

as shown in Fig. 119. The greyish powder that remains as an ash after it is burned is magnesium oxide (MgO). Mix a teaspoonful of powdered magnesium (Mg) with $1\frac{1}{2}$ teaspoonfuls of potassium chlorate ($KClO_3$) and you will have a flash-light powder.

Aluminum, the Lightest Common Metal. Aluminum (Al) gets its name from *alumen*, which means *clay*. After oxygen (O) and silicon (Si), aluminum (Al) is the most plentiful element we have, and all kinds of clays and micas contain it. Davy discovered the metal in 1808, and he first obtained it from aluminum sulphate ($Al_2(SO_4)_3 \cdot H_2O$), or *alum*, which is its common name, and this is made by treating pure clay with sulphuric acid (H_2SO_4). The metal is now made on a large scale by passing an electric current through aluminum oxide (Al_2O_3), which is dissolved in melted cryolite ($NaF + AlF_3$), a mineral of Greenland, that is formed of sodium fluoride (NaF) and aluminum fluoride (AlF_3). Aluminum (Al) is a whitish metal, the color of which lies between that of tin (Sn) and zinc (Zn), it is light, strong, and tough, weighs about $2\frac{1}{2}$ times as much as water (H_2O), and is both malleable and ductile. It is very resonant, and when a rod of it fixed at one end is struck with a piece of wood it gives a swelling musical sound.

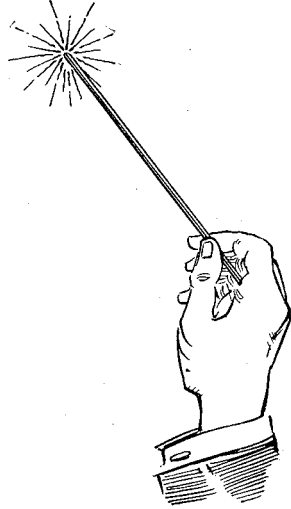


FIG. 119.—Magnesium Burning in Air.

Aluminum (*Al*) is largely used instead of copper (*Cu*) for electric transmission lines, for making utensils, in making pure steel, and for thermit, a high-temperature compound. The steel-makers put 1 part of aluminum (*Al*) in with 1000 parts of steel, and when the metals are melted the gases combine with the aluminum (*Al*), so that when the steel is cast it is free from blow-holes. The chief compounds of aluminum are aluminum oxide (Al_2O_3); aluminum hydroxide (AlO_3H_3); aluminum chloride ($AlCl_3$); aluminum silicate ($AlKSi_3O_8$), which when mixed with water (H_2O) is clay; and the alums, which are compounds formed of potassium (*K*) and aluminum (*Al*), called potassium alum ($AlK(SO_4)_2 + 12H_2O$); and sodium (*Na*) and aluminum (*Al*), called sodium alum ($AlNa(SO_4)_2 + 12H_2O$). When aluminum (*Al*) burns, it produces a very high temperature — about 3000 degrees Fahrenheit — and this will melt most metals. This fact is taken advantage of in thermit, which is the trade-name for a process. The following experiment shows how it works.

An Experiment with Aluminum. Mix a tablespoonful of powdered aluminum (*Al*) and a like amount of iron oxide (Fe_2O_3) in a small sand crucible; now push a piece of magnesium (*Mg*) wire down into the mixture and light it, as shown in Fig. 120, and the aluminum will take fire. The burning aluminum (*Al*) melts the iron (*Fe*) in the iron oxide (Fe_2O_3), and when the mass is cold you will find a button of pure iron (*Fe*) in the bottom of the crucible. This experiment must be done out-of-doors.

How the Experiment Works. The reason magnesium (*Mg*) wire is used to ignite the aluminum (*Al*) powder is

because it takes a hotter flame to fire the latter than a burning splint of wood can produce. The aluminum (*Al*) gets oxygen (*O*) in which to burn from the iron oxide (Fe_2O_3), and these combine to form aluminum oxide (Al_2O_3), while pure iron (*Fe*) remains in the bottom of the crucible. The reaction is this:

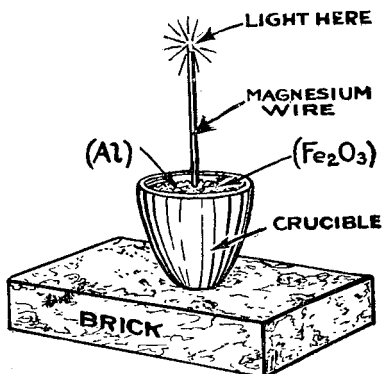
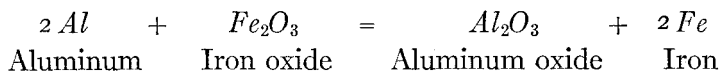


FIG. 120.—Making Iron by the Themit Process.

Manganese, the Hardening Metal. The Latin word for magnet is *magnes* and manganese (*Mn*), was named after it, not only because the ore in which it was found looked something like the natural magnet, or *lodestone*, as it is called, but also because it is slightly magnetic. This metal was discovered by Gahn in 1775 in an ore that Scheele named *manganese*.

The metal does not occur free in nature but is found in large quantities in a mineral called *pyrolusite*, which is

crude black manganese dioxide (MnO_2). It can be extracted by mixing this mineral and aluminum (Al), both in powdered form, in a crucible and igniting them, as explained under the heading of an "Experiment with Aluminum." It is a heavy, hard, and brittle metal of a grey color.

Compounds of Manganese. When manganese (Mn) combines with oxygen (O) it forms several compounds, the most common of which are manganese oxide (MnO) and manganese dioxide (MnO_2). It also forms several compounds when it combines with potassium (K), and among these are potassium manganate (K_2MnO_4) and potassium permanganate ($KMnO_4$). When mixed with steel, it forms an alloy of exceeding hardness, and this will be described farther along.

An Experiment with Manganese. Dissolve $\frac{1}{2}$ teaspoonful of ferrous sulphate ($FeSO_4$), that is, *copperas*, or *green vitriol*, in a test tube half full of water (H_2O) and add a couple of drops of sulphuric acid (H_2SO_4) to it. This done, dissolve $\frac{1}{2}$ teaspoonful of potassium permanganate ($KMnO_4$) in a test tube half full of water (H_2O) and you will have a solution of a deep purplish-red color. Now with your pipette add a drop at a time of the former to the latter, and the color will disappear.

Zinc, the Electric Metal. While zinc (Zn) is the negative element that is used in all primary battery cells for generating a current of electricity, it finds a wider application in the building industries, since it does not rust like iron (Fe), and in making brass and other alloys. It is found in various ores, and among these are *sphalerite*, or *zinc-blende*, (from the German *blenden*, meaning *to dazzle*),

which is zinc sulphide (ZnS), and also in *smithsonite* ($ZnCO_3$).

To separate the zinc from these compounds, in the first case, the sphalerite is crushed and then roasted, causing the sulphur (S) to pass off, and in the second case the smithsonite is powdered and mixed with coal and then heated,

which drives off the (CO_2).

The pure metal is of a bluish-white color and can be easily rolled into sheets when it is heated to 150 degrees Fahrenheit, but it is brittle when heated either above or below this point. Zinc oxide (ZnO) or *zinc white*, as it is commonly called by painters, zinc sulphate ($ZnSO_4 + H_2O$), or *white vitriol*, to give it its common name, and zinc chloride ($ZnCl_2$) are the chief compounds formed of zinc (Zn).

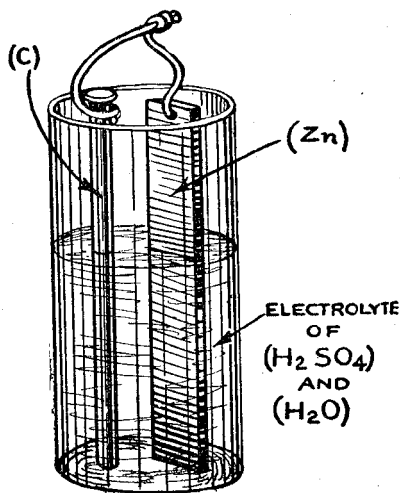


FIG. 121.—A Simple Electric Cell.

An Experiment with Zinc. Make a solution, called an *electrolyte*, by adding 1 fluid ounce of sulphuric acid (H_2SO_4) to a beaker three-fourths full of water (H_2O); put in a strip of zinc (Zn) and a rod of carbon (C), to one end of each of which you have fastened a copper wire, and you will have a simple battery cell. If now you will wind one of the wires around a nail and connect the end of it with the

end of the other battery wire, as shown in Fig. 121, the nail will become a magnet, and when this is the case you will know that a current is flowing in the wire.

Chromium, the Color-Making Metal. We get the word *color* from the Greek root *chroma*, and because this metal gives variously colored compounds it is called chromium (*Cr*). While it is not a very well known metal, still it was discovered over a hundred years ago. It is found in a mineral called *chromite*, which is ferrous chromite ($Fe(CrO_2)_2$), and in *crocoisite*, which is lead chromate ($PbCrO_4$). The metal is easily extracted from this mineral by the *thermit process*. (See Aluminum). Like manganese (*Mn*), chromium (*Cr*) is used for hardening steel (*Fe*), and alloys containing it will be described presently. The chief compounds of chromium (*Cr*) are potassium chromate (K_2CrO_4) and potassium dichromate ($K_2Cr_2O_7$).

Experiments with Chromium. Potassium dichromate ($K_2Cr_2O_7$) is the most common compound of chromium (*Cr*). It is made by dissolving chromium (*Cr*) in nitric acid (HNO_3). Heat a beaker half full of water (H_2O) until it boils, then remove it from the flame and stir in a teaspoonful of potassium dichromate ($K_2Cr_2O_7$); when it is cold, add 1 ounce of sulphuric acid (H_2SO_4) and stir the solution well with a glass rod. This done, pour it into your porcelain evaporating-dish and cover it with a board, let it stand for several hours, and dark red crystals will be formed in it. These are chromic acid (H_2CrO_4).

Pour off the red solution, then lay the crystals on a piece of flower pot, or other unglazed pottery, and cover them with a glass jar so that the air can not get to them, and in a

couple of days they will be quite dry. Put a teaspoonful of dry chromic acid (H_2CrO_4) in your porcelain evaporating-dish and add a few drops of 95 per cent ethyl alcohol (C_2H_5OH), which is grain alcohol, and the latter will immediately burst into flames, as shown in Fig. 122.

Iron, the Most Useful Metal. Iron (Fe) is such a common metal that it needs but little description. It is seldom

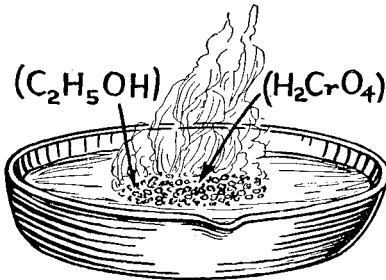


FIG. 122—Chromium Crystals and Alcohol
Bursting into Flames.

found in pure state but it is very plentiful in the ores of *magnetite* (FeO_4), *hematite* (Fe_2O_3), *siderite* ($FeCO_3$), and *pyrites* (FeS_2). To get the iron (Fe) out of these ores, they are mixed with coke (C) in a blast furnace and the coke (C) is then burned in a blast of air. The oxide or sulphur (S) in them then combines with the gases of the air, and the iron (Fe) melts and flows to the bottom of the furnace.

When other metals and substances are mixed with iron (Fe) it takes on new properties, and these alloys will be described farther on. There are numerous iron (Fe) chemical compounds, and among them are ferrous carbonate ($FeCO_3$), ferrous sulphate ($FeSO_4$), and ferrous sulphide (FeS); also ferric chloride ($FeCl_3$) and ferric oxide (Fe_2O_3), which latter is *iron rust*.

An Experiment with Iron. To make a little ferrous sulphide (FeS), dissolve $\frac{1}{2}$ teaspoonful of ferric ammonium

sulphate ($(NH_4)_2SO_4 + Fe_2(SO_4)_3 + 24H_2O$) in a test tube half full of water (H_2O). Now put $\frac{1}{2}$ teaspoonful of sulphur (S) and a bit of paraffin wax the size of a pea into another test tube; fit a cork that has a bent delivery tube in it into the mouth of the latter, and place the end of this

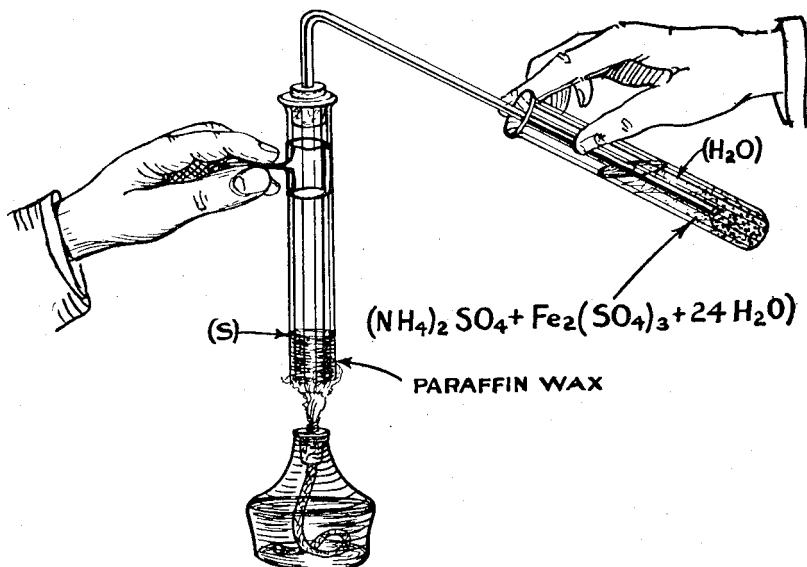


FIG. 123.—Making Ferric Sulphide.

in the test tube containing the ferric ammonium sulphate (see formula above) solution, as shown in Fig. 123. Finally, melt the paraffin and sulphur (S) over the flame of your lamp or burner, and let the hydrogen sulphide (H_2S), which is a gas and smells like rotten eggs, pass through it for 3 or 4 minutes. Soon there will be a black precipitate formed, and this is ferrous sulphide (FeS).

Nickel, the Non-Rusting Metal. Nickel (*Ni*) is a white metal with a slightly yellowish tinge; it is very hard, has a high melting point, and takes a fine polish. It is never found free except in meteorites, but it is found in combination with arsenic (*As*), and is also obtained from a mineral called pentlandite ($(Ni, Cu, Fe)S$). To extract the nickel (*Ni*) from its ore, the latter is roasted, which drives off the sulphur (*S*), and then smelted to separate it from the copper (*Cu*) and the iron (*Fe*). As it rusts very slowly in moist air and because it takes a beautiful silvery polish, it is largely used in electroplating iron (*Fe*) and steel (*Fe, C*) articles of all kinds.

There are many compounds of this metal, including the chloride ($NiCl_2, H_2O$), the sulphate ($NiSO_4, H_2O$), and the oxide (Ni_2O_3). Nickel ammonium sulphate ($(NH_4)_2SO_4, NiSO_4, H_2O$) is used for making nickel sulphide (*NiS*), nickel carbonate ($NiCO_3$), nickel tetraborate ($NiB_4(OH)_3$), and other nickel compounds.

How to Nickel-Plate a Coin. To electroplate a copper coin with nickel (*Ni*), dissolve a teaspoonful of nickel ammonium sulphate (see formula above) in a test tube two-thirds full of boiling water (H_2O). Now wrap a thin copper wire around the coin and dip it in a solution made by dissolving $\frac{1}{2}$ teaspoonful of sodium hydroxide (*NaOH*), that is, caustic soda, in a beaker half full of boiling water (H_2O).

This hot solution will dissolve all the grease and oxide and leave the coin perfectly clean. This done, put the coin into a smaller beaker and pour over it the nickel solution, which you have allowed to get cold. Finally, put

a strip of clean zinc (Zn) into the solution and let it stand for 5 or 10 minutes. The nickel (Ni) will be deposited upon the coin and the latter will be *nickel-plated*.

Tin, the Soft, Malleable Metal. "Tin" is an old Anglo-Saxon word, and *stannum* is its Latin name, so from this we get the symbol for it (Sn). This metal was one of the earliest known, as the fact that it has been found in Egyptian tombs goes to show. In the days of the early Greeks tin (Sn) was found only in the British Isles and, hence, these were called the *Tin Islands*. It is a soft, white metal and so malleable that it can be rolled into exceedingly thin sheets which we call *tin-foil*.

The chief ore it is contained in is *cassiterite* (SnO_2), or *tin-stone*, as it is commonly called, and this is found in the Straits Settlement, Bolivia, England, and Nigeria. The metal is extracted from its ore by pulverizing the latter, washing it, and then roasting it to drive out the impurities, after which it is smelted with coke (C). The chemical compounds formed of tin (Sn) include the chlorides, the oxides, stannic acid (H_2SnO_3), etc.

An Experiment with Tin. This is an experiment in which stannous chloride ($SnCl_2$) is used to separate the metallic mercury (Hg) that is in a mercuric chloride ($HgCl_2$) solution. Make a little stannous chloride ($SnCl_2$) solution by dissolving $\frac{1}{2}$ teaspoonful of granulated tin (Sn) in a test tube half full of hydrochloric acid (HCl). Next dissolve $\frac{1}{2}$ teaspoonful of mercuric chloride ($HgCl_2$), the common name of which is *corrosive sublimate*, and which you want to handle very carefully, as it is *poisonous*, in a test tube half full of water (H_2O). Now add a few drops of the tin