solution, and the metallic mercury (Hg) will appear as a grey powder and fall to the bottom of the test tube.

Lead, the Heavy Metal. Lead (Pb) like tin (Sn) is one of the oldest known metals. It gets its symbol from *plumbum*, which is its Latin name, and it was widely used by the ancient Romans for weights, utensils, and water pipes. It is found free in small quantities, but the greater part of it is extracted from a mineral called *galena* (PbS), which is *lead sulphide* (PbS). To get rid of the sulphur (S), the ore is roasted, and this drives it off. As lead (Pb) does not rust, it is largely used for plumbing, and because it does not react with hydrochloric acid (HCl) or dilute sulphuric acid (H_2SO_4), it is used for making vessels for holding these acids. It is also the metal that is used for making storage battery plates.

In combination with other elements it forms lead oxides, one of which is *minium or red lead* (Pb_3O_4), and lead carbonate ($PbCO_3$), which is *white lead*, both of which are used for making paint; lead nitrate ($Pb(NO_3)_2$)[1], lead acetate ($Pb(CO_2CH_3)_2H_2O$), that is, *sugar of lead*, so-called because it has a sweet taste, lead sulphate ($PbSO_4$), and lead sulphide (PbS).

How to Make a Lead-Tree. You can make the pretty vegetable-like growth called a *lead-tree*, or Arbor Saturni, by precipitating the lead (Pb) from one of its salts by means of zinc (Zn). Dissolve 1 ounce of powdered lead nitrate ($Pb(NO_3)_2$) in a pint bottle of water (H_2O). Now tie a bit of granulated zinc (Zn) to one end of a thread, then fix the other end to a cork and suspend it in the lead solution

[1] This salt is made by treating lead (Pb) with nitric acid (HNO_3).

so that it will be in the center of the jar. In the course of several hours the lead (*Pb*) will be slowly deposited in the form of a tree, as shown in Fig. 124. While this action is going on, the zinc (*Zn*) will pass into the solution and so exchanges places with the lead, thus:

$$\underset{\text{Zinc}}{Zn} + \underset{\text{Lead nitrate}}{Pb(NO_3)_2} = \underset{\text{Zinc nitrate}}{Zn(NO_3)_2} + \underset{\text{Lead}}{Pb} \downarrow$$

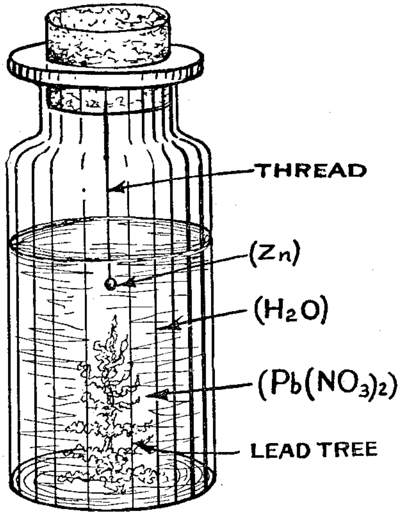

FIG. 124.—How to Make a Lead-Tree.

Copper, the Prehistoric Metal. After the *stone age* came the *copper age*, and the reason that copper (*Cu*) was the first metal to be used by the pre-historic races is because it is found free in nature, and, what was also fortunate for them, it was soft enough to be welded into shape while it was cold. In the early Roman days it was brought from an island in the Mediterranean called *Cyprus*, and they named this metal *Cyprium aes*, which means *Cyprium brass*. Then as time went on it was called *cuprium*, then it degenerated into *cuper*, and we call it by the good old Anglo-Saxon name of copper (*Cu*). It is not only found free in considerable quantities but it occurs plentifully in many kinds of ores.

It is, as you probably know, a tough, reddish metal, and as it does not rust to any great extent and wears well it is widely used by all nations for making coins of the smallest value. For the same reason, it is also used for making shells for rifles and guns, for cooking utensils, and as it is the next-best conductor of electricity,[1] it is especially useful for electric wires and apparatus.

With other elements it forms various compounds, and these belong to two distinct series, the first of which is called *cuprous compounds* and the second *cupric compounds.* These compounds include the chlorides, bromides, oxides, hydroxides, carbonates, cyanides, acetates, sulphates, and sulphides. Cupric hydroxide ($Cu(OH)_2$) is used with ammonium hydroxide (NH_4OH) to form a compound that has this formula ($Cu(NH_3)_4(OH)_2$). Cellulose ($C_6H_{10}O_5$) in the form of paper or cotton will dissolve in this solution, and when this is forced through minute holes in steel plates, threads of *artificial silk* are formed.

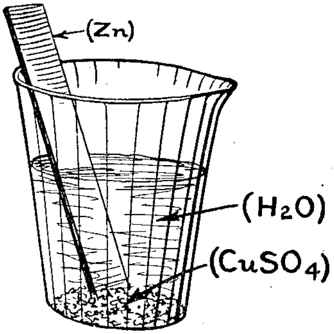

FIG. 125. How to Electroplate with Copper.

An Experiment with Copper. Put 1 ounce of cupric sulphate ($CuSO_4$), or *copper sulphate*, *blue vitriol*, or *bluestone*, as it is variously called, in a beaker of warm water (H_2O), stir it well, and set a strip of zinc (*Zn*) in it, as shown in Fig. 125. Very soon the zinc (*Zn*) will be plated with copper

[1] Silver (*Ag*) is the best conductor.

(Cu), and some of the zinc (Zn) will take the place of the copper (Cu) in the solution, and it becomes zinc sulphate ($ZnSO_4$) thus:

Zn	+	$CuSO_4$	=	$ZnSO_4$	+	Cu
Zinc		Copper sulphate		Zinc sulphate		Copper

Bismuth, the Easily Fusible Metal. Although bismuth (Bi) is found free in nature, still it is not a commonly known metal. Just why it is called bismuth (Bi) seems not to be known, and Agricola, who discovered it in 1529 called it *wiessmatte*, which means a *blooming meadow*, because of the variegated colors it shows when it is tarnished. It is found in ores formed of bismuth trioxide (Bi_2O_3), and bismuth trisulphide (Bi_2S_3), or *bismuth glance* as it is called. Bismuth (Bi) is a pinkish-colored metal, very brittle, melts at a low temperature, and has the peculiar property of expanding when it cools.

Bismuth (Bi) does not tarnish when exposed to air, and when heated to redness it burns and forms bismuth trioxide (Bi_2O_3). It united with fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and nitrogen (N). Bismuth nitrate ($Bi(NO_3)_3, H_2O$) is the best known and most important salt of this metal, and this forms the well-known cosmetic so largely sold for beautifying ladies' complexions under the name of *pearl white*.

Experiments with Bismuth. Drop some finely powdered bismuth (Bi) into a jar of chlorine (Cl) and it will take fire.

Put a bit of bismuth (Bi) on a piece of charcoal (C) and heat it. It will then form a yellow film, which is bismuth trioxide (Bi_2O_3).

Antimony, the Metal that Expands. This metal was discovered by Valentino in the latter part of the 15th century and it gets its name from two Greek words which mean *against* and a *monk*, because some monks were poisoned by medicine made from it. Antimony (*Sb*) is found free in nature, but the chief supply comes from an ore called *stibnite* — hence the symbol (*Sb*),— which is black antimony sulphide (Sb_2S_3); and this ore is roasted in the air to drive out the sulphur (*S*).

Antimony (*Sb*) has a silver-white color and, like bismuth (*Bi*), it is brittle, melts at a low temperature, and expands on cooling. For the last reason, it is mixed with lead (*Pb*), which contracts, for making type, and very sharp edges result. The well-known remedy called *tartar emetic* is a chemical compound formed of potassium (*K*), antimony trioxide (Sb_2O_3), tartaric acid ($C_4H_6O_6$), and water (H_2O).

There are quite a number of antimony compounds, and these include stibine (SbH_3), which is *antimoniuretted hydrogen*, made by the action of zinc (*Zn*) and hydrochloric acid (*HCl*) on some compound of antimony (*Sb*) which is soluble. Then there are the halides, oxides, and the sulphides, antimony salts, such as antimony nitrate ($SbNO_3$) and antimony sulphate ($Sb(SO_4)_3$), antimonic acid (H_3SbO_4), and the sulphantimonites and sulphantimonates.

Experiments with Antimony. Heat a bit of antimony (*Sb*) by laying it on a piece of charcoal (*C*), and bringing the flame of your alcohol lamp or Bunsen burner to bear on it with a blowpipe, as shown in Fig. 126, and the melted bead of metal will show a network formed of antimony trioxide (Sb_2O_3). Now melt a small amount of antimony (*Sb*) in a crucible, grip the crucible with a pair of tongs and, holding it out at arm's length, pour the antimony upon the ground. It will form smoking globules that rebound and rush up like lava thrown out of a volcano.

Mercury, the Liquid Metal. This strange metal which

FIG. 126.—How to Heat Antimony with a Blow-Pipe.

is a liquid at ordinary temperatures was a great favorite of the old alchemists, for other metals except iron (*Fe*) and platinum (*Pt*) will dissolve in it, and in this way *amalgams* are formed. The Latin name for mercury (*Hg*) is *hydrargyram*, and this is the source of its symbol (*Hg*).

It is a bright, silvery-white metal, and it is found both free in nature, as little drops, and in combination with sulphur (S) in mercuric sulphide (HgS), or *cinnabar*, as it is called. To get the mercury (Hg) out of the latter, the ore is roasted, causing the oxygen (O) of the air to combine with the sulphur (S) in it. Sulphur dioxide (SO_2) is formed, and the mercury (Hg), which passes off as a vapor, is caught, and then condensed again, thus:

HgS	+	O_2	=	Hg	+	SO_2
Mercuric sulphide		Oxygen		Metallic mercury		Sulphur dioxide

Of the compounds of mercury (Hg), the most common ones are mercuric oxide (HgO); mercurous chloride ($HgCl$), or *calomel*, as it is called in medicine; mercuric chloride ($HgCl_2$), which is corrosive sublimate; mercurous iodide (HgI), mercuric iodide(HgI_2), and mercuric sulphide (HgS), which brings us back to the ore we started from.

An Experiment with Mercury. Clean a small rod of zinc (Zn) with a little dilute sulphuric acid (H_2SO_4), and then roll it around in a few drops of mercury (Hg), and it will be coated all over with the latter, or amalgamated, as it is called. Zinc battery plates are *amalgamated*, and the layer of mercury (Hg) prevents a *local action* from being set up between the impure particles in the zinc (Zn) and the atoms of the latter, which lessens the current output of the battery.

Silver, the Queen of Metals. The Latin name for silver (Ag) is *argentum*, and since S is the symbol for sulphur, Ag is used as the symbol for silver. It is the least valuable of the precious metals, but owing to its many good properties it is widely used in the arts. It is found free in nature and also in combination with sulphur (S) as silver sulphide (AgS), and this, in turn, is often found in galenite (PbS). It is extracted from these ores by Parke's process.[1]

Silver (Ag) does not tarnish in air, but the fumes of sulphur (S) coat it with a thin film. It is the best of all known conductors of electricity, but as it is much more costly than copper (Cu), and the latter is nearly as good, it is not used for this purpose. Finally, it is the favorite metal for coinage, and much of it is made into silverware. It is also largely used for electroplating and in photography.

The chief compounds that are formed with it are silver chloride ($AgCl$), silver nitrate ($AgNO_3$), silver bromide ($AgBr$), and silver iodide (AgI). There are other salts of silver (Ag) and many complex compounds of it, but these need not be gone into here.

An Experiment with Silver. Since silver (Ag) is too soft to be used alone for coins, it is mixed, or alloyed, as it is called with a little copper (Cu). Hold a silver dime in a gas flame with your pair of forceps until it is quite hot, then put a couple of drops of water (H_2O) on it and let it cool, and there will be a black spot on it. This spot is cupric oxide (CuO), that is, *copper oxide*, and it is caused by the copper (Cu) in the coin combining with the oxygen (O) of the water (H_2O).

Gold, the King of Metals. Gold (Au), that wonderful yellow metal, was the warp, and the struggles of those who sought it were the woof of which some of the most thrilling scenes in the world's history were woven. Long ages ago

[1] A description of this process will be found in Alex. Smith's "Inorganic Chemistry," published by the Century Co., New York.

it was called by the Latin name of *aurum*, and it is from this that we get the symbol, *Au*.

Gold (*Au*) is usually found free in nature — very often in quartz sand and also encased in quartz. It is separated from the former by washing and from the latter by mercury (*Hg*), which forms an amalgam with it; when this is gently heated, the mercury (*Hg*) passes off as a vapor and the gold (*Au*) remains behind. Gold (*Au*) is a soft metal and so malleable that it can be beaten into leaves of such exceeding thinness that it takes a quarter of a million of them to make a pile 1 inch high.

Gold (*Au*) will not set hydrogen (*H*) free from acids, it is not affected by air, and it will not dissolve in any kind of acid except *aqua regia*, a mixture of hydrochloric acid (*HCl*) and nitric acid (HNO_3). It has always been used for jewelry and for coinage, and to make it hard enough for these purposes it must be *alloyed* with a little copper (*Cu*). It is also used for making gold leaf, for gold plating, and formerly to a considerable extent in photography.

Gold (*Au*) combines directly with chlorine (*Cl*), and when dissolved in aqua regia it gives chlorauric acid ($HAuCl_4.4H_2O$). Auric chloride ($AuCl_3$), or *gold chloride*, which was once much used for toning photographic prints, is made by heating chlorauric acid ($HAuCl_4.4H_2O$); the latter gives up its hydrogen chloride (*HCl*) and leaves the red crystals of auric chloride ($AuCl_3$) behind. Gold (*Au*) also combines with bromine (*Br*), and there are several other compounds of it.

An Experiment with Gold. Get a sheet of gold leaf of a sign-painter, or a painter's supply house, and hold it up before a white light. You will observe that the light passes through the gold leaf quite easily.

Platinum, the Regal Metal. The word platinum (*Pt*) comes from the Spanish *platinå*, which means silver (*Ag*), and since these metals bear a decided resemblance to each other in the matter of color, it is quite likely that the regal metal was taken for the queen of metals when it was first found. Platinum (*Pt*) is chiefly found free in the gravel of river beds, and most of it comes from the Ural Mountains. It is quite hard, cannot be melted in the flame of a Bunsen burner, but does so in an oxyhydrogen flame or the electric arc.

Platinum (*Pt*) is a very heavy metal, a piece of it weighing nearly three times as much as a piece of iron (*Fe*), and twice as much as a piece of lead (*Pb*) of the same size. It has a very small chemical activity, by which is meant that it resists the action of most substances, and hence it is largely used in making crucibles, evaporating-dishes, and other apparatus required by the chemist.

One of the chief compounds made of platinum (*Pt*) is platinic chloride ($PtCl_4$), and this is done by dissolving the metal in *aqua regia* and then evaporating the solution, causing the acids to pass off.

How Alloys are Made. The name alloy, is given to two or more different metals when they are melted together. While an alloy thus produced is simply a *mixture* of the metals, it possesses properties entirely different from either or all of them.

Alloys of Magnesium and Aluminum. Aluminum (*Al*) is a metal that is hard to work in a lathe and also to polish,