ON THE

MICROCOSMIC SALT,

ACIDS, BASES, AND WATER,

AND A NEW AND EASY

METHOD OF ANALYSING SUGAR.

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ON MICROCOSMIC SALT.*

Bergman was the first to remark, that "I am not "acquainted with any acid which can endure the "fire upon charcoal, except that of the Microcosmic "Salt. This salt is neutral, but triple, containing "both the volatile and mineral alkali. The Phos-"phoric Acid saturated with volatile alkali cannot "be brought to crystallize, which yet always "happens upon the accession of a proper quantity "of mineral alkali, and the triple salt, which results "from hence is commonly called *Microcosmic Salt.* "Upon fusion of the charcoal, this sends forth its "volatile alkali; so that the portion of acid which "had been before saturated with it, being now set "at liberty, is the better able to exert its effect "upon other bodies. I made choice of the mineral "alkali well depurated; the vegetable, on account "of its deliquescence, is less proper."

Bergman was mistaken; it has no *volatile* alkali, only the *mineral* alkali.

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* See Physical and Chemical Essays, by Sir T. Bergman, translated by Dr. Cullen, vol. II. page 82. London, 1788.

M. Anatole Riffault was the first that discovered the fact. See *An. de Chimie* (1822)

He has it—Solid Matter, ...47475
Liquid Matter, Ammonia & Water. } .52525

I have it,

Biphosphoric Acid = 48 } Solid Matter
Soda = 28 }
— 76

Ammonia = 15 } Liquid Matter
Water, 8 atoms = 64 }
— 79

155

155 : 76 : : 1 : .4903 solid matter
155 : 79 : : 1 : .5097 water, & ammonia.

It seems that the acid 48 and the soda 28 go together, deserting the water and ammonia by heat, and cling to each other, as Biphosphate of Soda, commonly called *Phosphate of Soda.*

ON THE MIXTURE OF SULPHATE OF MAGNESIA AND THE BIPHOSPHATE OF SODA: NO MAGNESIA IN THE *SOLID FORM*, BUT IN THE *LIQUID FORM*.

The Sulphate of Magnesia and Biphosphate of Soda are to be taken in the atomic proportions; that is, as I take them, Sulphuric Acid 35, Magnesia 17½; and Biphosphoric Acid 48, and Soda 28, all exempt from water.* I call it by the name of *Biphosphoric Acid*, but it is commonly called *Phosphate of Soda* of the shops.

I have given my reasons in the paper that I have published on the Phosphates and Arseniates.

If equal measures of the Sulphate of Magnesia of the specific gravity of 1.042, and the Biphosphate of Soda of the specific gravity 1.063 (this last warmed a little, about blood heat,) were taken, they will answer the end intended. In the first instance the mixture for a minute will be entirely *liquid*, but in ten minutes it will be gradually *solid;* it may be turned upside down without

* I took the *crystallized* Sulphate and Biphosphate at first going off; but the *water* has nothing to do with the fact. It *accidentally* happens the *water* has *nearly* the same *proportion* as the *simple Salts* without the water.

shedding one drop. A multitude of *small* crystals will be formed so as to retain the water. About 12 atoms of water will be found about 1 crystal (24) of the *simple Phosphoric Acid*, as I have called it, (3 vol. *new series, Manchester Memoirs*, 1819), and now call it the *Phosphoric Acid*, as distinguished from the *Biphosphoric*.

The solid may be squeezed together on a muslin, or paper filtre, till it will not drop, and still retain the 12 atoms of water, which will most of them go off by drying them a few days; but a bright red heat is necessary to get off the last atom of water.

I used 572 grains of 1.042 of Sulphate of Magnesia, and as many grains of 1.063 Biphosphate of Soda, generally speaking; any other proportion will not give the *solid* a maximum, that is, atom to atom.

The *solid* and *liquid* are now to be dealt with.

By squeezing till drop dry the *solid* comes out at an average about,

78 Grains.
60 Grains, dryed a day in the open air.
34 Grains, dryed a day or two more.
31 Grains, dryed a day more.
20 Grains by a *red heat*, long continued.*

* I suppose it had lost four grains by manipulation. It should have been 24.

We have accounted for the **24** grains in the *solid form* below.

We are now to account for the **94½** grains remaining in the *liquid* form.

By dropping Nitrate of Lead into the liquid, it will be found that **35** grains will match the lead, and drop down accordingly, producing **132** Sulphate of Lead.

By pouring Lime Water into the remaining liquor till it ceases to throw down a precipitate, there will be found to require **24** grains of Lime to form Phosphate of Lime, exactly equal to the **24** Phosphoric Acid.

There still remains the *Nitrate of Magnesia*. By pouring in Lime Water there will come down Magnesia, as it is substituted by Lime Water; the Magnesia is a *brownish* white powder, and is seen to flow very slowly down the liquor; it amounts to 17½ Grains.

There remains then the Nitrate of Lime in a neutral state.

ESSAY ON THE QUANTITY OF ACIDS, BASES AND WATER IN THE DIFFERENT VARIETIES OF SALTS; WITH A NEW METHOD OF MEASURING THE *WATER* OF CRYSTALLIZATION, AS WELL AS THE *ACIDS* AND *BASES*.

READ AT THE LITERARY SOCIETY, OCTOBER 6TH, 1840.

In 1807 I first published in my system of Chemistry, Part I, the atom of *water;* it was 1 for Hydrogen, and 7 for Oxygen = 8, the relative weight of an atom of water. I have seen no reason for alteration from that time to this, in 1840.

In 1819, M. Thenard succeeded in fastening 2 atoms of Oxygen to 1 of Hydrogen; an instance of uncommon merit, and reflects great credit on his perseverance: I happened to be in Paris, three years after this, and was highly gratified in seeing this experiment performed by himself. This shows that *charcoal* is superior to *hydrogen* in attracting oxygen, as universally shown in books of Chemistry.

It will be seen in the 2 vol. of my Chemistry, published in 1827, that I have adopted

35 for Sulphuric Acid,

45 for Nitric Acid,

23 or rather 24, Phosphoric Acid,

19.4....Carbonic Acid,

31.8....Oxalic Acid,

17 or 17½ Magnesia,

42......Potash,

28......Soda,

24......Lime, &c. &c.

The *acids* and *bases* are tolerably well known; but the *water* is susceptible of great variation, from exposing them to heat and cold.

Since the atomic theory was discovered, various authors have given the atomic weights; some in 100 weights of the salts, and others in the acknowledged weights of the atoms. Amongst others, Dr. Thomson, Dr. Henry, Dr. Wollaston, &c. M. Gay-Lussac, Thenard, Dumas, &c., amongst the French; and Berzelius, Mitcherlish, &c. in Sweden and Germany. Some have succeeded better than others; and it is my present duty to remark on these authors.

Most of the salts contain *water*; certain degrees of heat drive off, more or less of the waters. Thus *Sulphate* of *Magnesia* contains 6 atoms of *water*, at 64° of temperature; it loses about 1 atom of water for 45° or 50° of temperature by Fahrenheit; it loses the whole, or 6 atoms of water, by 300° or 400° of heat, and does not gain it again for some days.

Bergman, who was an excellent chemist in the former part of last century, and before atomic numbers appeared, had the merit of ascertaining that *water* constituted 48 per cent of *Sulphate* of *Magnesia*, which is the very number I maintain.

Dr. Henry states the number 44 per cent of water in Sulphate of Magnesia, in 1810; but it was probably in the summer season when he made his experiments; he observes, it is nearly half the weight of the salt.

Mr. Kirwan states the water of crystallization to be 53,75 per cent in 100 grains, which Dr. Henry believes is a little above the truth.

It may not be amiss to give a list of a few of the authors who have given their respective opinions on the subject of *Water* in the *Sulphate* of *Magnesia,* to show the diversity of opinion.

Bergman. . . 1783	52 Sulphate of Magnesia	48 Water	= 6	atoms
Kirwan 1800	46.25	53.75 . .	= 7 —	atoms
Henry 1810	56	44	$=5\frac{1}{2}$	atoms
Dalton. 1810	60	40	= 5	atoms
Henry. 1815	50	50	= 6 +	atoms
Gay-Lussac. 1820	48.57.	51.43. . .	= 7 —	atoms
Thomson. . . 1825	48.57.	51.43. . .	= 7 —	atoms
*Henry 1823, 1829	48.57.	51.43. . .	= 7 —	atoms
Phillips 1824, 1836	46.4.	53.6. . . .	= 7 —	atoms
Berzelius . . . 1835	49.10.	50.90. . .	= 6 +	atoms
Dalton. 1840	52	48.	6	atoms

Generally speaking, there is *one* Acid to *one* Base, and there are a *number* of atoms of water, from one to twelve atoms, or more ; there are other salts which are destitute of water, and have nothing but an Acid and a Base.

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* There is a curious mistake in regard to the late Dr. Henry and M. Gay-Lussac.—In 1820, Tome 13, page 308, M. Gay-Lussac states, " Le Dr. " Wollaston, dans son Memoire sur les equivalens chimique, avoit fixé, " d'apres les experiéncê du Dr. Henry, le nombres equivalent, ou le poid " de l'atome de la Magnesia à 24. 6 et la quantitie d'eau dans le sulphate de " la Magnesia crystallizé à 51.527 pour cent, ou 7 atoms, &c." He goes on, &c. and finds the means of three experiments to give 51.43 for the loss per cent.

I never understood that Dr. Henry found 51.43 water in Sulphate of Magnesia; on the contrary, he quotes this (51.43) as Gay-Lussac's experiment, and not as his own, in two or three later Editions.

It is probable that M. Gay-Lussac has confounded *Mr. Kirwan's* for *Dr. Henry's* experiments.

Dr. Wollaston, in 1814, has given in the Philosophical Transactions, four salts, with the atoms of water to them, viz.—

Sulphate of Copper,.. with 5 atoms of water,
Sulphate of Iron, ... with 8 atoms of water,
Sulphate of Zinc,.... with 7 atoms of water,
Sulphate of Magnesia, with 7 atoms of water.

One or two of these are wrong ; but it is probable he has borrowed them from other quarters, and he is generally correct in other particulars.

Seven atoms of water are of rare occurrence as joined to a particular atom of salt. I have seldom or never met with it.

The new method of ascertaining the quantity of *water* in the salts is now to be discussed : I have a bottle with a stopper, which just contains 572 grains of pure water,* when the stopper is put in, and wiped clean and dry, at the temperature of 60° of Fahrenheit. A graduated tube or jar is necessary, of five or six inches long, and one quarter of an inch in diameter, to measure *exactly to a grain* of water. A platina wire is appended to the neck of the bottle, so as to be weighed more conveniently.

* Not material the *quantity* of water it contains, be it more or less.

An *ounce*, more or less, is to be weighed of any salt; it is then to be put into the bottle, capable of containing 572 grains of pure water, (the water having been carefully transferred into another glass vessel of more ample dimensions,) and the salt dissolved, and carefully transferred and weighed, in the 572 bottle again, and the spare liquor (if any), is to be put into the narrow graduated tube.

We have then 572 of pure water + the pure water of the salt + the *solid* (or *liquid* matter of the salt whatever it may be), all altogether, in a *liquid* form, in the bottle and the narrow tube.

I was greatly surprized at the results :—if the salt was *anhydrous*, it would all go into the bottle, exactly filling it to a grain; showing that the salt enters into the *pores* of the water.

If the salt contained *water*, the *quantity* of *water* was measured by the *narrow tube* in all cases whatever, showing that the *solid* matter had in reality entered the *pores* of the water.

To give an instance :—Let 100 grains of Sulphate of Magnesia be taken in its ordinary state, and afterwards made *anhydrous*, by exposing it to a temperature of 4 or 500° of Fahrenheit—then take respectively 200 and 300 grains of the same salt and expose them to the same high temperature. After they have been made *anhydrous* let each be dissolved separately in 572 grains of pure water, when it will be found that the different solutions remain of the same *bulk* as the water was previously to the salt being dissolved in it, and each solution would fill a bottle capable of containing only 572 grains of pure water. The first solution would consist of 572 grains of water + 52 grains of *solid* matter = 624 grains;—the second solution 572 grains of water + 104 grains of *solid* matter = 676 grains;—and the third 572 grains of water + 156 grains of *solid* matter = 728 grains.

But if the Sulphate of Magnesia was taken in its ordinary state, and 100 grains dissolved in 572 grains of pure water, the *water of crystallization* in the salt would increase the bulk of the water by 48 grain measures, and the solution would consist of 572 + 48 grains of *water* + 52 grains of *solid* matter = 672 grains—a solution of 200 grains of the same salt would consist of 572 + 96 grains of *water* + 104 grains of solid matter = 772 grains—and a solution of 300 grains of the salt would consist of 572 + 144 grains of *water* + 156 grains of *solid* matter = 872 grains.

The *solid* matter would go into the *pores* of the water.

It will be remembered, that the *water* and *solid matter* are the same in *bulk* as the *water* itself. This is the reason why the *narrow tube* exactly indicates the *water* of the salt.

Thus, **100** grains of *Sulphate of Magnesia* contains
48 of water, and **52** solid matter.

Thus, **200** grains of *Sulphate of Magnesia* contains
96 of water, and **104** solid matter.

Thus, **300** grains of *Sulphate of Magnesia* contains
144 of water, and **156** solid matter.

And so on in multiple proportions of the water in *bulk*, and the *solid matter* only adds to the *weight*.

I have tried the Carbonates, the Sulphates, the Nitrates, the Muriates or Chlorides, the Phosphates, the Arseniates, the Oxalates, the Citrates, the Tartrates, the Acetates, &c. &c. and have been universally successful.—Only the water adds to the *bulk*, and the *solid matter* adds to the *weight*.

The multiplier for *water* is, say **1.000** at **60°** temperature; then the multiplier for water and *solid matter* is **1.112** at **60°** temperature.

Suppose I take *water* of **1000** grains weight, and the *Sulphate of Magnesia* and *water* of **1112** grains weight, they will be of the same *bulk*.

There is a very easy method to ascertain the per centage this way, of the *solid*, in any liquid solution. It is only to lay $\frac{11.2}{100}$ per cent upon it.

To give an example: suppose **572** of solution give **615** grains weight in **572** *bottle* and **48** water, &c. to *spare*, required the *solid* matter?

```
572) 615 (1.0752
            11.2
          -------
            1504
           8272
          -----        572
          .84224        48
          ------       ---
                       620
          1684480
         505344
         -------
Solid............ 52.2
Liquid ......... 47.8
                 ----
                100
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I take **7** for *ammonia*, instead of **11.2** for the *ammoniacal* salts; but it is only for the *ammonia*, not for the *Sulphates* and *Nitrates*, &c. for the rest, that is the *Sulphates*, &c. **11.2** is used.

Some uncertainty remains in regard to this.

ON A NEW AND EASY METHOD OF ANALYSING SUGAR.

WHEN I published my Table of the relative *weights* of the ultimate particles of gases and other bodies, in October, 1803,* there were 21 I enumerated. *Hydrogen* was 1, the lowest; *Sulphuric Acid* 25.4, was the highest.

These weights were extended to 37 in 1808, in my 1st Edition of Chemistry; and in the part 2nd, in 1810, to 60 in number. In 1827, in my 2nd volume, to 80 in number.

Hydrogen was still 1; the highest was still *Silver* and *Lead*, and *Mercury;* they were 90, the weight of an atom.

One was the standard of *water* for specific gravities, at common temperature: I used to estimate the *solid matter* by fixing a small product upon the *decimal*, of 1.25 I estimated at 27 per cent of *solid*

* Vol. I. *new series*, Manchester Memoirs.

matter; and 1.50 at 56 per cent; and in this way I could estimate, with tolerable certainty, for upwards of twenty years, the value of a commodity *in solution with water* in a general way.

In a paper read to this Society, March 31st, 1840, "On the quantity of *Acids, Bases,* and *Water*, in the different varieties of Salts, with a new method of measuring the *water* of crystallization," I hit upon the mode of taking the *water* and the *salt* separately. The *water* was 572 grains; the salt was more or less, but it was *exactly* weighed.

I soon found that the *water* of the salt (if any was present) was measured *exactly* by the *narrow* tube. If 20 or 100 grains, more or less, it was 20 or 100 grains, and the bottle was always full besides.

It soon occurred to me, that if an *anhydrous* salt was the subject in solution in 572 water, it would all go into the bottle, *exactly filling it;* and I found it to be the case in all instances, whether it was 10 grains or 200 grains of *anhydrous* salt, it would go into the bottle, exactly filling it. This fact was new to me, and I suppose to others. It is the greatest *discovery* that I know of next to the atomic theory.

Whether 1, the *weight* of an atom of hydrogen, or 90, the *weight* of an atom of lead, were in proportion to their *weight* or to their *bulk*, I had never made up my mind. Upon the whole I was inclined to think that they were in proportion to their *weights* till within a few months ago; I am now *decidedly* of opinion that they are in proportion to their *bulks*, as will be demonstrated, I think, by their crystallization; and it is to be observed, more especially, in the article *Sugar*, which I find is the most *easy* to analyze, and it has been the most *difficult*. Witness the very difficult processes of Dr. Ure and Dr. Prout, with that of 24 tapers burning underneath to equalize the heat.

It is my opinion that the simple atoms are *alike*, *globular*, and all of the same *magnitude* or *bulk*, whether of *hydrogen* 1, or *lead*, 90.

My friend Mr. Ewart, at my suggestion, made me a number of equal balls, about an inch in diameter, about 30 years ago; they have been in use ever since, I occasionally showing them to my pupils. One ball had 12 holes in it, equidistant; and 12 pins were stuck in the other balls, so as to arrange the 12 around the one and be in contact with it: they (the 12) were about $\frac{1}{10}$ of an inch asunder. Another ball, with 8 equidistant holes in it: and they (the 8) were about $\frac{3}{10}$ of an inch asunder, a regular series of equidistant atoms.

The 7 are an awkward number to arrange around 1 atom.

The 6 are an equidistant number of atoms, 90° asunder, 2 at the poles, and 4 at the equator.

The 5 are a *symmetrical* number, 2 at the poles, and 3 at the equator: but the 3 at the equator are 120° asunder, and the 2 at the poles are 90° from the equator.

The 4 is a split of the 8, a regular number and equidistant.

The 3 are around the equator at 120° asunder.

The 2 at two opposite poles, &c.

I had no idea at that time (30 years ago) that the atoms were all of a *bulk;* but for the sake of illustration I had them made alike.

I exposed 100 grains of Sugar for half an hour to a heat of 270° or 300° Fahrenheit: it was beginning to become fluid, about 2 — grains; but the rest was *solid* and a little browned.

I have a bottle that holds 572 grains of water up to the neck, and a nicely ground stopper, so as to be wiped clean and dry; this is to be filled with distilled water, and then poured into a convenient glass with a spout to it, that it may be re-conveyed into the bottle again.

One hundred grains of *double refined* Sugar,* carefully weighed, are to be poured into the glass, and stirred about with a very slender stick of glass till it is all dissolved. It is then to be re-conveyed into the bottle, taking care that there is not a drop lost; a little dexterity is required, but it is easily managed; the *glass rod* is to be regarded, and the best way is to *stroke* the glass rod till it is clean and dry. Then the remainder is to be poured into the *narrow tube*,† and the number of grains is then read off.

Fifty grains may be used, more or less, of the

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* *Double* and *Single* refined are all the same.

† The *narrow tube* is to measure the grains of *water and sugar* overplus, or *water* itself, which is the same *measure*.

Sugar, but 100 grains I mostly used. I generally used 100 grains for the *prime* experiment.

	100	Sugar grains, dissolved in
	572	Water grains
gave	672	grains by weight.
In specific gravity Bottle	606	grains
In narrow tube	66	grains
	672	grains by weight.

The specific gravity bottle did not vary more than 606 or 607, or 1 grain at most.

It was long known that Sugar was disposed to resolve itself *Solid* and *Liquid*. The *solid* part is *charcoal*, and the *liquid* part is *water*.

Gay-Lussac and *Thenard* had set that matter at rest.

I had the Memoir of *Gay-Lussac* and *Thenard* by me, and did not know, two days ago, that I had it. I was curious to look at it, and to my surprise it was, 42.47 charcoal.

and 57.53 water.

100

The Memoir was printed in 1811, and I suppose I must have got it at Paris in 1822.

	Weight.		
I made mine	42.37	charcoal,	retaining 5.4 for the weight of an atom,
and	57.73	water,	retaining 8 for the weight of an atom.
	100		

according to my weight in Vol. 2, page 352.

The Memoir alluded to was by burning the charcoal by oxmuriate of potash ; a mode very different from mine, which is much more simple ; but the former was much better than had hitherto been used.

I find 9 *charcoal* atoms,
and 8 *water* atoms are in combination.

That is, 1 *central* atom charcoal ;
and 8 *water* and *charcoal* combined ; that is,
8 triplets.

The way I arrange them is the *only* way they can be arranged, in globular atoms all of a size, or they would interfere with one another.

Central 1 atom of *charcoal*.
8 atoms of *oxygen*, around the central atom, not in contact.
16 atoms of *charcoal* and *hydrogen*, around the *oxygen*, in contact.

No *contact* between oxygen and oxygen, charcoal and charcoal, and hydrogen and hydrogen, whatever; they having a *repulsion* to each other.

—100 grains of Sugar in 572 water will be exhibited crystallized; it is very differently crystallized, and yet is the same *weight* as before.

—100 *East India* Sugar, such as is commonly used; it has a *superabundance* in charcoal ½ grain.

—100 *West India* Sugar, such as is commonly used; it has also a *superabundance* of charcoal* 1 grain.

Dr. Turner and Dr. William Gregory, (page 914) in their Edition, mentions as *Leibig's* statement, C 12, H 9, O 9, + 2 aq., that is 16 nearer the *water*, but is still somewhat wide of the truth. In some modern books we have 12C, H11, O11, which is very near the truth.

Why would not they appeal to the *original authors* in 1811?

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* One hundred grains of refined Sugar, after being dissolved in 572 of water, will be exhibited in crystals; it is a very different state of *crystallisation*, after being done in a slow oven of 4 or 500° of heat. It is of 4 or 5 tenths of an inch across in a small circular plate from a centre, very different from what we see in ordinary. It is the same in *weight*, not losing 1 grain; after being kept two or three years it is 100 grains still: I should suppose if it was kept 100 years, it would be of the same weight, not losing a particle.

It is most remarkable that there are 5.4 atoms charcoal; but these are in atomic proportions: for

charcoal water hydrogen. water. charcoal. water.

5.4 : 8 :: 43 : 57., or **5.4 : 1 + 7 :: 43 : 57.**

Now that I have found the *clue* to the theory of this kind of atoms, I have only to follow on the clue methodically.

SUGAR.

— **1** is the central atom of *charcoal;*

— 8 on surrounding it of *oxygen, apart* from each other; and

—16 of *charcoal* and *hydrogen* in contact with each other; and in all **25** atoms to form **1** atom of *Sugar.*

TARTARIC ACID.

— **1** is the central atom of *charcoal;*

— **6** surrounding it of *oxygen, apart* from each other;

—12 of *charcoal* and *hydrogen* in contact with each other; in all **19** atoms to form an atom of *Tartaric* Acid.

ACETIC ACID.

—**1** is the central atom of *charcoal;*

—**4** are surrounding it of *oxygen, apart* from each other; and

—8 of *charcoal* and *hydrogen* in contact with each other; in all **13** atoms to form an atom of *Acetic* acid.

OXALIC ACID.

—1 is the central atom of *charcoal;* and

—2 are atoms of *oxygen, apart* from each other; and

—4 are the surrounding atoms of *oxygen* and *hydrogen* in contact with each other. 7 in all the atoms of *Oxalic* acid, and 4 of water.

VINIC ACID.

—1 is the *central* atom of *charcoal; hydrate* of *Water* is the surrounding atom in the *Vinic* acid.

CITRIC ACID.

—1 is the *central* atom of *charcoal;* (if it may be so called) 1 atom of *water* is attached to it. As *Berzelius* found long ago. Vol. V. 1815, Dr. Thomson's Journal.

The *Experimentum crucis* after all is in the following example :—Take 100 grains of *Sugar,* dissolve it in 100 *water,* which will just melt it (after stirring about awhile with a small glass rod;) then pour it out into a glass *measure* of upwards 160 grains ; it will be found 157 grains precisely.

The 57 grains of *pure* water has arisen out of the Sugar, and the 43 grains remain in, buried *invisibly* in the *pores* of the water. This follows, as all *solid* bodies remain in *fluids*, adding to the *weight* and not to the *bulk* of them, as I have shewn in my paper, on the Quantity of Acids, Bases and Water in Salts, &c.