CHEMICAL PARADOXES.

We are accustomed to associate the idea of combustibility with paper. If it be wrapped tightly around a metallic rod it can be held in a gas flame without burning. The metal carries the heat away from it as fast as applied, becoming hot itself. After a while it will reach a temperature, provided the flame is large enough, at which the paper will burn.

This same phenomenon can be more strikingly exhibited by making a vessel of paper, filling it with water, and applying heat. No matter how hot the flame over which it is placed may be, it will not burn. The water will boil, and the heat be absorbed, or rendered latent, in the production of steam. An egg can thus be boiled in a paper saucepan—quite in the Easter vein if we were a little earlier in the season.

A sieve may be made to hold water or to float. If the interstices are very fine and the wire bright and dry, the water will not wet it, because a film of air will adhere to the wires. The lower surface of the water is divided by the meshes into a number of little spheroidal projections, in which the capillary force or internal gravitation and also cohesion come into play. These hold the water together so that some considerable power is required to force the water through the meshes. Thus we can put quite a quantity of water in a fine sieve, or place one in water and it will float. If the wires are not perfectly bright we may distribute over their surface some powder which water will not wet. The dust of bituminous coal is excellent. Carrying out this principle, needles, if bright, may be made to float without the least trouble, and will float for a long time.

Water is to be made to boil by cold. A flask half full of water is maintained at ebullition for some minutes. It is removed from the source of heat, corked, inverted, and placed in one of the rings of a retort stand. If cold water is poured on the upturned bottom of the flask the fluid will start into violent ebullition. The upper portion of the flask is filled with steam which maintains a certain pressure on the water. By cooling the upper portion of the flask some of this is condensed, and the pressure reduced. The temperature at which water boils varies with the pressure. When it is reduced water boils at a lower heat. By pouring the cold water over the flask we condense the steam so that the water is hot enough to boil at the reduced pressure. To assert that water boils by the application of cold is a chemical sophism.

It seems paradoxical to see a genuine metal melt in boiling water. It is a general rule that alloys melt at a lower temperature than any of their components. By making an alloy of cadmium, bismuth, lead, and tin, in proper proportions, we form a compound that will melt far below the boiling point of water, or about 160° F. Yet the melting point of tin, the most fusible of the four, is over 450° F. A good way to exhibit this is to make teaspoons or punch ladles of it so that they will melt in the hot fluid. It would be an illustration of the old proverb, "There is many a slip 'twixt the cup and the lip."

Double decompositions are responsible for many of our titular experiments. By mixing solutions of ferric oxide and potassic ferrocyanide we obtain Prussian blue. The solutions may be so dilute as to be colorless. So two colorless solutions produce a colored one, the suspended precipitate coloring the mixture. So may chrome yellow, or lead chromate, and mercuric iodide, and hundreds of other reactions be made to repeat this phenomenon. The acid radicals in these cases change places with each other. By proper succession very pretty effects may be produced. Thus five colorless solutions may be made to produce a colorless, a red, a colorless, a white, and a black mixture, all that is necessary being to pour from the first vessel into the next, the second into the third, and so on. Numberless other combinations can be made.

To make two colored solutions produce a colorless one we may avail ourselves of the power possessed by nitric acid of bleaching indigo. Two solutions of indigo are made; one contains a good quantity of sulphuric and hydrochloric acids, the other contains potassic or sodic nitrate. On pouring them together and warming a colorless solution results, as the sulphuric acid sets free nitric acid and chlorine, which destroys the indigo.

Two liquids are to produce a solid. This is another double decomposition. Saturated solutions of calcic chloride and potassic carbonate are poured together, when a very heavy precipitate of calcic carbonate or chalk is thrown down. At the present time this seems rather a weak affair, but in its day it was called a chemical miracle. It is for this reason that I show it to you. It is historic.

Two gases may produce a solid. This is effected by a simple combination. Ammoniacal gas and hydrochloric acid gas are both absolutely gaseous at ordinary temperature and pressure. If brought together they combine, forming a white solid substance called ammonic chloride or sal ammoniac. It is the substance used by tinsmiths to brighten the faces of their soldering bolts before tinning them.

If we immerse the bulbs of two thermometers, one in quicklime and the other in ammonic nitrate, and add water to each, contrary effects are produced. The quicklime has a strong affinity for water, and combines with it eagerly with evolution of much heat. The nitrate of ammonia, on the other hand, without much affinity for water, is very soluble, so it dissolves quickly, and in its passage from the solid to the liquid state renders latent or absorbs a great quantity of heat, causing a fall in the temperature, if rightly managed, of forty degrees. It is a very instructive experiment. To make it really impressive the water should be added from the same flask, so that there can be no fear that water of different temperatures is made to effect the result.

We now come to some phenomena of combustion. As we generally see it, it takes place in the air, which supplies the oxygen. But we can substitute for the oxygen of the air that of a highly oxidized salt such as potassic chlorate. If we mix this with sulphur, which is very combustible, and rub the two in a mortar we get a series of quite violent detonations. By the use of phosphorus instead of sulphur we have a still more violent explosive, which has to be handled with more care. The products of these reactions are primarily sulphurous and sulphuric and phosphoric oxides.

If we mix this same chlorate of potash with a proper proportion of sugar we have a mixture that the touch of a match will ignite and burn with great splendor. The carbon of the sugar unites with the oxygen of the salt. But it is quite unnecessary to use fire to start it. A drop of oil of vitriol or sulphuric acid will start the reaction, so that the deflagration will take place by decomposing the chlorate. Thus we have a solid set on fire by contact with a liquid.

We have already used phosphorus in an experiment which showed its great affinity for oxygen. By boiling it with a strong solution of potassic hydrate a mixed phosphureted hydrogen is set free which is spontaneously combustible. In practice it is made to bubble through water, and each bubble as it bursts produces a flash and spontaneous combustion. In oxygen the explosive is very violent. This gas has a special interest, as the *ignis fatuus* has been explained by it—whether truthfully or not is not certain. It is one of the most beautiful exhibitions of spontaneous combustion in all chemistry. It is susceptible of many modifications.

As a finale I propose to exhibit to you fire under water. We select as two suitable substances phosphorus and chlorate of potash. These are placed in the bottom of a flask and water poured over them. To start and maintain the combustion we add sulphuric acid. A highly oxidizing compound is formed, and the phosphorus begins oxidizing or burning with a bright light. To make it more beautiful we can add phosphide of calcium, when, in addition to the white glow of the phosphorus, we have an elegant emerald green glow added to our fire under water. It is not a safe experiment by any means, as there is danger of breaking the vessel by the violent heat caused by the reaction. S.

FIREWORK FORMULÆ.

COLORED LIGHTS.

These fires serve to illuminate, hence intensity of light with as little smoke as possible is aimed at. In the preparation of such mixtures the ingredients, which should be perfectly dry, must be reduced *separately*, by grinding in mortar or otherwise to very fine powders, and then thoroughly but carefully mixed together on sheets of paper with the hands or by means of cardboard or horn spatulas.

The mixtures are best packed in capsules or tubes about one inch in diameter and from six to twelve inches long, made of stiff writing paper. Greater regularity in burning is secured by moistening the mixtures with a little whisky and packing them firmly down in the cases by means of a wooden cylinder, then drying. To facilitate ignition a small quantity of a powder composed of mealed powder 16 parts, niter 2, sulphur and charcoal each 1, loosely twisted in thin paper, is inserted in the top. The tubes are best tied to sticks fastened in the ground.

WHITE LIGHTS.

Saltpeter	4 ounces.
Sulphur	1 ounce.
Black sulphide of antimony	1 "

YELLOW LIGHTS.

I.

Chlorate of potash	4 ounces.
Sulphide of antimony	2 "
Sulphur	2 "
Oxalate of soda	1 ounce.

II.

Saltpeter	140 ounces.
Sulphur	45 "
Oxalate of soda	30 "
Lampblack	1 ounce.

GREEN LIGHTS.

I.

Chlorate of baryta	2 ounces.
Nitrate of baryta	3 "
Sulphur	1 ounce.

II.

Chlorate of potash	20 ounces.
Nitrate of baryta	21 "
Sulphur	11 "

RED LIGHTS.

Nitrate of strontia	25 ounces.
Chlorate of potash	15 "
Sulphur	13 "
Black sulphide of antimony	4 "
Mastic	1 ounce.

PINK LIGHTS.

Chlorate of potash	12 ounces.
Saltpeter	5 "
Milk sugar	4 "
Lycopodium	1 ounce.
Oxalate of strontia	1 "

BLUE LIGHTS.

Chlorate of potash	3 ounces.
Sulphur	1 ounce.
Ammonio-sulphate of copper	1

For colored fires, where the mixtures are ignited in shallow pans and maintained by additions of the powders, the compositions are somewhat different.

WHITE FIRE.

Niter	16 ounces.
Mealed powder	4 "
Sulphur	8 "

YELLOW FIRE.

Niter	2 ounces.
Sulphur	4 "
Nitrate of soda	20 "
Lampblack	1 ounce.

RED FIRE.

Niter	5 ounces.
Sulphur	6 "
Nitrate of strontia	20 "
Lampblack	1 ounce.

BLUE FIRE.

Niter	8 ounces.
Sulphur	2 "
Sulphate of copper	4 "

GREEN FIRE.

Niter	24 ounces.
Sulphur	16 "
Nitrate of baryta	48 "
Lampblack	1 ounce.

BENGAL FIRE.

Sulphur	4 ounces.
Mealed powder	4 "
Antimony	2 "
Lampblack	16 "

COLORED STARS FOR ROCKETS.

	White.	Yellow.	Red.	Blue.	Green.	5 points.
Niter	16				—	–
Sulphur	8	1	—	—	2	7
Mealed powder	4	—	—	—	—	10
Charcoal	—	1	–	—	—	—
Nitrate of soda	—	6	—	—	—	–
Chlorate of potash		—	5	8	3	
Nitrate of strontia	—	–	20	—	–	—
Gum dammar	—	—	4	4	—	–
Sulphate of copper	—	—	—	4	—	
Nitrate of baryta	—	–	—		6	—

The materials are separately reduced to fine powders, mixed with the hands, moistened with whisky containing a little gum, moulded into small lumps, and dried. A small quantity of the following composition placed beneath the ball serves to throw it out of the tube:

Niter	3 ounces.
Sulphur	1 ounce.
Mealed powder	8 ounces.
Charcoal	3 "

The tubes are usually made by winding and pasting over a half inch mandrel a dozen turns or more of heavy straw paper. One end of the tube is plugged with clay or clay and plaster, and the other primed with a quick match as described under colored lights.

"Flower pots" and "fountains" are usually made in a similar manner, only the diameter and capacity of the tubes are greater. These tubes should be made of metal.

ROCKET COMPOSITION.

Niter	26 ounces.
Sulphur	5½ "
Charcoal	19 "

The head of the rocket is usually charged with a number of vari-colored stars similar to those used in Roman candles.

Lances are small paper cases, two to four inches in diameter, filled with composition, and are used to mark the outlines of figures. They are attached endwise to light wooden frames or sticks of bamboo and connected by streamers or quick match. The following are some of the compositions used in these:

	White.	Yellow.	Red.	Blue.	Green.
Niter	26	—	16	8	96
Sulphur	9	4	10	2	64
Mealed powder	5	4	7½	—	—
Nitrate of soda	–	16		—	—
Lampblack		2	–	—	8
Nitrate of strontia	—	—	30	—	–
Sulphate of copper		—	—	4	—
Nitrate of baryta	—	–	–	—	192

Sun cases are cases made like rocket tubes and filled with the following composition:

Niter	1 ounce.
Sulphur	1 "
Mealed powder	16 ounces.
Charcoal	4 "

They are attached to wooden frames to give long rays of sparkling light.

COMPOSITIONS FOR PIN-WHEELS, ETC.

	Common.	Brilliant.	Chinese.	White.
Niter	6	[illegible]	1	6
Sulphur	1	1	1	7
Mealed powder	16	16	7	16
Charcoal	6	—	—	—
Steel filings		7	–	–
Cast iron filings	—	–	7	—

Streamers or quick matches, used for communicating fire quickly from one tube to another in display pieces, are composed of the following composition packed in slender continuous paper tubes:

Niter	2 ounces.
Sulphur	1 ounce.
Mealed powder	16 ounces.
Charcoal	4

The mixture for golden rain is composed of:

Niter	16 ounces.
Sulphur	11 "
Mealed powder	4 "
Lampblack	3 "
Flowers of zinc	1 ounce.
Gum arabic	1 "

All the materials used in fireworks must be in the state of fine powders and perfectly dry.