding a drop or two of acid to the ordinary blue solution. Do not make the colour too deep until you have tried the experiment.

hydrochloric acid, and the solution in the beaker is ordinary blue litmus solution, diluted with water to the colour desired. The acid reaction changes the blue fountain to a red one.

Hydrochloric acid is usually prepared by the action of strong sulphuric acid on common salt, and the apparatus used is similar to that for chlorine (see experiment 67).

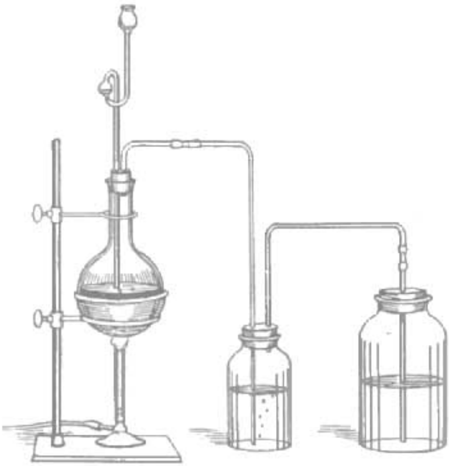

FIG. 47.

A better way of preparing hydrochloric acid is seen in Fig. 47. The flask on the left should only be heated *gently*, if at all. Copious fumes emerge from it when full. The middle flask has sulphuric acid in it through which the gas is allowed to bubble in order that it may dry. The third flask should be quite dry.

EXPERIMENT 126

A Change of Volume

Place an ounce of lump-sugar in a strong, tall glass jar, and pour upon it enough hot water to cover it; then add slowly double the volume of strong sulphuric acid, stirring the mixture with a glass rod. In a few seconds the colourless liquid will become brown, then black; and in a few minutes it will boil up, the jar becoming filled with a coal-black mass of carbon.

Experiment 127

A Change of Temperature

In a narrow, tall glass jar, or in a large test tube or glass flask, place as many lumps of baryta as will nearly fill it. The baryta must be quite dry, and the lumps should be large, with plenty of air spaces between them. Baryta, also called barium monoxide, is a substance resembling quicklime in many respects, but it is more energetic in the particular action we are considering. Pour cold water over the lumps of baryta. The heat thereby developed will be so great as presently to make the water actually boil; and ere long some pieces of the baryta will become red hot.

Experiment 128

Another Zoological Transformation

Draw or design on cardboard or paper a leopard, which the necessities of the case demand must depart somewhat from the general colouring of his species by having yellow spots on a light or white ground. The spots must be painted in with a mixture of potassium chromate and hydrochloric acid. If the design be placed in a bell jar and subjected to the action of sulphur dioxide, the spots will be changed from yellow to green.[1]

[1] Compare Experiment 28. These experiments can obviously be extended.

Chemically, if not zoologically, the leopard *can* change its spots.

To generate sulphur dioxide, see Experiment 73.

Experiment 129

A Change of Colour

If freshly-gathered flowers be placed in sulphur dioxide, the colour is discharged; if the flowers are then steeped in water made slightly acid with a little sulphuric acid, the colour is restored.

Experiment 130

To Extinguish a Candle by Cooling it

The "cooling" here referred to is not brought about by simply plunging a candle into cold water, or anything of that kind. The object of the experiment is so to cool down the flame that it will cease to burn—its temperature being lowered below the point of ignition.

To accomplish this, all that is necessary is to make a spiral coil of copper wire and place it (quite cold) over the flame, which will go out. Heat the coil and repeat the operation, and the flame will continue to burn. From these two results a very pretty little magical trick can easily be evolved. I leave it to the ingenuity of my readers.

Experiment 131

Fire from Water

If a small piece of sodium be dropped on a piece of either filter or blotting paper placed on water, it soon melts, and then takes fire. Sodium dropped on the surface of hot water also takes fire, but not on cold.

Experiment 132

A Study in Yellow

If a piece of sodium be first lighted and then placed in a jar of oxygen, it burns with an intense yellow flame. All the other colours of the spectrum being absent, the colour effect, especially upon the human visage, is an extremely ghastly one, and shows most vividly what a terrible deprivation it would be to live in a world of monotone, *i.e.* possessing but a single colour.

Experiment 133

Philosopher's Wool

Melt some zinc in an iron ladle and make it quite red hot. If a little dry nitre be thrown upon the surface and gently stirred into the metal, it burns with an intense white light, whilst large quantities of white flakes ascend and again descend. The residuum is oxide of zinc, called by the alchemists the "Philosopher's Wool."

Experiment 134

Spur Rowels

A very pretty parlour firework can be made in the following way. Mix together nitre, sulphur, and lamp black in the proportion of 8 : 4 : 3.

Powder the nitre and sulphur separately, and again grind when mixed, and finally the charcoal must be rubbed in carefully, till the whole is of a uniform dark grey tint—

almost a black. As the mixture proceeds, ram a little into a small paper case and set it on fire. If the stars or pinks come out in clusters and spread well without being accompanied by other and duller sparks, it is a sign that the whole is well mixed. If, however, the sparks are ejected sluggishly and take some time to burn, the mixing and rubbing in the mortar must be continued. But the pounding process must not be carried too far or the sparks will be too small. If the lamp black be heated red hot in a closed vessel and powdered when cold it is better. The sparks thrown into the air have the shape of the rowel of a spur, whence the name of the experiment. The difficulty consists in effecting the complete mixture of the charcoal.

In consequence of the finely divided condition of this substance, the sparks are consumed so rapidly that they do not burn the hand when falling on it, nor will they set anything on fire.

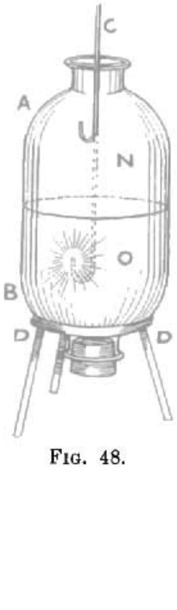

FIG. 48.

EXPERIMENT 135

In and Out

Place a bell-jar full of nitrogen over a similar inverted jar of oxygen as shown in Fig. 48. This can be done by first filling the lower jar with oxygen, covering the bottom with a greased glass plate and inverting it as shown. Then fill the other jar with nitrogen, making use of the same device. Thus, on placing the two jars one above the other, and carefully drawing away the glass plates, we have a continuous jar, the bottom half full of oxygen and the top half full of nitrogen. On plunging in a lighted taper, it can be made to burn or go out according as it is held low or high in the gases, in the manner described in Experiment 79.

Experiment 136

Self-Luminous Steam

Place a little phosphorus in a copper kettle full of water and boil. Close up all orifices in the kettle save the spout, and even this can be partly closed, so as to project the steam in a small jet. This jet of steam will be luminous in consequence of minute particles of sulphur being carried up mechanically with the steam. This experiment has a very pretty effect when performed in a darkened room.

Experiment 137

Soluble Glass

This peculiar product can be obtained by melting together in a crucible fifteen parts of sand, ten parts of carbonate of potash, and one part of charcoal. Thoroughly mix before melting. Cold water will wash away the excess of alkali, and after this has been done the powdered glass may be boiled with water in the proportion of one part of the former to five of the latter, when it gradually dissolves. This solution can be evaporated to a thick pasty fluid, which looks like a jelly when cool, and on exposure to the air in thin films changes to a transparent, brittle, but not hard glass.

Experiment 138

Iron Wire Burning in Oxygen

Take four feet of thin iron wire, such as is used for binding flowers; make it into a spiral by coiling it round a thick pencil or thin round ruler, and attach to one end about a quarter of an inch of wax vesta. It is now ready for burning. Proceed as in experiment 113. Try also wires of other metals.

Experiment 139

Aqua Regia

Take a piece of gold leaf and place it in a test tube or old wine glass. Pour in some nitric acid and warm gently. The gold is undissolved. Treat another piece similarly with strong hydrochloric acid: this has also no action. Mix the two acids together: the gold dissolves rapidly.

Experiment 140

The White and Black Statue

Construct a small figure or statue of white paper or cardboard, and moisten it with a solution of acetate of lead. Expose it to fumes of sulphuretted hydrogen, and it will turn black.

It may be as well to mention *en passant*, for the benefit of those who may not be acquainted with it, that this gas has the odour of rotten eggs and cabbage water combined.

Experiment 141

How to Freeze Mercury in a Red Hot Vessel

This apparently impossible feat was first performed by Faraday. The experiment as carried out by him was performed with solid carbon dioxide (see Chap. XI.), placed in a red hot crucible. After pouring in a little ether, the mercury was quickly added, and in a few seconds was frozen solid.

Experiment 142

Burning Air

Fill a large glass jar with coal-gas and place it, with its mouth downwards, in the ring of a retort stand or some such contrivance, the mouth being covered with a glass plate. Fill a bladder or gas bag with air and attach it by means of rubber tubing to a piece of glass tubing, with the end drawn out to a point in order to make a jet. Place a light weight on the bag to produce a gentle stream of air. Light the coal-gas at the mouth of the jar, and steadily introduce the jet of air. The air will be ignited at the flame of the burning coal-gas, and as it is pushed up into the interior of the globe will continue to burn, showing clearly that air will burn in an atmosphere of coal-gas.

Similarly oxygen can be shown burning in hydrogen. Great care must be taken that coal-gas only, and not coal-gas mixed with air, is in the jar, or there may be an explosion.

Experiment 143

Burning Copper Wire

Raise some sulphur to boiling point in a test tube or similar vessel. Insert a coil of fine copper wire and vivid combustion follows.

Experiment 144

A Soluble Gas

Provide a large and deep glass vessel nearly full of water; also an empty jar (of course full of air), and another and similar glass jar full of ammonia collected by upward displacement.

Plunge the jar full of air, mouth downwards, quickly but steadily into the water. The water rises but a short distance owing to the air. Do the same with the one full of ammonia gas; the water rushes up and fills the jar, owing to the great solubility of the gas in water, which dissolves at 0° C. 1050 times its volume of gas. It is best to cover the mouth of each jar with a greased plate, and remove it under water.

For magical use of this experiment see next chapter.

Experiment 145

Salamander's Hair [1]

Soak a thread in a saturated solution of salt and water; let it dry, and again soak it. Do this several times. To all appearances there is nothing unusual about the thread. Suspend a length of it from a suitable support, and hang on to the end a light ring. Set fire to

[1] The salamander is an amphibious animal, fabled to be able to live in fire.

the thread; it will burn from one end to the other but will not break, nor will the ring fall. The *thread* is really burnt, but not the salt—a little tube of that substance being left of sufficient solidity and strength to support a light ring.

When performing the experiment avoid doing it in draughts or currents of air.

An improved form of this experiment is to fasten the ends of four threads to a piece of muslin about three inches square, also prepared like the thread. Suspend the muslin by the four corners as shown in Fig. 49, and place in it an empty (blown) egg. Set fire to the hammock and threads; they will burn, but the egg will not fall.

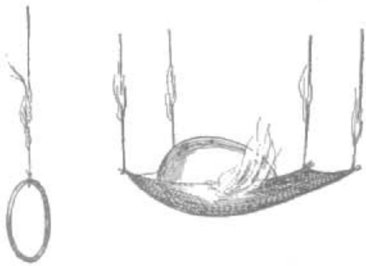

FIG. 49.

An experiment of a much more startling nature could be performed with a full egg or even something heavier by using very fine platinum wire encased in a combustible substance. Platinum will only melt in a very high temperature, and extreme fineness and great pliability are therefore obtainable with it. To keep up the illusion, however, it must not appear to be wire.

EXPERIMENT 146

The Mysterious Scorpion

Fill a clear glass bowl nearly full of water, and place on the surface a number of lumps of camphor of unequal size, so arranged as to take the form of some grotesque animal—a scorpion, for instance, as in Fig. 50. After a short time the strangely made animal begins to move of its own accord, bending its arms as if it were trying to swim, and also its tail. This little experiment never fails to excite much interest and amusement. The mysterious movements are probably caused by inequalities in what is known as the surface tension of the water, due to the elastic skin which it is now known to possess.

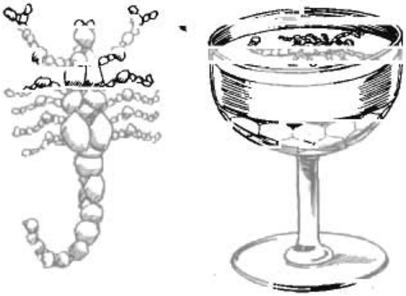

FIG. 50.

EXPERIMENT 147

The Extinguished and Relighted Candle

FIG. 51.

The materials required are two small dolls, two quill pens (toothpicks answer admirably, or two little pieces of metal or glass tubing of small bore), a *very* little gunpowder, a little piece of phosphorus, and an ordinary candlestick and candle.

The arms of the dolls are so arranged as to hold the ends of the tubes close to their mouths, as shown in Fig. 51. In the end of one quill farthest from the mouth is placed a little gunpowder, and in the corresponding end of the other quill a fresh cut piece of phosphorus.

The doll with the gunpowder-loaded quill is first brought to the candle, and the little explosion puts the candle out, driving the hot smoke towards the other quill containing the phosphorus. The heat of this smoke is sufficient to ignite the phosphorus, and by means of this the candle can be re-ignited.

The phosphorus must be freshly cut. If left too long exposed to air a premature ignition may result.

Experiment 148

How to Plunge your Hand into Real Water and yet not Wet it

In a glass dish nearly full of water throw a small bright object that can be easily seen. Then announce that you are about to pick the object out of the water with your bare fingers without wetting them.

To do this it is only necessary to sprinkle the surface of the water with a powdered substance having no cohesion with water, and therefore not wetted by it. Lycopodium powder is such a substance. The powder forms around your hand a true glove, on which the water has no action, any more than it has on the feathers of a live bird. Water runs from it as from the proverbial duck's back. An even better method is to rub the hand well with the powder instead of sprinkling it on the water.

Experiment 149

The Eruption of Vesuvius

A large and rather tall clear glass jar; some water; a bottle of French (red) wine; some sand; a small wide-necked bottle; a cork and a piece of very fine bore glass tubing, are all the materials needed for this little experiment. (See Fig. 52.)

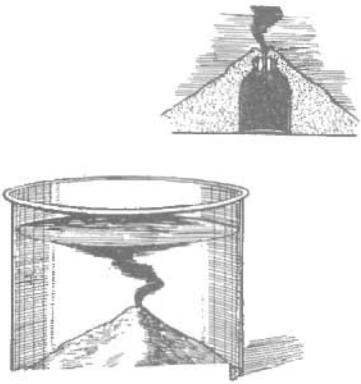

Fig. 52.

The small bottle is filled with wine. The length of glass tubing is passed through the cork and the latter fitted into the neck of the small bottle; and the whole is then placed at the bottom of the large jar. Sand is piled up round the bottle in the form of a volcanic cone, with the centre of its crater at the top of the glass tube. Nearly fill the large glass jar with water and give it a stir round. Owing to the wine being of slightly less density than the water it will ascend in a thin wavy stream, spreading out on the surface as the water is disturbed. Instead of wine, dyed alcohol or ether can be used and afterwards fired to add to the effect.

Experiment 150

The Mysterious Migration.

This is a very striking experiment. Obtain two wine glasses of the same size and diameter with ground edges.

Fill the one with water, the other with (red) wine. Place over the top of the glass filled with water a piece of fine net or muslin (or very fine meshed metal gauze), slightly larger than the top of the glass, and bend or fasten down all round (Fig. 53). Lay a piece of thin glass over the muslin or gauze, invert the glass (the water does not run out), and place it exactly over the glass of wine. Gently slide away the piece of glass between the two. Do not allow a single bubble of air to enter, and both glasses must be absolutely full of their respective liquids. At the end of about ten minutes the two liquids will have changed places.

Fig. 53.

Experiment 151

How to make a Lump of Sugar Float on Water

The lump of sugar must first be immersed in collodion (such is still used in photography), an ethereal solution of a substance almost identical with gun cotton. When the solution evaporates it leaves behind a transparent layer, resembling gold-beater's skin, possessing considerable tenacity. Place the lump of sugar in a current of air for a day or two, in order that all the ether may evaporate. Its appearance will then be that of an ordinary lump of sugar. It may then be placed with other lumps in a sugar basin.

On dropping it into a glass of water it first sinks to the bottom, but after a few seconds rises to the surface and there remains. Any other lumps dropped into the water behave, of course, like ordinary sugar. The prepared lump really dissolves in the water—it is the collodionized shell only that rises. To the eye the illusion is perfect, but not to the touch—no one must be allowed to handle it after it has risen. Another way of exhibiting this experiment is first to allow one or two persons to drop in lumps out of the basin, in which there is none prepared. Then, by a little piece of sleight of hand, the prepared lump is introduced and dropped in.

Experiment 152

How to Plunge a Sheet of White Paper into Ink without Blackening it

An inkstand—preferably large and with a wide opening; an old used stone ink-bottle quite dry inside; and some well powdered black rosin or colophony are all the apparatus required. You invite someone to dip a sheet of white paper (rolled up into the form of a cylinder) into the inkstand, which is about half full of ink. See that it is well dipped in, and that plenty of ink is brought out with it. On the excuse of filling up the inkpot, you pretend to pour in some ink out of the bottle, but the fluid is really rosin powder and water. When the surface of the ink is so covered, the roll of paper can be plunged in without any fear of actual contact with the ink. When taking out the paper, shake it slightly in order to prevent any powder adhering to it. (Compare Experiment 148.)

Experiment 153

More Spontaneous Combustion

Take a piece of ordinary glass tubing five inches in length, and with the aid of the bunsen burner close one end. Fill the tube one-third full of either oxalate of lead or tartrate of lead. Draw out the other end of the tube nearly to a point, leaving a small opening of not less than one-eighth of an inch. Heat in a bunsen burner, after having well shaken the tube and spread the contents out evenly in the bottom half. Apply the heat first at the closed end and gradually all over the tube, until the contents have all turned black and vapour has ceased to issue from the open end. This should then be quickly closed up by holding it in the upper part of the bunsen burner.

Lay the tube on one side to cool.

When it is desired to show the experiment, well shake the tube to loosen the contents. Then make a nick in the middle of the tube, break it (as directed in Chapter XVI.), and at the same instant scatter the contents.

A show of sparks produced by the burning metal is the result.

Experiment 154

An Ink that can be really Erased

Inks exist which under the action of light entirely disappear—so far as the visual organs are concerned. Ordinary ink is bleached by chlorine; but in practically all such cases, either by chemical action or by the aid of photography, it is possible to revive the characters thus effaced.

The ink which we are about to consider can be absolutely obliterated, leaving no trace.

It is made as follows: dilute some starch in water to the consistency of a cream, and add a few drops of tincture of iodine.

Dip the pen into the ink thus formed, and write on ordinary paper. The writing appears quite distinct, of a dark brown colour, and will dry almost immediately.

To obliterate it, it is only necessary to rub it with a handkerchief or with the hand, it will disappear as easily as chalk from a blackboard and leave no trace.

Experiment 155

An Experiment on the Radioactive Properties of an ordinary Gas Mantle

We are accustomed to look on a gas mantle as something which, under the action of ignited coal-gas, gives forth a brilliant light; and when it is mentioned in connection with photography, we naturally assume that its light-giving properties only are in question.

But there are other properties possessed by this appliance which, though less generally known, are equally potent from a photographic point of view, and we will now proceed to show how a good mantle can affect a sensitive plate and produce a photograph of itself, without the action of any light, camera, lens, or anything of the kind.

Cut the mantle open and press it flat on a metal plate; burn off the cotton. Wrap a photographic plate in a sheet of black opaque paper, or place it in an airtight envelope, and lay it on the mantle, using every care not to break the latter. Place the whole carefully in a drawer in the dark and leave for ten days or a fortnight. On developing the plate it will be found that an image of the mantle has been formed on the plate in the dark by the rays from the thorium contained in the mantle, thorium being a radioactive substance. Much stronger effects can be obtained from uranium or uranium salts.

EXPERIMENT 156

Becquerel Rays

Procure some uranium salts (both uranium itself and all its compounds so far investigated are radioactive), scatter them, so that they form a design of some kind, on the opaque envelope containing a photographic plate. Complete the experiment as in 155, and you will have a photograph of your design.

CHAPTER XV

THE EFFECTIVE PRESENTATION OF CHEMICAL EXPERIMENTS

To perform a series of chemical experiments in a laboratory, and to present the same as part of an entertainment of a magical or quasi-magical nature, are two totally different things. Success or non-success in the latter case depends far more on the manner in which they are presented, than on the experiments themselves. Let us take Experiment 24 and develop it, dealing first with the effects.

We enter an ordinary dining-room—papered in plain dark red. We are asked to take our seats at a large dining-table, the centre of which is covered with a plain green cloth. There is nothing on the table save a large and handsome flower-stand full of flowers. We glance round the room. It contains several porcelain vases filled with flowers, and the rest of the furniture and effects are just such as one would expect to find in an ordinary dining-room. The lights are extinguished as for a spiritualistic séance. A young lady at the piano plays soft and dreamy music, and beyond this for a time nothing happens. The music increases slightly in intensity, and suddenly a luminous hand appears and floats over the heads of the spectators; then as suddenly disappears. Next a luminous electric bell is seen, which rings sharply on one side of the room, and vanishes.

Almost immediately the bronze figure of a knight in armour on the mantelpiece becomes self-luminous, as also does the face of the clock, whose hands move and point to a certain hour. Fluorescent gleams of varying hues of white and blue and green now begin to dart about the room over the heads of the spectators. These are sometimes straight, sometimes wavy, sometimes whirling round and round. Again all is dark. A fluorescent decanter now appears on the sideboard—rises from it and remains suspended high in the air. Then a greenish fluorescing tray appears below the decanter, followed by a beautifully luminous glass. Next, a glass sugar basin—also fluorescing—filled with self-luminous sugar, comes into view on the tray. Several pieces of sugar leave the basin and fall into the glass, into which the decanter now pours a stream of fluorescing liquid; and a white spoon is seen turning round and round in the liquid to help dissolve the sugar. In a twinkling of the eye all this vanishes. A self-luminous skull—fluorescing white—with greenish eye balls and bluish teeth, next appears—a gruesome and most weird object, with flickering fluorescent gleams flashing to and fro upon it. From the top right hand corner of the room there floats down a little white cherub on outstretched wings. The glimmering skull gnashes its teeth, gives forth streams of luminous vapour, and disappears, the cherub vanishing in a joyous burst of music a moment later.

The lights are turned up, the performance is ended. All these wonderful effects are but an extension of Experiment 24, an elaborate development, of course, and one requiring a considerable sum of money to produce; but it is quite possible and by no means difficult.

The chief things required are an induction coil giving an eighteen inch spark, and a quantity of those chemicals mentioned in the experiments in question, which fluoresce brilliantly under the action of the X-rays. The X-ray tube in which these rays are generated is concealed in the large vase of flowers in the centre of the table. The tube itself is enclosed in an opaque black silk or cardboard receptacle. Round the tube moves a partial lead screen (opaque to the rays), which can shield one end on one side or top or bottom of the room according to its position. The music is to conceal any noise the electrical apparatus may make. The coil is in an adjoining room. The very high tension of the electricity used requires great care in insulation, in order to get it to pass from the coil and through the X-ray tube without leaking. Certain objects become visible at a time owing to the mechanical movements of the lead screen; others appear and disappear by being taken out of and put into black velvet bags by confederates. The self-luminous hand is merely a stuffed glove coated with tungstate of calcium, suspended by a thread from a thin black rod. The skull is of papier mâché, coated in places with different fluorescing materials; and so on.

Let us next take quite a simple experiment, well within the reach of anyone—No. 144, for example—and see what can be made of it. Apparently it is not an experiment at all likely to lend itself to much development, nor does it seem to be a particularly effective one in any case. It is, however, for this reason, all the more suited to our present purpose, and we shall show it as an experiment on the PENETRABILITY OF MATTER.

The apparatus is as in Experiment 144, but the two jars are on a stand on a *slightly* higher level than the large glass vessel nearly full of water and close to it. The entertainer, coming forward, addresses his audience thus: "You have all heard, I am sure, of the Impenetrability of Matter. I beg your pardon? You say it does not matter? Oh, yes, it does—pray don't think that *I* am to be diverted from my purpose by a Byronian pun—

> 'When *I* speak on the subject of matter
> It is *much* matter what *I* say!'

To resume: all matter occupies a certain space; in the space where *I* am, *you* cannot be; in the space where *you* are, *I* cannot be. What's that, sir?"

"You can drive a nail into wood."

"Excuse me, sir, you cannot; what you do is to *thrust aside* the wood, but the wood is not where the nail is, nor the nail where the wood is. 'Two things cannot occupy the same space at once' — such is the dictum of the scientists. I will now proceed to demonstrate to you that the scientists must be wrong. I have here (indicating apparatus) a large glass jar nearly full of water, and on the water floats a cork. There are two glass jars—I see my assistant has placed them upside down; however, that is of no consequence. I pick up this one (picking up the one containing air and thrusting it down into the large jar of water in such a manner as to carry down the cork inside the jar).

"The jar is not full of water—the floating cork shows you that the water has risen but a little way in the jar. Why? Because the jar was full of air, and before the water can go in, the air must come out. *Sublata causa effectus tollitur*; or in other words, remove the air and the water can enter.

"I have here a precisely similar jar, and I am now about to perform the same experiment with it (picks up the jar containing the ammonia gas and performs the same experiment; the water rushes up and fills the jar).

"Lest you should think there is some trickery connected with the jar—such as a hole in the bottom—I remove it, invert, and pour water into it (suiting the actions to the words). Not a drop runs out.

"The jar was not a vacuum with nothing in it, for the end was open and air free to rush in whilst I was in the act of moving it to the top of the water. Who can now dispute the truth of the assertion, *That two things* CAN *be in the same place at the same time?* Let all speak at once or be for ever silent."

The best chemical tricks are performed by the aid of mechanical adjuncts. Experiments 7 and 15 are cases in point. Here the desired chemicals are introduced through the bottom of the glass. If the glass or goblet have a top placed on it as in Fig. 54, for the ostensible purpose of keeping anything out; obviously the top can be made to assist. The lid has a small hole in it marked *A*, which can be closed with a little pellet of wax. A piece of horse-hair is firmly fixed around the wax, and a black thread attached to it. The required chemical in solution is poured into the lid (if the top is clear glass, as it should be, the solution must be uncoloured), and a glass, or preferably mica,

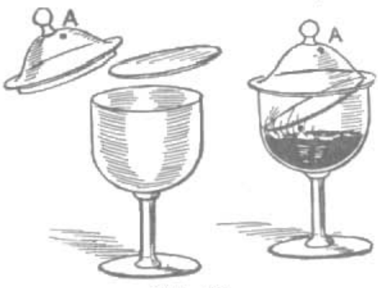

Fig. 54.

disc fastened on by what is generally erroneously termed suction.

At the right moment the thread is pulled, the wax comes off, air enters through the hole *A*, the suction is relieved, the disc and its contents fall, and the desired effect is attained. If the goblet be held in one hand, and the other hand be placed on the top, with the object, of course, of preventing any fraudulent chemical getting in and affecting the transformation, the pellet of wax can be scratched off with the nail, and a slight shake helps the mixing.

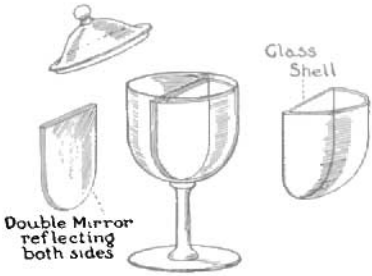

FIG. 55.

Another mechanical adjunct is an ordinary looking wine glass or tumbler, somewhat deeply ribbed, and pieces of thin coloured glass (red, yellow, blue, green), which exactly fit the tumbler.

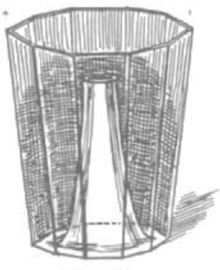

FIG. 56.

When filled with water, with the edge of coloured glass towards the spectators, it looks clear; but when the glass shutter is turned round so that it faces the spectators the liquid appears as port, sherry, etc., according to the colour used.

Another contrivance is shown in Fig. 55. Here a mirror partition is fitted into a wine glass, so that when the mirror is turned towards the audience the glass appears to be entire.

A glass shell occupies one of the spaces between the mirror and the glass, and any liquid may be poured into this without its touching whatever may be concealed in the other space at the back of the partition.

Yet another mechanical adjunct is shown in Fig. 56. This is generally used for producing dry things from a glass apparently full of liquid. The wine glass depicted in the former illustration is also used for the same purpose.

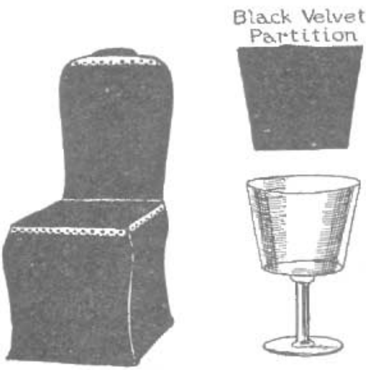

FIG. 57.

A similar contrivance is shown in Fig. 57.

By far the best mechanical adjunct is the following, which admits of seemingly impossible changes and transformations, not only in the matter of colour, etc., but of volume also.

The principle is at least over 2000 years old, and was used by the ancient Egyptians in some of their temple tricks in almost exactly the same way as described below.

The device depends on the simple and well-known principle that a liquid always seeks its own level. Supposing that we have a large bowl supported on a stand by a stem of clear glass E F (Fig. 58); and the stand is placed on a table as shown. By means of suitable rubber tubing, let us establish a connection between the interior of the bowl and "behind the scenes," where there is a tank of water so arranged that it can be raised or lowered. If the tank be at exactly the same level as the top of the wooden stand on which the bowl is placed, *i.e.*, just above E, *the glass tube will be full of water.* So arrange matters behind the scenes that the supply tank cannot be lowered below this. If the supply tank be raised, the water will flow into the bowl, its passage through the tube being quite invisible even if a lighted candle be placed behind it as shown in the illustration.

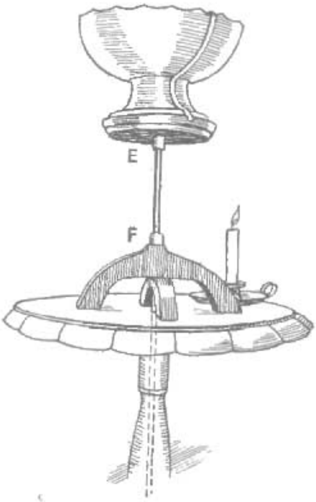

FIG. 58.

Suitable chemicals (in the dry tabloid form) dropped into the bowl—after it has been passed round for examination—can be made to produce any coloured liquid desired. The connection between the stand and bowl is made by means of a piece of flexible tubing secretly hooked over the back of the bowl when adjusting it on the stand. Unless the eyes of the audience be at a higher level than the top of the bowl, there is no necessity to cover it with a handkerchief or anything of that kind.

The bowl is obviously inexhaustible.

Instead of using the bowl and stand, let us replace them by the performer himself and a kettle, watering can, coffee-pot or teapot. The performer comes forward and exhibits the kettle or other vessel. He removes the lid, turns it upside down, and shows clearly that it is empty. He then goes to the table and allows his left hand to rest upon it, then standing in a negligent attitude he proceeds to pour from the kettle into a number of glasses standing on the table various coloured liquids. This result is brought about through the working of the same mechanical principle as obtained in the case of the bowl and glass tube. A piece of flexible tubing runs from the left hand up the left arm of the performer, across his shoulders and down his other arm to his other hand, in which he grasps the kettle by the handle. This handle is hollow and is directly connected with the spout. Thus the fluid does not enter the body of the kettle at all, simply passing from the supply tanks behind the scenes up the leg of the table, along its top to where the performer's left hand rests, up one arm, down the other, into the handle, and out at the spout.

Instead of the supply tank behind the scenes and the liquid finding its own level, the performer can dispose about his person indiarubber bladders containing various fluids, and by pressing on them force their contents up the various tubes to the top of his right shoulder, whence they will flow down as before. On releasing the pressure the flow will of course cease. The kettle, or whatever vessel is used, can be divided up into various compartments, with little tubes leading up into the handle. In the handle also are little air holes, which can be covered or uncovered at will by the fingers. Each compartment is also connected with the spout by other corresponding tubes, and the various liquids poured out at will.

The principle obviously is one of atmospheric pressure.

CHAPTER XVI

LABORATORY DIRECTIONS

Hints and Cautions

ALWAYS see that stick phosphorus is kept in a bottle with sufficient water in it *completely* to *cover* the phosphorus. If the bottle gets upset *immediately* refill it.

Always cut phosphorus in a shallow dish under water. Never pick it up with the fingers, always use a pair of forceps. Use blotting paper to dry it.

Always add sulphuric acid to water in a thin stream—never pour water on sulphuric acid.

Always keep potassium and sodium completely under oil; never under any circumstances put a piece of either in the mouth.

Never pour out ether, or bring an uncorked bottle of it, near a naked light.

Always carefully throw away (down the sink) all solutions (especially if poisonous) as soon as finished with.

Always place the cork or stopper in a bottle *immediately* after using it, and never put the wrong cork in any bottle. Put all bottles back into their proper places.

Always thoroughly wash and clean everything after use, *especially the pestle and mortar.* This should be well scrubbed, lest traces should be left of a substance which, when ground with another, might cause an explosion.

Never grind together in a mortar phosphorus and chlorate of potash, or you will have a violent and probably disastrous explosion.

Never grind two substances at once in a mortar unless expressly told to do so.

Never mix the gases hydrogen and chlorine together, unless, of course, under proper supervision and with due precautions. In diffused daylight a slow combination takes place; but in bright daylight or under the influence of powerful artificial illuminants, such as burning magnesium wire, the electric arc, etc., they combine immediately with explosive violence, and the vessel containing them is shattered, if it be a glass bulb, even to a fine dust.

In experimenting with hydrogen, always remember that that gas when mixed with air is explosive, and be sure that you have hydrogen only. Similarly with hydrogen and oxygen. When showing oxygen burning in hydrogen, be sure that both are pure.

When procuring chemicals, always see that you get the right ones.

Never use concentrated acids where dilute ones would do as well.

When substances (solids) are to be mixed, always powder them first and then stir them together till the mixture is as uniform as possible; they cannot be *too* thoroughly mixed.

When using the bunsen burner always see that the holes at the bottom are open; see also that the gas is ignited only at the very top of the burner and not at the bottom. The lighting at the bottom shows that too much air is entering; turn it out, regulate, and light again.

Always apply heat gently at first. To avoid cracking flasks, use wire gauze or sand bath.

Always carefully dry any articles that might rust.

1 centigrade degree = $\frac{9}{5}$ Fahrenheit degree
1 Fahrenheit degree = $\frac{5}{9}$ centigrade degree
To convert centigrade to Fahrenheit

$$\frac{C^\circ \times 9}{5} + 32 = F^\circ$$

To convert Fahrenheit to centigrade

$$\frac{(F^\circ - 32) \times 5}{9} = C^\circ$$

Freezing point on Fahrenheit $+32^\circ$
" " centigrade 0
Absolute zero of temperature -273° C

Don't throw *sand* or solid substances down drains.

Glass tubing can be easily bent in an ordinary burner. Hold it the long way of the flame, and heat equally all round before you begin to bend it. When soft, its own weight will practically bend it into a curve. To round off sharpened edges, make them just red-hot in a bunsen burner or blow-pipe and allow them to cool.

To cut glass tubing, make a notch in the tubing with a small triangular file and then snap—pulling and bending at the same time.

Cork borers are most useful. They are simply thin brass tubes of different sizes, one end being sharpened. The other end can be placed in a handle if desired. They can be easily made at home.

Always bore through from the small end of the cork, turning and pushing at the same time.

A borer just a shade larger than the glass tubing to be inserted should generally be used.

By first slightly greasing the tubing and then the cork, a perfectly air tight joint can be made without the aid of melting paraffin wax or sealing wax over it, which under the action of heat is liable to crack and leak.

When generating a gas in a flask, do not insert the tube taking off the gas—the delivery tube—more than a quarter of an inch below the cork.

To collect gases, jars about the size of pickle bottles but of white glass, are very suitable for preliminary experiments at any rate. But they should be ground at the top, *i.e.* the top edge should be true. If the edges are unequal, they can be made true in the following way:—

Place on a flat surface a sheet of emery paper of medium coarseness. It is best glued to a flat piece of wood 2 inches thick, and not less than 8 inches square. Hold the jar firmly and grind with a circular motion.

Render the joint between a glass plate and a jar air-tight by means of grease.

When using mercury, take care not to drop any on the floor, as it spreads all over the room in tiny globules which can only be partially recovered.

To clean mercury, squeeze it through clean muslin or linen, and afterwards through a piece of dry clean washleather.

Mercury is best kept under sulphuric acid, in a special bottle with a glass tap at the bottom, through which as much as may be required is drawn off. After it has been used and cleaned as described above, empty it back into the bottle.

Always protect corks from the action of chlorine by dipping them in melted (hot) paraffin wax. Similarly, metals should be protected from the action of mercury.

Never use indiarubber tubing with chlorine gas; if you do, wash well in running water afterwards.

When mixing a solid and a liquid in a flask which is afterwards to be heated, see that no dry powder is left at the bottom of the flask or it may crack.

Always use dry jars for experiments with hot sodium (or potassium). Remember that sodium coming in contact with water explodes violently.

Don't hold the face near a piece of sodium (or potassium) when it is moving about on the surface of water, no matter whether it is ignited or not. It often finishes with a slight explosion, and a particle might lodge in the eye.

In preparing ammonia gas, dry the ammonium chloride by placing it in an evaporating dish or basin, and heating it gently on a piece of wire gauze over a bunsen burner, turned down very low. Mix all the chloride and two-thirds of the lime; pour into a flask, and add the remaining lime in a layer on the top.

Always cover the mouth of a jar of this gas with a piece of cardboard, with a hole in centre for the tube; keep this on until the greased glass plate is exchanged for it.

To test when a jar of ammonia gas is full, hold a piece of reddened litmus near the mouth. When the jar is full the litmus will turn blue.

If acid be spilt on the hand, immediately place it under a copious stream from the tap. If spilt on the table or floor, scatter whitening on it.

Hydrofluoric acid being very corrosive, none of it should be allowed to get on the skin.

Never put anything away dirty. An instrument that would take ten seconds to wash directly after use may take as many minutes to clean a week later.

Wash glass vessels first well under the tap, and finally in distilled water when it is required that they should be free from all traces of salts. Allow them to drain and dry; the insides need not be wiped.

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