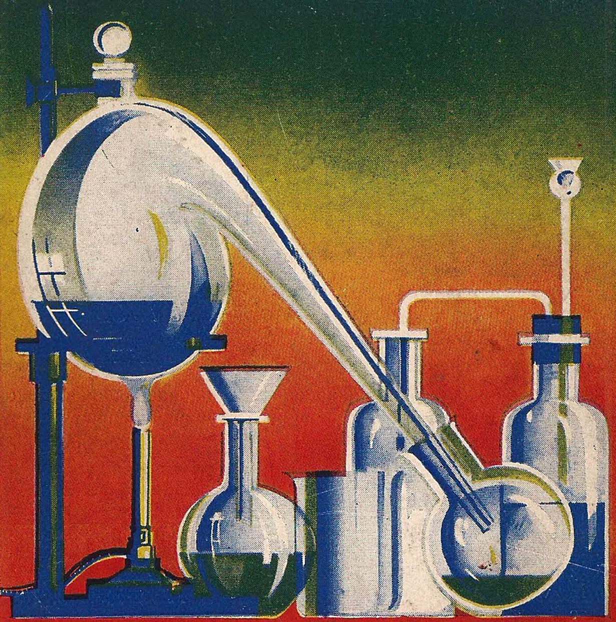
KEMEX

REGISTERED

CHEMICAL EXPERIMENTS



INSTRUCTIONS

FOR

OUTFITS 2 AND 3

MECCANO LIMITED

LIVERPOOL ENGLAND

PRICE - ONE SHILLING

PRODUCT of MECCANO LIMITED LIVERPOOL

KEMEX

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CHEMICAL EXPERIMENTS

Everything in the world around us is built of chemical elements and their compounds. These compounds undergo ceaseless changes, and the study of these changes forms the basis of the wonderful science of chemistry. The Kemex Outfits have been introduced to provide apparatus, materials and instructions for carrying out a series of fascinating experiments, in which the secrets of chemical science are revealed.

The No. 2 Outfit contains the necessary apparatus and chemicals to make a chemical garden that actually grows, to dye wool and silk, to make soap, and to smelt metals from their compounds. With this Outfit 250 interesting experiments can be carried out.

The No. 3 Outfit is planned on a much wider scale, and with it from 350 to 400 experiments can be made. It covers the whole range of the No. 2 Outfit, and has additional apparatus and materials for a further series of experiments showing how chemistry is applied in the home and in the factory.

To get the greatest fun from your Kemex Outfit you should read the *"Meccano Magazine,"* in which special articles link up with the Outfits and describe new and interesting experiments in all branches of chemistry.

Kemex Outfits for Chemical Fun!

1. THE BEGINNINGS OF CHEMISTRY

The earliest chemical experiments date back to prehistoric times, and were concerned with the crude operations by which primitive Man produced metals from their ores. The first metals to be noticed by Man were probably gold, silver and copper, which would attract his attention by reason of their bright colour. He would soon find that gold and silver were of little practical use on account of their softness, but that copper could be made into satisfactory weapons, tools and domestic utensils of many kinds. We do not know how or when the art of smelting copper was discovered, but it has been suggested that it came about in the later stages of what is known as the Stone Age, through the accidental use of copper ore stones in the fire-pits built for cooking purposes. Later came the discovery that copper could be hardened by the addition of tin, thus producing the alloy bronze. Possibly this discovery was made accidentally during the smelting of copper ores along with which were ores containing tin.

It is probable that copper and bronze were in use as far back as 10,000 years ago. Certain Egyptian relics of these metals are believed to date back 7,000 years, and there is evidence that copper tools were made in Ireland some 2,500 years B.C. while in Great Britain bronze is thought to have been in use until 1,000 B.C.

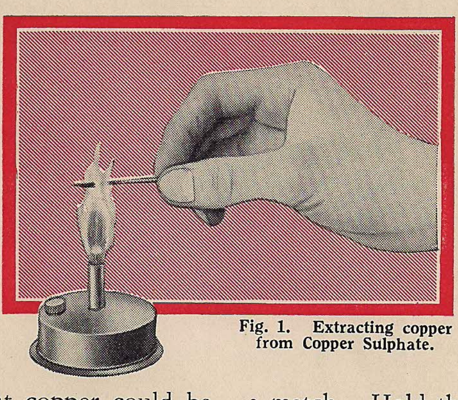

Fig. 1. Extracting copper from Copper Sulphate.

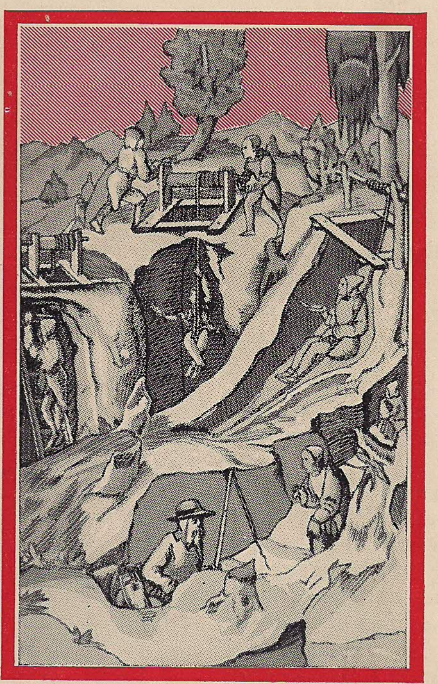

Fig. 2. Mediæval miners descending shafts by means of ladders, ropes and steps cut in the rock.

Experiment in Copper Smelting

In view of the great antiquity of copper smelting it will be interesting to commence our chemical experiments with one of this nature. For this we require a piece of wood about 4 in. in length and about twice the thickness of a match. Hold the end in the flame of the Spirit Lamp (Part No. K22) until the wood begins to char, and then rub it with a large crystal of washing soda. Some of the soda is absorbed, and by repeating the action the end of the stick becomes transformed into a piece of charcoal thoroughly soaked in soda.

Crush a few small crystals of Copper Sulphate (No. K108); place as much as possible of the substance on the charred stick, and hold this in the flame (Fig. 1). The blue powder becomes white, and further colour changes take place as the match continues to burn, the mass becoming black with a reddish tint in places. The soda prevents the wood from burning away quickly, and also acts as a " flux." A flux is a substance used to help in separating metals from the other constituents of their ores; in this case the soda assists the materials on the wood to become liquid.

Stop the heating before the charred end of the wood burns away or falls off, and break the end off into the Evaporating Dish (Part No. K8), half filled with water. With the point of a penknife, or the end of a Glass Rod (Part No. K16), crush the charred end and stir it into the water, and then give the dish a circular movement in order to wash the remains. Add more water and continue the movement, tilting the dish slightly so that the water swirls out over the edge, this process being similar to that used by gold prospectors when washing gold-bearing gravel in a pan. The light charcoal is washed away, the remaining soda is dissolved, and finally reddish-brown particles are left at the bottom of the dish. These particles are flakes of copper smelted out of the Copper Sulphate. Most of the water remaining on the copper may be removed by blotting paper, and gentle warming of the dish completes the drying.

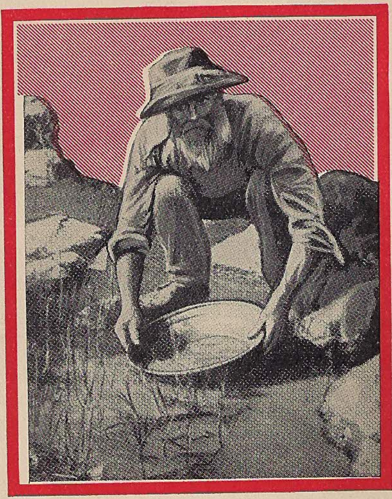

Fig. 3. A prospector at work, panning gold-bearing gravel.

Analytical chemists make use of tests of this kind when they suspect an unknown substance to contain compounds of copper. They complete the test by adding dilute nitric acid drop by drop until the reddish-brown flakes are dissolved. This may be done before removing the last trace of water, and gentle warming may be necessary. A blue solution is formed, and the colour becomes far more intense if a few drops of ammonia are added to the liquid. This striking colour change is characteristic of copper and makes itself evident when only a minute proportion of copper is present.

Miniature Smelting Furnace

The copper-smelting experiment may be carried out more conveniently on the Charcoal Block (Part No. K21). Near one end of this scrape a round depression about $\frac{1}{2}$ in. in diameter and $\frac{1}{4}$ in. deep, and place in it a mixture of Copper Sulphate (No. K108) with an equal amount of washing soda, first crushing the materials together. The charcoal block is then held in the hand while the flame of the spirit lamp is directed on to it by means of the Blowpipe (Part No. K20) as shown in Fig. 4, thus forming a miniature smelting furnace.

The blowpipe is used partly to direct the flame in the direction required and partly to make it hotter by introducing more air. The nozzle should be slightly outside the flame of the lamp, and on the opposite side to that on which the charcoal block is held. It is not

Fig. 4. A miniature smelting furnace formed by scraping a depression on a Charcoal Block.

necessary to blow hard, for if the flame is shielded from draughts it is easily directed on to the mixture of Copper Sulphate and washing soda, which at first should be held in the tip of the side flame produced, and afterwards brought nearer to the lamp.

The mixture in the hollow of the charcoal block melts and finally becomes a dry hard mass, which is scraped out into water in the porcelain dish and washed as already described.

Three Metals that are Magnetic

Other metals that may be extracted similarly from their compounds are iron, nickel,

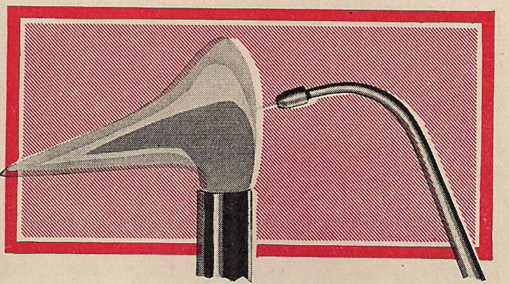

Fig. 5. When metals are being smelted on charcoal the nozzle of the blowpipe should be held just outside the flame.

and cobalt, the experiments being carried out with the Ferrous Ammonium Sulphate (No. K110), Nickel Ammonium Sulphate (No. K120) and Cobalt Chloride (No. K105) contained in the Outfit. These metals are obtained in the form of dark grey powders. There is no difficulty in recognising them, however, for they are magnetic, and in each experiment the dark grains left in the porcelain dish adhere to a magnet dipped into them.

If the experiment is repeated with Lead Nitrate (No. K113) the metal is obtained in the form of a small grey bead, for the temperature is high enough to melt the lead formed. This bead marks paper. In addition, a yellow stain forms on the charcoal block on the side furthest from the blowpipe. This is due to the burning of some of the lead, and it consists of a compound known as litharge, or lead oxide. How it is formed will be explained later.

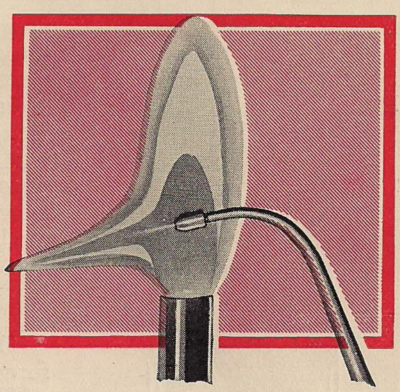

Fig. 6. Higher temperatures suitable for burning Zinc are obtained when the nozzle of the blowpipe is placed inside the flame.

An interesting experiment may be made with the Granulated Zinc (No. K134) included in the Outfit. Place a few small pieces in a hole scraped in the charcoal block, and heat these strongly with the tip of the blowpipe flame. The Zinc burns and is changed into a powder, part of which spreads over the surface of the block. This powder has the peculiar property of being yellow when hot and white when cold, and the colour change may be brought about repeatedly by alternately heating and cooling.

Since Zinc burns so readily when heated in the blowpipe flame, it cannot be obtained by heating its compounds with soda on a charcoal block. These compounds give zinc oxide as a powdery stain that is at first yellow and becomes white on cooling, and this is as useful a guide to the analyst as the production of the metal itself would be.

The Iron and Steel Industry

Wood was burned in the early furnaces in which metals were smelted, and this was the source of the charcoal required to bring about the reduction of the ore to the metal. When larger furnaces came into use, air was blown in through tubes in order to produce higher temperatures, exactly as in our experiments with the blowpipe. To this day the native ironworkers of Central Africa feed their furnaces with wood and iron ore, and fan the flames by means of bellows that drive air through bamboo tubing. The temperature