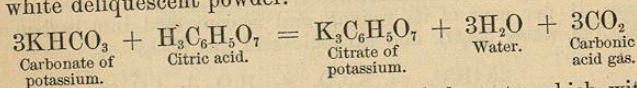


(K_2CO_3) and carbonate of hydrogen, or true carbonic acid (H_2CO_3); it is "acid carbonate of potassium" or "hydric potassium carbonate." Hence in constitution it is an acid salt, although not acid to the taste.

Salts whose specific names end in the syllable "ate" (carbonate, sulphate, etc.) are in general conventionally so termed when they contain an acidulous radical, or the characteristic elements of an acid whose name ends in "ic," and from which acid they have been or may be formed. Thus the syllable "ate," in the words sulphate, nitrate, acetate, carbonate, etc., indicates that the respective salts contain a radical whose name ended in *ic*, the previous syllables, sulph-, nitr-, acet-, carbon-, indicating what that radical was—the sulphuric, nitric, acetic, or carbonic. Occasionally a letter or syllable is dropped from or added to a word to render the name more euphonious; thus the sulphuric radical forms sulphates, not sulphurates.

Citrate of Potassium.

Fifth Synthetical Reaction.—Dissolve a few grains or more of bicarbonate (or 8 parts) of potassium in water, and add (6 parts of) citric acid ($H_3C_6H_5O_7$) until it no longer causes effervescence. The resulting liquid is a solution of citrate of potassium ($K_3C_6H_5O_7$) (*Liquor Potassii Citratis*, U. S. P., sp. gr. 1.059). Evaporated to dryness, in an open dish, a pulverulent or granular residue is obtained, which is the official *Potassii Citras*, U. S. P., a white deliquescent powder.



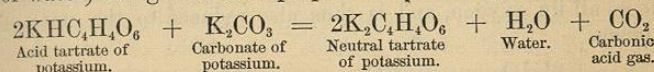
Citrates.—The citric radical or group of elements, which with three atoms of hydrogen forms a molecule of citric acid, and with three of potassium citrate of potassium, is a trivalent grouping; hence the three atoms of potassium in a molecule of the citrate. The full chemistry of citric acid and other citrates will be subsequently described.

Nitrate of potassium (KNO_3) (*Potassii Nitras*, U. S. P.) and *Sulphate of potassium* (K_2SO_4) (*Potassii Sulphas*, U. S. P.) could obviously also be made by saturating nitric acid (HNO_3), and sulphuric acid (H_2SO_4), respectively, by carbonate of potassium. Practically, they are not made in that way—the nitrate occurring, as already stated, in nature, and the sulphate as a by-product in many operations. Both salts will be hereafter alluded to in connection with nitric acid.

Tartrate of Potassium.

Sixth Synthetical Reaction.—Place a few grains of carbonate of potassium in a test-tube with a little water, heat to the boiling-point, and then add acid tartrate of potassium ($KHC_4H_4O_6$ or KHT) till there is no more effervescence; a

solution of neutral tartrate of potassium (K_2T) results, the *Potassii Tartras* of the United States Pharmacopœia, the old "Soluble Tartar." Crystals (4- or 6-sided prisms) may be obtained on concentrating the solution by evaporation and setting the hot liquid aside. Larger quantities are made in the same way, 20 of acid tartrate and 9 of carbonate (with 50 of water) being about the proportions necessary for neutrality.

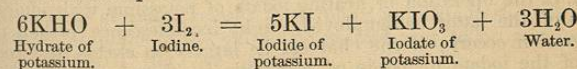


Tartrates.— $C_4H_4O_6$ are the elements characteristic of all tartrates; they form a bivalent grouping; hence the formula of the hydrogen tartrate, or tartaric acid, is $H_2C_4H_4O_6$; that of the potassium tartrate $K_2C_4H_4O_6$; of the intermediate salt, the acid potassium tartrate (cream of tartar), $KHC_4H_4O_6$. If the acid tartrate of one metal and the carbonate of another react, a neutral dimetallic tartrate results, as seen in Rochelle salt ($KNaC_4H_4O_6 \cdot 4H_2O$), the *Soda Tartarata* of the British Pharmacopœia (*Potassii et Sodii Tartras*, U. S. P.).

Acid salts (e. g. $KHC_4H_4O_6$), that is, salts intermediate in composition between a normal or neutral salt (e. g. $K_2C_4H_4O_6$) and an acid (e. g. $H_2C_4H_4O_6$), will frequently be met with. All acidulous radicals, except those which are univalent, may be concerned in the formation of such acid salts.

Iodide of Potassium.

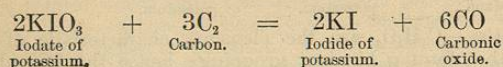
Seventh Synthetical Reaction.—Into a solution of potash, heated in a test-tube, or flask, or in an evaporating basin, according to quantity, stir a small quantity of solid iodine. The deep color of the iodine disappears entirely. This is due to the formation of the colorless salts, iodide of potassium (KI) and iodate of potassium (KIO_3), which remain dissolved in the liquid. Continue the addition of iodine so long as its color, after a few minutes' warming and stirring, disappears. When the whole of the potash in the solution of potash has been converted into the salts mentioned, the slight excess of iodine remaining in the liquid will color it, and thus show that this stage of the operation is completed.



Separation of the Iodide from the Iodate.—Evaporate the solution to dryness. If each salt were required, the resulting solid mixture might be digested in spirit of wine, which dissolves the iodide, but not the iodate. But the iodide only is used in medicine. Mix the residue, therefore (reserving a

grain or two for a subsequent experiment), with about a twelfth of its weight of charcoal, and gently heat in a test-tube or crucible until slight deflagration ensues.*

The crucible may be held in a spirit or air-gas flame, or other fire, by tongs. (Scissors-shaped and other "crucible-tongs" are sold by all makers of apparatus.) Under these circumstances the iodide remains unaffected; but the iodate loses all its oxygen, and is thus also reduced to the state of iodide.



Treat the mass with a little water, and filter to separate excess of charcoal; a solution of pure iodide of potassium results. (*Potassii Iodidum*, U. S. P.) The latter may be used as a reagent or it may be evaporated to a small bulk and set aside to crystallize.

Properties.—Iodide of potassium crystallizes in small cubical crystals, very soluble in water, less so in spirit. One part in twenty of water forms "Solution of Iodide of Potassium," U. S. P. Exposed to air and sunlight, pure iodide of potassium becomes slightly brown owing to the liberation of iodine. Under these circumstances a little carbonate of potassium is produced by action of the atmospheric carbonic acid and a little hydriodic acid (HI) is set free, and the latter, attacked by oxygen, yields a trace of water and of free iodine. The ozone in the air (see "Ozone" in Index) may also contribute to the liberation of iodine from such compounds as iodide of potassium.

The addition of charcoal in the above process is simply to facilitate the removal of the oxygen of the iodate of potassium. Iodate of potassium (KIO_3) is analogous in constitution, and in composition, so far as the atoms of oxygen are concerned, to chlorate of potassium (KClO_3), which has already been stated to be more useful than any other salt for the actual preparation of oxygen gas itself. Hence the removal of the oxygen of the iodate might be accomplished by heating the residue without charcoal. In that case the liberated oxygen would be detected on inserting the incandescent extremity of a strip of wood into the mouth of the test-tube in which the mixture of iodide and iodate had been heated. The charcoal, however, burns

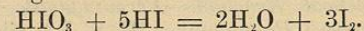
* If, in the operation of heating iodate of potassium with charcoal, excess of the latter be employed, slight incandescence rather than deflagration occurs; if the charcoal be largely in excess, the reduction of the iodate to iodide of potassium is effected without visible deflagration or even incandescence.

Deflagration means violent burning, from *flagratus*, burnt (*flagro*, I burn), and *de*, a prefix augmenting the sense of the word to which it may be attached. Paper thrown into a fire simply burns, nitre deflagrates. *De-tonate* (*detono*) is a precisely similar word, meaning to explode with violent noise.

out the oxygen more quickly, and thus economizes both heat and time.

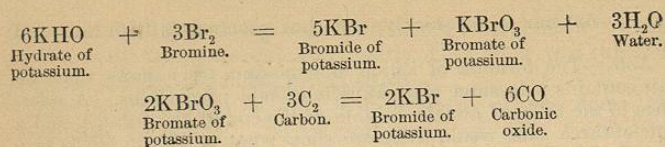
Note.—The formula of iodide of potassium (KI) shows that the salt contains potassium and iodine in atomic proportions. A reference to the table of atomic weights at the end of the volume, and a rule-of-three sum, would therefore show what weight of salt is producible from any given weight of iodine.

Detection of Iodate in Iodide of Potassium.—Iodate of potassium remaining as an impurity in iodide of potassium may be detected by adding to a solution of the latter salt some weak acid (say tartaric), shaking, and then adding mucilage of starch; blue "iodide of starch" is formed if a trace of iodate be present, not otherwise. By the reaction of the added acid and the iodate of potassium, iodic acid (HIO_3) is produced, and by reaction of the added acid and the iodide of potassium, hydriodic acid (HI) is produced; neither of these two acids alone attacks starch, but by reaction on each other they give rise to free iodine, which then forms the blue color. This experiment should be tried on a sample of pure iodide of potassium and on a grain or two of the impure iodide reserved from the previous experiment. Iodide of potassium containing iodate would, obviously, yield free iodine, which is excessively corrosive, on the salt coming into contact with the acids of the stomach.



Note on Nomenclature.—The syllable *ide* attached to the syllable *iod*, in the name "iodide of potassium," indicates that the element iodine is combined with the potassium. An *iodate*, as already explained, is a salt containing the characteristic elements of iodic acid and of all iodic compounds. Inorganic salts one of whose names ends in *ide* are those which are, or may be, formed from elements. The names of salts which are, or may be, formed from compounds include other syllables, *ate* being one (see page 72). The only other syllable is *ite*, which is included in the names of salts which are, or may be, formed from acids and radicals whose names end in *ous*: thus hyposulphite of sodium, etc. To recapitulate: an inorganic salt whose name ends in *ate* contains a compound acidulous radical whose name ends in *ic*; a salt whose name ends in *ite* contains a compound acidulous radical whose name ends in *ous*; an inorganic salt whose name ends in *ide* contains an element for its acidulous radical. Thus sulphide relates to sulphur, sulphite to the sulphurous radical, sulphate to the sulphuric radical, and so on with other inorganic "ides," "ites," or "ates."

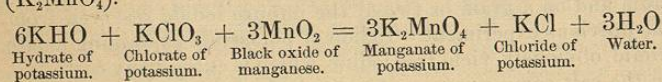
Bromide of Potassium (*Potassii Bromidum*, U. S. P.)—This salt is identical in constitution with iodide of potassium, and may be made in exactly the same way, bromine being substituted for iodine. The formula of bromic acid is HBrO_3 . It will be noticed that the following equations are similar in character to those showing the preparation of iodide of potassium:—



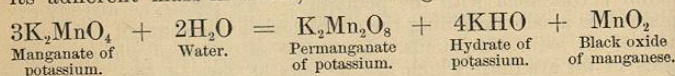
Bromide of potassium may also be made by decomposing solution of bromide of iron (FeBr_2) by solution of pure carbonate of potassium (K_2CO_3), evaporating and crystallizing.

Manganates of Potassium.

Eighth Synthetical Reaction.—Place a fragment of solid caustic potash (KHO), with about the same quantity of chlorate of potassium (KClO_3), and of black oxide of manganese (MnO_2) on a piece of platinum foil.* Hold the foil by a small pair of forceps or tongs in the flame of a blowpipe for a few minutes until the fused mixture has become dark green—apparently black. This color is that of *manganate of potassium* (K_2MnO_4).



Ninth Synthetical Reaction.—*Permanganate of Potassium* ($\text{K}_2\text{Mn}_2\text{O}_8$) (*Potassii Permanganas*, U. S. P.), which is purple, is obtained, or rather a solution of it, on placing the foil and its adherent mass in water, and boiling for a short time.



On the large scale, the potash set free in the reaction is neutralized by sulphuric or, better, carbonic acid, and the solution evaporated to the crystallizing point. Further details will be given in connection with manganese.

Solutions of manganate or permanganate of potassium and of sodium so readily yield their oxygen to organic matter, that they are used on the large scale as disinfectants, under the name of "Condy's Disinfecting Fluids."

Synthetical Reactions bringing under consideration the remaining official compounds (namely, bichromate, arsenite, chlorate, cyan-

* The foil may be 1 inch broad by 2 inches long. No ordinary flame will melt the platinum; fused caustic alkalies only slowly corrode it, and very few other chemical substances affect it at all; hence the same piece may be used in experimenting over and over again. Most metals form a fusible alloy with platinum, and phosphorus rapidly attacks it, hence such substances, as well as mixtures likely to yield them, should be heated in a small porcelain crucible.

ide, ferrocyanide, and ferridcyanide of potassium) are deferred at present.

(b) Reactions having Analytical Interest (Tests).

Note.—These are reactions utilized in searching for small quantities of a substance (in the present instance of potassium) in a solution. They are best performed in test-tubes or other small vessels. Each reaction should be expressed, in the form of an equation or diagram, in the student's note-book. *All previous or future equations given in this volume should be transferred to the note-book in the form of diagrams, constructed as described on pages 63 and 64, unless the student can with ease construct the equations without the aid of the manual.*

*First Analytical Reaction.**—To a solution of any salt of potassium (chloride,† for example) add a few drops of hydrochloric acid and of a solution of perchloride of platinum (PtCl_4), and stir the mixture with a glass rod; a yellow granular or slightly crystalline precipitate‡ slowly forms. (The precipitate is the double chloride of platinum and potassium, and its composition is expressed by the formula $\text{PtCl}_4\cdot 2\text{KCl}$.)

Memoranda.‡—When the precipitate is long in forming, it is some-

* As already indicated, chemical reactions are scarcely analytical or synthetical in themselves, but, rather, performed with an analytical or synthetical object. Indeed, not unfrequently one and the same reaction is both a synthetical and an analytical reaction. Thus this first, so-called, "analytical reaction" is a synthetical reaction if performed with the object of preparing a specimen of the double chloride of platinum and potassium. It is an analytical reaction, or, rather, has analytical interest, if performed with the object of demonstrating the presence of potassium. Chemical reactions in themselves are operations, not so much of analysis (resolution) or synthesis (combination) or of analysis and synthesis conjoined, as of what has sometimes times been termed *metathesis* (transposition). Molecules are not torn to atoms in an operation performed with an analytical object, nor are the atoms put together or set together in an operation (perhaps the same operation) performed with a synthetical object: but in both operations the atoms of the molecules undergo metathesis, that is, exchange places, or are transposed. In short, chemists use the words "analytical" and "synthetical" in a conventional rather than a strictly etymological sense.

† A few fragments of carbonate of potassium, two or three drops of hydrochloric acid, and a small quantity of water, give a solution of chloride of potassium at once, $\text{K}_2\text{CO}_3 + 2\text{HCl} = 2\text{KCl} + \text{H}_2\text{O} + \text{CO}_2$.

‡ By *precipitation* (from *precipito*, to throw down suddenly) is simply meant the formation of particles of solid in a liquid, no matter whether the solid, the *precipitate*, subsides or floats.

§ Experiments with such expensive reagents as perchloride of platinum are economically performed with watch-glasses, drops of the liquid being operated on.

times of an orange-yellow tint. If iodide of potassium happen to be the potassium salt under examination, some iodide of platinum (PtI_4) will also be formed, giving a red color to the solution, and a larger quantity of the precipitant (that is, the precipitating agent) will be required.

Precaution.—Only chloride of potassium forms this characteristic compound; hence, if the potassium salt in the solution is known not to be a chloride, or if its composition is unknown, a few drops of hydrochloric acid must be added, otherwise some of the perchloride of platinum will be utilized for its chlorine only, the platinum being wasted. Thus, if nitrate of potassium (KNO_3) be present, a few drops of hydrochloric acid enable the potassium to assume the form of chloride when the perchloride of platinum is added, nitric acid (HNO_3) being set free.

Explanation.—The precipitate is, practically, insoluble in water. It is for this reason that a very small quantity of any soluble potassium salt (or, rather, of the potassium in that salt) is thrown out of solution by perchloride of platinum.

Note on Nomenclature.—When distinct molecules of salts unite and form a single crystalline compound, the product is termed a double salt. The double chloride of potassium and platinum is such a body.

Acid Tartrate of Potassium.

Second Analytical Reaction.—To any solution of any salt of potassium add excess of strong solution of tartaric acid ($\text{H}_2\text{C}_4\text{H}_4\text{O}_6$), and shake or well stir the mixture; a white granular precipitate of acid tartrate of potassium ($\text{KHC}_4\text{H}_4\text{O}_6$) will be formed.

Note.—By “excess” of any test liquid (such as the “solution of tartaric acid” just mentioned) is meant such a quantity as is *probably* rather more than sufficient to convert the whole weight of the compound attacked into the compound produced. Thus, in the present case enough acid must be added to convert the whole of the potassium salt operated on into acid tartrate of potassium. What the weight of salt operated on was must be mentally estimated, roughly, by the operator. It is not necessary in analyzing to know the exact weights of salts employed. The analyst must use his judgment, founded on his knowledge of the reaction (as shown by an equation) and of the molecular weights of the substances employed in the reaction as well as by the rough estimate of the amount of material on which he is experimenting.

Limits of the Test.—Acid tartrate of potassium is soluble in about 180 parts of cold and in 6 parts of boiling water. Hence, in applying the tartaric test for potassium, the solutions must not be hot. Even if cold, no precipitate will be obtained if the solutions are very dilute. This test, therefore, is of far less value than that first mentioned. The acid tartrate of potassium is less soluble in diluted alcohol than in water; so that the addition of spirit of wine renders the reaction somewhat more delicate.

Cream of Tartar.—The precipitate is the *Bitartrate or Acid Tartrate of Potassium* (*Potassii Bitartras*, U. S. P.), though the official preparation is not formed in the above manner; on the contrary, the acid is derived from the salt, which, often mixed with some tartrate of calcium, occurs naturally in the juice of many plants.

Memorandum.—When the tartaric acid is added to the salt of potassium, and the acid tartrate formed, the acid whose chief elements were previously with the potassium is set free; and in such acid solutions the acid tartrate is somewhat soluble. To prevent loss on this account, acid tartrate of sodium, or Bitartrate of Sodium, U. S. P., $\text{NaHC}_4\text{H}_4\text{O}_6$, H_2O , a salt tolerably soluble in water, may be used as a test instead of tartaric acid (Plunkett). The sodium, uniting with the acidulous radical, thus gives a neutral instead of an acid solution. But this advantage is of less importance from the fact that more water is introduced by the saturated solution of acid tartrate of sodium than by a saturated solution of tartaric acid.

Third Analytical Reaction.—The *flame-test*. Dip the looped end of a platinum wire into a solution containing a potassium salt, and introduce the loop into the lower part of a spirit-flame, the flame of a mixture of gas and air, a blowpipe flame, or other slightly colored flame. A light violet or lavender tint will be communicated to the flame, an effect highly characteristic of salts of potassium.

Fourth Analytical Fact.—Salts of potassium are not volatile. Place a fragment of carbonate, nitrate, or any other potassium salt, on a piece of platinum foil, and heat the latter in the flame of a lamp; the salt may fuse to a transparent liquid and flow freely over the foil, water also if present will escape as steam, and black carbon be set free if the salt happen to be a tartrate, citrate, etc.; but the potassium compound itself will not be vaporized. This is a valuable negative property, as will be evident when the analytical reactions of ammonium come under notice.

QUESTIONS AND EXERCISES.

70. Name the sources of Potassium.
71. Give the source, formula, and characters of Carbonate of Potassium.
72. Distinguish between synthetical and analytical reactions.
73. How is the official *Liquor Potassæ* prepared?
74. What is the systematic name of Caustic Potash?
75. State the chemical formula of Caustic Potash.
76. Construct an equation or diagram expressive of the reaction between Carbonate of Potassium and slaked lime.
77. Define a *hydrate*.

78. What group of atoms is characteristic of all carbonates?
 79. Define the term *radical*.
 80. How is "Sulphurated Potash" made, and of what salts is it a mixture?
 81. What is the formula of the acetic radical—the radical of all acetates?
 82. Draw a diagram showing the formation of Acetate of Potassium.
 83. Give a general process for the conversion of carbonates into other salts.
 84. What is the difference between Carbonate and Bicarbonate of Potassium? How is the latter prepared?
 85. What is the relation between salts whose specific names end in the syllable "*ate*," and acids ending in "*ic*"?
 86. Draw out diagrams or equations descriptive of the formation of Tartrate of Potassium from the Acid Tartrate, and Citrate from the Carbonate of Potassium.
 87. Distinguish between a normal and an acid salt.
 88. How is Iodide of Potassium made? Illustrate the process either by diagrams or equations.
 89. Describe the appearance and chemical properties of Iodide of Potassium.
 90. Work out a sum showing how much Iodide of Potassium is producible from 1000 grains of Iodine? Ans. 1307 grains.
 91. Give a method for the detection of Iodate in Iodide of Potassium. Explain the reaction.
 92. Has the syllable "*ide*" any general significance in chemical nomenclature?
 93. What are the differences between sulphides, sulphites, and sulphates?
 94. Mention the chemical relations of Bromide to Iodide of Potassium.
 95. Describe the formation of Permanganate of Potassium, giving equations or diagrams.
 96. How do manganate and permanganate of potassium act as disinfectants?
 97. Enumerate the tests for potassium, explaining by diagrams or equations the various reactions which occur.

SODIUM.

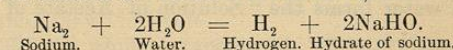
Symbol Na. Atomic weight 23.

Formula Na₂. Probable molecular weight 46.

Memoranda.—Most of the sodium salts met with in Pharmacy are obtained directly from carbonate of sodium, which is now manufactured on an enormous scale from chloride of sodium (common salt, sea-salt, bay-salt, or rock-salt), the natural source of the sodium salts. When pure, salt (*Sodii Chloridum*, U. S. P.) occurs "in small white crystalline grains, or transparent cubic crystals, free from moisture;" the best varieties commonly contain a little chlo-

ride of magnesium and sometimes other impurities. Besides the direct and indirect use of carbonate of sodium, or carbonate of soda, as it is commonly called in medicine, it is largely used for household cleansing purposes under the name of "soda," and in the manufacture of soap. Nitrate of sodium also occurs in nature, but is valuable for its nitric constituents rather than its sodium. Sodium is a constituent of about forty chemical or Galenical preparations of the Pharmacopœias.

Sodium is prepared by a process similar to that for potassium, but with less difficulty. Castner obtains it comparatively cheaply by distillation from a mixture of soda, carbon, and iron contained in steel vessels. It has a bright metallic lustre when freshly cut, but rapidly absorbs oxygen and moisture and carbonic acid gas from the air, and thus becomes coated with carbonate of sodium. It displaces hydrogen from water, yielding a solution of hydrate of sodium, but unless the sodium is confined to one spot by placing it on a small floating piece of filter-paper, the action is not sufficiently intense to cause ignition of the escaping hydrogen. When the latter does ignite, it burns with a yellow flame, due to the presence of a little vapor of sodium. It crystallizes in octahedra. Its atom is univalent, Na'.



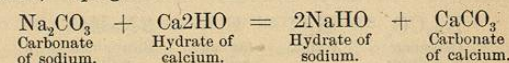
It similarly attacks alcohol, yielding ethylate of sodium (see Index). It may be kept beneath the surface of a liquid containing neither moisture nor oxygen in any form (mineral naphtha).

REACTIONS HAVING (a) SYNTHETICAL AND (b) ANALYTICAL INTEREST.

(a) Reactions having Synthetic Interest.

Hydrate of Sodium. Caustic Soda.

First Synthetic Reaction.—The formation of solution of hydrate of sodium or caustic soda, NaHO (*Liquor Sodæ*, U. S. P.). This operation resembles that of making solution of potash already described, and its strength is the same, "about 5 per cent.;" sp. gr. about 1.059.



The practical student should refer to the remarks made concerning solution of potash, applying them to solution of soda. If solution of soda be evaporated to dryness, and the residue fused and poured into moulds, solid hydrate of sodium (*Soda*, U. S. P.) is obtained. Common and cheap caustic soda is now largely employed in various manufactures. This variety is a by-product in the preparation of carbonate of sodium, but, though highly useful as a chemical agent, is too impure for use in medicine. The United States Pharmacopœia recognizes *Liquor Sodæ* made from solid caustic soda 56 parts, and dis-

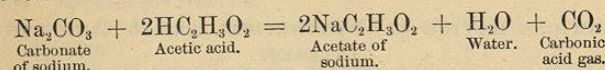
tilled water 944 parts; or from caustic soda of any other strength if only an equivalent amount be used.

Second Synthetical Reaction.—The reaction of sulphur and carbonate of sodium at a high temperature resembles that of sulphur and carbonate of potassium; but, as the product is not used in medicine, the experiment may be omitted. It is mentioned here to draw attention to the close resemblance of the potassium salts to those of sodium.

Acetate of Sodium.

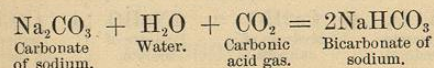
Third Synthetical Reaction.—Add the powder or fragments of carbonate of sodium (Na_2CO_3) to some strong acetic acid in a test-tube or evaporating-basin as long as effervescence occurs, and then evaporate some of the water.* When the solution is cold, crystals of Acetate of Sodium ($\text{NaC}_2\text{H}_3\text{O}_2 \cdot 3\text{H}_2\text{O}$) (*Sodii Acetas*, U. S. P.) will be deposited. A ten per cent. solution in distilled water forms the "Solution of Acetate of Sodium," B. P.

Acetate of sodium effloresces in dry air, and loses all its water of crystallization when gently heated. It supports a temperature of 270° or 280° F. without decomposition, but above 300° soon chars.



Bicarbonate of Sodium.

Fourth Synthetical Reaction.—The action of carbonic acid (H_2CO_3) or carbonic acid gas (CO_2) and water (H_2O), on carbonate of sodium (Na_2CO_3). This resembles that of carbonic acid on carbonate of potassium, but is applied in a different manner. The result is bicarbonate of sodium (NaHCO_3) (*Sodii Bicarbonas Venalis*, U. S. P.).

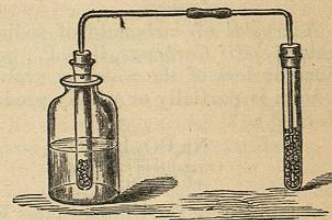


Process.—Heat crystals of carbonate of sodium in a porcelain crucible until no more steam escapes. Rub the product, in a mortar, with two-thirds its weight of more of the crystals and place the powder in a test-tube or small bottle into which carbonic acid gas may be conveyed by a tube passing through

* The "water" alluded to occurs in the acid, which, though commonly termed "acetic" acid, is really a solution of that acid in water.

a cork and terminating at the bottom of the vessel. To generate the carbonic acid gas fill a test-tube having a small hole in the bottom (or a similar piece of glass tubing, of which one end is plugged by a grooved cork) with fragments of marble, insert a cork and delivery-tube, and connect the latter with the similar tube of the vessel containing the carbonate of sodium by a piece of India-rubber tubing. Now plunge the tube of marble into a test-glass, or other vessel, containing a mixture of one part hydrochloric acid and two parts water, and loosen the cork of the carbonate-of-sodium tube until carbonic acid gas, generated in the marble tube, may be considered to fill the whole arrangement; then replace the cork tightly and set the apparatus aside. As the gas is absorbed by the carbonate of sodium, hydrochloric acid rises into the marble tube, and generates fresh gas, which, in its turn, drives back the acid liquid, and thus prevents the production of any more gas until further absorption has occurred. When the salt is wholly converted into bicarbonate (NaHCO_3), it will be found to have become damp through the liberation of water from the crystallized carbonate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$). (It would be inconveniently moist, even semi-fluid, if a part of the carbonate had not previously been rendered anhydrous.) The *Sodii Bicarbonas*, U. S. P., is the commercial bicarbonate purified from any carbonate or traces of other salts by introducing it into a percolator and passing water through it till the washings cease to precipitate a solution of sulphate of magnesium, when the bicarbonate of sodium is removed from the percolator and dried on bibulous paper in a warm place.

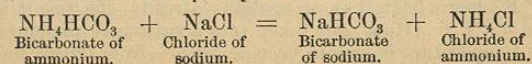
Fig 17.



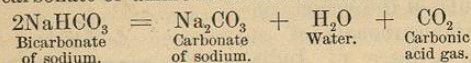
Preparation of bicarbonate of sodium.

The carbonate of sodium may be placed, not in a test-tube or bottle, but in a vertical tube the bottom of which is loosely closed by a grooved cork. Any water of crystallization that is set free then runs off (into a basin or cup beneath), and takes with it any impurities (chlorides or sulphates, etc.) that may have been present in the original salt.

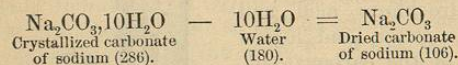
Bicarbonate of sodium is also now largely prepared by adding bicarbonate of ammonium to a strong solution of common salt; bicarbonate of sodium is precipitated.



The resulting chloride of ammonium is reconverted into carbonate (p. 91); the latter, more fully carbonated, again used for producing bicarbonate of sodium. Indeed, carbonate of sodium (*Sodii Carbonas*, U. S. P.) is commercially made by heating the bicarbonate thus obtained, the carbonic acid then liberated serving for the converting of the carbonate of ammonium into bicarbonate of ammonium.



A crystal of carbonate of sodium is carbonate of sodium plus water (*Sodii Carbonas*, U. S. P.; see "Carbonates"); on heating it, more or less of the water is evolved, and anhydrous carbonate of sodium is partially or wholly produced (*Sodii Carbonas Exsiccatus*, U. S. P.).



According to the United States Pharmacopœia dried carbonate of sodium is to be prepared by exposing crystals of carbonate of sodium to warm air for several days to effloresce, and then to a temperature of about 45° C. until half the original weight is obtained. 286 parts would thus become 143, and the latter would thus still retain 37 parts of water. In other words, the dried carbonate contains 72.6 per cent. of anhydrous carbonate and 27.4 per cent. of water. The crystals contain, obviously, a little more than 37 per cent. of anhydrous carbonate and nearly 63 per cent. of water. *The student should verify all these figures.*

Note on Nomenclature.—Anhydrous bodies (from *a*, *a*, and *ὕδωρ*, *hudōr*, i. e. without water) are compounds from which water has been taken, but whose essential chemical properties are unaltered. Salts containing water are *hydrous* bodies; of these the larger portion are crystalline, and their water is then termed *water of crystallization*. Non-crystalline *hydrous* compounds were formerly spoken of as *hydrated* substances; *hydrates* are, however, a distinct class of bodies, salts derived from water by one-half of its hydrogen becoming displaced by an equivalent quantity of another radical. *Anhydrides* form still another distinct class of chemical substances; they are derived from acids; in short, they are acids from which, not exactly water as water, but the elements of water have been removed, the essential chemical (acid) properties being thereby greatly altered. (For illustrations, see Index, "Anhydrides.")

Water of Crystallization.—The water in crystallized carbonate of sodium is in the solid condition, and, like ice and other fusible substances, requires heat for its liquefaction. Many salts (freezing-mixtures), when dissolved in water, give a very cold solution. This is because they and their solid water, if they have any, are then, absorbing some heat from surrounding media, converted into liquids. Take away from water some of its heat, the result is ice. Give to ice (at 32° F.) more heat than it contains already, the result is water (still at 32° F.). (Heat thus taken into a substance without increasing its temperature is said to become *latent*—from *latens*, hiding; it

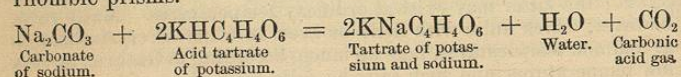
is no longer discoverable by the sense of touch or the thermometer. The term *latent* gives a somewhat incorrect idea, however, of the process; for our knowledge of the extent and readiness with which one form of force is convertible into another renders highly probable the assumption that heat is in these cases converted into motion, the latter enabling the molecules of a solid to take up the new positions demanded by their liquid condition.) The only apparent difference between ice and the water in such crystals as carbonate of sodium is that ice is solid water in the free, and water of crystallization solid water in the combined state. The former can only exist at and below 32° F.; the latter may exist at ordinary temperatures. Many salts, however, which unite with little or even no water of crystallization at common temperatures, take up much, according to Guthrie, at very low temperatures, and such salts he calls *cryohydrates* (*κρυος*, *kruos*, icy cold, frost). On the other hand, all water of crystallization is dispelled at high temperatures. In chemical formulæ, the symbols representing water are usually separated by a comma from those representing salts. The crystals of acetate of sodium (of the third reaction) contain water in this loose state of combination—water of crystallization ($\text{NaC}_2\text{H}_3\text{O}_2 \cdot 3\text{H}_2\text{O}$). It is just possible, however, that this so-called "water of crystallization" is in a more intimate state of combination than is indicated by such a formula as that just given.

"*Soda-water.*"—A solution of bicarbonate of sodium in water charged with carbonic acid gas under pressure constitutes the official *Liquor Sodæ Effervescens*, B. P., and, like the "potash-water" of the shops, is a true medicine, an antacid. Ordinary "soda-water," however, is in many cases simply a solution of carbonic acid gas in water, and would be more appropriately termed "aërated water;" any medicinal effect it may possess is due to the sedative influence of its carbonic acid gas on the coats of the stomach. At common temperatures water dissolves about its own volume of carbonic acid gas, both being under the same pressure. One pint of the official soda-water contains 30 grains of bicarbonate of sodium and a pint of carbonic acid gas; but the solution is under a pressure of four atmospheres—including the ordinary pressure of our atmosphere, four atmospheres altogether—so that four pints of the gas at ordinary atmospheric pressure are required for the quantity mentioned.

Solubility of Gases in Water.—Whatever the weight and volume of a gas dissolved by a liquid at ordinary atmospheric pressure, that weight is doubled by double pressure, the two original volumes of gas thereby being reduced to one; trebled at treble pressure, the three original volumes of gas being reduced to one; quadrupled at quadruple pressure, the four original volumes of gas being reduced to one, and so on. This is a general law (Henry and Dalton) regarding the solubility of gases in liquids under given temperatures. An average bottle of "soda-water" contains about four times the weight of carbonic acid gas which can exist in it without artificial pressure, so that on removing its cork three times its bulk escapes, its own bulk remaining dissolved.

Tartrate of Potassium and Sodium.

Fifth Synthetical Reaction.—To some hot strong solution of carbonate of sodium (about three parts) in a test-tube or larger vessel add acid tartrate of potassium (about four parts), till no more effervescence occurs; when the solution is cold, crystals of the tartrate of potassium and sodium (*Potassii et Sodii Tartras*, U. S. P.), the old *Rochelle Salt*, will be deposited—($\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$). The crystals are usually halves of right rhombic prisms.

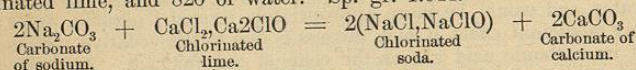
**FORMULÆ OF TARTRATES.**

Tartaric acid	HH C ₄ H ₄ O ₆
Acid tartrate of potassium	KH C ₄ H ₄ O ₆
Tartrate of potassium and sodium	KNaC ₄ H ₄ O ₆

Very close analogy will be noticed in the constitution of the molecules of these salts. When the other tartrates come under notice, it will be found they also have a similar constitution.

Hypochlorite of Sodium.

Liquor Sodæ Chloratæ, U. S. P., "Labbaraque's Solution," is made by decomposing solution of carbonate of sodium by solution of chlorinated lime; 100 parts of the carbonate, 80 of chlorinated lime, and 820 of water. Sp. gr. 1.044.

**Iodide and Bromide of Sodium.**

These salts (NaI, NaBr), *Sodii Iodidum* and *Sodii Bromidum*, are similar to the iodide and bromide of potassium in constitution, and are prepared with the same manipulations, soda being used instead of potash. The bromide of sodium, however, must be crystallized from warm solutions or rhombic prisms containing water ($\text{NaBr}, 2\text{H}_2\text{O}$) will be deposited.

Other Sodium Compounds.

Synthetical Reactions portraying the chemistry of the remaining official compounds (namely, nitrate, sulphate, hyposulphite, borate, arseniate, and valerianate of sodium) are deferred until the several acidulous radicals of these salts have been described.

Phosphate of Sodium.—The preparation and composition of this salt will be most usefully studied after bone-ash, the source of it and other phosphates, has been described. Bone-ash is phosphate of calcium (see page 109).

The *Citro-Tartrate* (*Sodæ Citro-tartras Effervescens*, B. P.) is a mixture of bicarbonate of sodium (17 parts), citric acid (6), and tartaric acid (8), heated (to 200° or 220° F.) until the particles

aggregate to a granular condition. When required for a medicinal use, a dose of the mixture is placed in water; escape of carbonic acid gas at once occurs and an effervescing liquid results. This substance may be regarded as the official representative of the popular "Effervescing Citrate of Magnesia," which will be further noticed in connection with the salts of magnesium (page 118).

Soda powders are formed of 30 grains of bicarbonate of sodium and 25 of tartaric acid wrapped separately in papers of different color. When mixed with water, tartrate of sodium ($\text{Na}_2\text{C}_4\text{H}_4\text{O}_6$) results, a little bicarbonate also remaining.

In the manufacture of *Carbonate of Sodium* from chloride, the source of the sodium is chloride of sodium, and of the carbonic radical carbonate of calcium in the form of limestone. By one process the chloride is first converted into sulphate, the sulphate is then roasted with coal and limestone, and the resulting *black-ash* lixiviated (*lixivia*, from *lix*, lye—water impregnated with alkaline salts; hence *lixivation*, the operation of washing a mixture with the view of dissolving out salts). The lye, evaporated to dryness, yields crude carbonate of sodium (soda-ash). By another process the carbonate of sodium is obtained by heating bicarbonate of sodium, and the latter by mixing strong solutions of chloride of sodium and bicarbonate of ammonium. The last-named results from the action of carbonic acid gas (liberated on heating bicarbonate of sodium) on carbonate of ammonium, and this again from the reaction of heated mixture of chloride of ammonium and limestone. By either process common salt and limestone are the prime sources respectively of the sodium and carbonic radical in carbonate of sodium. The process will be further described in connection with Carbonates.

Deliquescence and Efflorescence.—The carbonates of sodium and potassium, chemically closely allied, are readily distinguished physically. Carbonate of potassium quickly absorbs moisture from the air and becomes damp, wet, and finally fluid—it is *deliquescent* (*deliquescent*, melting away). Carbonate of sodium, on the other hand, yields some of its water of crystallization to the air, the crystals becoming white, opaque, and pulverulent—it is *efflorescent* (*efflorescent*, blossoming forth).

Analogy of Sodium Salts to Potassium Salts.—Other synthetical reactions might be described similar to those given under Potassium, and thus citrate, iodate, bromate, chlorate (*Sodii Chloras*, U. S. P.), NaClO_3 , manganate and permanganate of sodium, and many other salts be formed. But enough has been stated to show how analogous sodium is chemically to potassium. Such analogies will constantly present themselves. In few departments of knowledge are order and method more perceptible; in few is there as much natural law, as much science, as in chemistry.

Substitution of Potassium and Sodium Salts for each other.—Sodium salts being cheaper than potassium salts, the former may sometimes be economically substituted. That one is employed rather than the other is often merely a result due to accident or fashion. But it must be borne in mind that in some cases a potassium salt