CHAPTER VIII.

WHAT BASES AND SALTS ARE.

In the previous chapter I told you about *acids*, and in this chapter I shall tell you about *bases* and *salts*. Now though these three compounds are entirely unlike each other, still they are very closely related, for *salts are formed by the action of acids on bases*. While it is easy to tell an acid if it is a fairly strong one by testing it with litmus paper, some acids are so weak that they have no effect whatever on it, but the fact that they form salts when they are brought into contact with bases shows that they are really acids.

While you may never have heard of bases before, you have often seen them, for they go under the familiar names of lime ($Ca(OH)_2$), soda lye ($NaOH$), and potash lye (KOH), and these compounds all go under the general heading of *alkalis*. These bases are formed by dissolving metals of various kinds in water (H_2O), and the compounds which result easily cut grease and have a very corrosive, or *caustic*, action on the skin and flesh. It is just possible that you did not know there were any metals which would dissolve in water (H_2O); well, there are a few, though these are not at all common in their pure state and, hence, they are seldom seen outside of the laboratory, but they are quite plentiful in the various compounds that nature provides, as you will presently see. These metals are calcium (Ca),

sodium (Na), potassium (K), and some others, all of which I shall tell you about in the next chapter.

Finally, a salt is a compound that is formed when an acid and a base combine and during the reaction of which all, or a part, of the hydrogen (H) of the acid is replaced by the atoms of the metal; in this case the hydrogen (H) is set free just as it is when zinc (Zn) or iron (Fe) is dissolved in an acid.

What the Bases Are. As I mentioned above, the three bases that are the most used and, hence, the best known, are caustic lime ($Ca(OH)_2$), caustic soda ($NaOH$), and caustic potash (KOH). Now, as you know, water (H_2O) consists of hydrogen (H) and oxygen (O); calcium (Ca) is a very light metal, and when it is thrown into water (H_2O) it dissolves; in doing so it sets some of the hydrogen (H) of the water (H_2O) free and takes its place, and the compound thus formed is called calcium hydroxide ($Ca(OH)_2$), or caustic lime, or slaked lime, which are its common names.

The word hydroxide means, simply, that the base contains both hydrogen (H) and oxygen (O). Thus calcium hydroxide has the formula ($Ca(OH)_2$), sodium hydroxide has the formula ($NaOH$), and potassium hydroxide the formula (KOH). The most common properties of bases are their alkaline taste and their power to *neutralize* acids, that is, to take away their acid qualities.

What the Salts Are. Now when you bring an acid and a base together, the first result of the action they set up is the formation of water (H_2O), and the second is the formation of a salt. Thus when you make hydrochloric acid

(HCl) act on sodium hydroxide ($NaOH$), water (H_2O) is formed and also a salt that is called sodium chloride ($NaCl$), which is common table salt. Sodium nitrate ($NaNO_3$) is formed by the action of nitric acid (HNO_3) on sodium hydroxide ($NaOH$), potassium chloride (KCl) is formed by the action of hydrochloric acid (HCl) on potassium hydroxide (KOH), potassium nitrate (KNO_3) by the action of nitric acid (HNO_3) on potassium hydroxide (KOH), and so on.

How to Make Calcium Hydroxide. Calcium hydroxide ($Ca(OH)_2$) in spite of its big name is simply *slaked lime.* To make it, you start with calcium oxide (CaO), which is *quicklime*, and this is made by burning limestone ($CaCO_3$) in a kiln. Calcium oxide (CaO) or quicklime, is a very white, porous solid, and when water (H_2O) is poured on it, they unite and a great deal of heat is evolved, and this converts some of the water (H_2O) into steam.

To make a little calcium hydroxide ($Ca(OH)_2$), get some pieces of fresh quicklime, that is calcium oxide (CaO), put them in an earthen bowl and pour a little hot water (H_2O) over them. They will then unite, and the powder which is left is calcium hydroxide ($Ca(OH)_2$), or slaked lime.

How the Experiment Works. The action can be shown thus:

CaO	+	H_2O	=	$Ca(OH)_2$
Calcium oxide		Water		Calcium hydroxide

How to Make Sodium Hydroxide. Sodium hydroxide ($NaOH$) is *caustic soda*, or *soda lye*, and it is largely used for making soaps from fats. To make sodium hydroxide ($NaOH$), half fill a test tube with water (H_2O), and then dis-

solve in it ½ teaspoonful of sodium carbonate (Na_2CO_3), the common name of which is *sal soda* and which is often called just *soda* for short, and the same amount of calcium oxide (CaO).

Now hold the test tube over the flame of your lamp or burner for two or three minutes and then put it in the test-tube rack and let it stay there until the solution is perfectly clear. To show that it is an alkali, dip the end of a strip of red litmus paper into it and it will turn blue.

How the Experiment Works. The action that takes place when it is formed is this: the calcium oxide (CaO) and the sodium carbonate (Na_2CO_3) together with the water (H_2O) form calcium carbonate ($CaCO_3$), which settles to the bottom of the tube and sodium hydroxide ($NaOH$) is the clear liquid above it, or:

CaO	$+ Na_2CO_3 +$	H_2O	$=$	$CaCO_3$	$+$	$NaOH$
Calcium oxide	Sodium carbonate	Water		Calcium carbonate		Sodium hydroxide

How to Make Potassium Hydroxide. This hydroxide (KOH), the common names of which are *caustic potash*, *potash lye*, and just *lye* for short, can be used for making hard soap, but as it is more costly than sodium hydroxide ($NaOH$) it is not used by commercial soap-makers. It is, however, a familiar substance in the household and is used for cleaning purposes and making soft soap.

To make potassium hydroxide (KOH), you start with potassium carbonate (K_2CO_3) or potash, as it is called, or you can use wood ashes, which contain considerable amounts of it, and, indeed, this used to be the only source from which potash, or lye, was obtained. Dissolve 1 tablespoonful of

potassium carbonate (K_2CO_3) or 2 tablespoonfuls of wood ashes in a beaker half full of water (H_2O), and heat this over the flame of your lamp until the solution begins to boil.

Now put in 1 teaspoonful of calcium hydroxide ($Ca(OH)_2$), which is slaked lime that has been made with good quicklime, and keep stirring the mass with an iron rod. This done, let the solution, which is the potassium hydroxide (KOH), get cool, and pour it off very carefully into a bottle, after which it is ready to use for your experiments. Keep it well corked up, or the air will change it back into potassium carbonate (K_2CO_3).

How the Experiment Works. The reaction in this case is that the potassium carbonate (K_2CO_3) and calcium hydroxide ($Ca(OH)_2$) form calcium carbonate ($CaCO_3$) and potassium hydroxide (KOH). As the calcium carbonate ($CaCO_3$) is insoluble, that is, it will not dissolve in the solution, it falls to the bottom, while the potassium carbonate (K_2CO_3) and the calcium hydroxide ($Ca(OH)_2$) are soluble, that is, they dissolve in the solution, and it becomes potassium hydroxide (KOH).

The reaction is more easily understood from the following equation:

$$\underset{\text{Potassium carbonate}}{K_2CO_3} + \underset{\text{Calcium hydroxide}}{Ca(OH)_2} = \underset{\text{Calcium carbonate}}{CaCO_3 \downarrow} + \underset{\text{Potassium hydroxide}}{2KOH}$$

Wherever you come to an arrow pointing down in an equation it shows that the compound is precipitated.

EXPERIMENTS WITH HYDROXIDES.

How to Make Mortar. Mix equal parts of calcium hydroxide ($Ca(OH)_2$), that is, *slaked lime*, and *sand*, which latter is formed largely of silicon dioxide (SiO_2), and you will have a sample of mortar. Now let this stand in the air, and the water (H_2O) will soon dry out and calcium carbonate ($CaCO_3$) is slowly formed, and the mass becomes very hard, or sets, as it is called.

How the Experiment Works. First of all, the sand does not act chemically on the lime in any way, but simply serves to give it body and to make it porous. As the water (H_2O) is drying out from the lime, the latter absorbs carbon dioxide (CO_2) from the air; this changes the lime into calcium carbonate ($CaCO_3$), and this with the sand makes a hard, solid mass. The following equation shows the action that takes place:

$Ca(OH)_2$	+ CO_2	= $CaCO_3$	+ H_2O
Calcium hydroxide	Carbon dioxide	Calcium carbonate	Water (which dries out)

Other Things Made with Lime. Plaster is simply calcium hydroxide ($Ca(OH)_2$), that is, slaked lime mixed with *hair*, which holds it together when the former has changed into calcium carbonate ($CaCO_3$). *Portland cement* is made by heating together slaked lime ($Ca(OH)_2$) and *aluminum silicate* ($Al_2Si_2O_7, H_2O$), which is a hydroxide, and after the mass has been fused by the application of heat it is rolled to a powder. Concrete is simply Portland cement, broken rock, and sand mixed together with water (H_2O). When this sets, a material results that is as hard as stone and that lasts as long.

How to Make Hard Soap. This is an experiment with sodium hydroxide (*NaOH*) and *fat*. The fats used for making soaps are compounds of glycerine ($C_3H_5(OH)_3$) and palmitic acid ($C_{16}H_{32}O_2$) or stearic acid ($C_{18}H_{36}O_2$), and *soaps* are the *alkali salts* of the acids that are made when the fats are treated with sodium hydroxide (*NaOH*).

To make a little soap, put a bit of *lard*, which is a fat, about the size of a hazelnut, into a small saucer or, better, a porcelain evaporating-dish, and then pour a teaspoonful of wood alcohol (CH_3OH) over it. This done, dissolve a teaspoonful of sodium hydroxide ($NaOH$) in a like amount of water (H_2O) in a test tube, and then put 10 drops of this solution into the mixture in the dish. Now heat the dish over a low flame until the solution boils and all the alcohol (CH_3OH) has evaporated, which you will know when there is no longer any odor from it; then evaporate the solution slowly until a dry mass results, which will, or should be, soap. If it is not soap, then put a little more alcohol (CH_3OH) and sodium hydroxide ($NaOH$) in the dish and boil it again.

How the Experiment Works. When the sodium hydroxide (*NaOH*) and the glyceryl stearate ($C_3H_5(C_{18}H_{35}O_2)_3$) or fat, are heated together, the latter is decomposed and forms glycerine ($C_3H_5(OH)_3$) and sodium stearate ($NaC_{18}H_{35}O_2$) which is commonly called *soap*. The alcohol (CH_3OH) simply helps the reaction along and does not enter chemically into the process. When the reaction takes place the fat is said to be *saponified* and the process is called *saponification*. The following equation shows the reaction more clearly:

$$C_3H_5(C_{18}H_{35}O_2)_3 + 3\,NaOH = C_3H_5(OH)_3 + 3\,NaC_{18}H_{35}O_2$$

Glyceryl stearate	Sodium hydroxide	Glycerine	Sodium stearate or Soap

How to Make Soft Soap. To make *soft soap*, you need only to mix a little lard with some potassium hydroxide (KOH) and boil them, and they will saponify. Potassium hydroxide (KOH) is not used in making soap commercially, because sodium hydroxide ($NaOH$) is cheaper and does the work just as well or better.

How Soap-and-Water Cleans. When you mix soap and soft water (H_2O) they make a soap solution and this cleans the stains from the goods washed in them by separating the *vegetable* and *animal* oils and grease and washing out the dust and dirt that is in them. The first thing that happens when goods are washed in a soap solution is that the soap breaks up the oils and grease into little separate particles, and then forms a film around each one, like the sugar coating on a pill. When this is done, the water (H_2O) easily washes them away. If the goods have *mineral oils* in them, then they must be *dry cleansed*, that is, cleaned with *benzine* or *gasoline*, which dissolves the oils.

When the clothes are *dirty*, it means simply that they have a large amount of particles of carbon (C) on and in them, and much of this is soot. When the soap solution comes into close contact with them, which it does when the clothes are boiled and rubbed, the particles of dirt are easily washed away by rinsing the clothes in water (H_2O).

HOW TO MAKE VARIOUS SALTS.

How to Make Sodium Chloride. Since you can buy a pound of sodium chloride ($NaCl$), that is, common table

salt, for a few cents it is not good economy to make it, but it is well worth your while to do so for the experience it will give you. To make a little, dissolve a tablespoonful of sodium hydroxide ($NaOH$), that is, caustic soda, in a small beaker half full of water (H_2O).

Now fill a test tube one-fourth full of water (H_2O) and add an equal amount of hydrochloric acid (HCl). This done, pour the dilute acid, a very little at a time, into the solution of caustic soda ($NaOH$) and keep testing it with blue litmus paper right along; the instant it changes the paper from blue to red add a few drops of caustic soda ($NaOH$), and it will be neutral, that is, it will be neither acid nor alkali and hence, it will not change blue litmus paper red nor red paper blue.

When this point is reached, pour the solution from the beaker into a porcelain dish and evaporate it over a water bath until there is nothing left but a white residue which is neither an *alkali* nor an *acid* but a *salt*, and this is sodium chloride ($NaCl$).

How the Experiment Works. The reaction that takes place is clearly shown by the following equation:

HCl	+	$NaOH$	=	$NaCl$	+	H_2O
Hydrochloric acid		Sodium hydroxide		Sodium chloride		Water

How to Make Sodium Sulphate. Put a little sodium chloride ($NaCl$), into a test tube and pour on enough sulphuric acid (H_2SO_4) to cover it. Now hold it over the flame of your lamp or burner, and very soon hydrochloric acid gas (HCl) and sodium sulphate (Na_2SO_4), the common

name of which is *Glauber's salt*, will be formed; the gas will, of course, escape and the salt will be left behind.

How the Experiment Works. The following equation shows the reaction:

$2NaCl$	+	H_2SO_4	=	Na_2SO_4	+	$2HCl \uparrow$
Sodium chloride		Sulphuric acid		Sodium sulphate		Hydrochloric acid gas

How to Make Sodium Nitrate. To make some sodium nitrate ($NaNO_3$), which is commonly called *Chili saltpetre*, proceed exactly as described in the above experiment, but use nitric acid (HNO_3) and caustic soda ($NaOH$) instead. The reaction that takes place gives sodium nitrate ($NaNO_3$) and water (H_2O).

How the Experiment Works. The following equation shows what takes place:

HNO_3	+	$NaOH$	=	$NaNO_3$	+	H_2O
Nitric acid		Caustic soda		Sodium nitrate		Water

The solution must be evaporated, and when the water (H_2O) has passed off, the sodium nitrate ($NaNO_3$) alone will remain.

How to Make Potassium Chloride. This salt (KCl) is a white substance in the form of crystals, and the larger part of it comes from the great potash beds at Stassfurt, Germany. Giant kelp, or seaweed, as it is commonly called, contains about 9 per cent of it, and from this it is now extracted to some extent commercially.

To make a little potassium chloride (KCl), follow the directions given for making sodium chloride ($NaCl$), but use hydrochloric acid (HCl) and potassium hydroxide (KOH), that is, caustic potash for the base.