Elements of Chemistry

Antoine-Laurent Lavoisier

C H A P. I.

Of the Inſtruments neceſſary for determining the Abſolute and Specific Gravities of Solid and Liquid Bodies.

THE beſt method hitherto known for determining the quantities of ſubſtances ſubmitted to chemical experiment, or reſulting from them, is by means of an accurately conſtructed beam and ſcales, with properly regulated weights, which well known operation is called *weighing*. The denomination and quantity of the weights uſed as an unit or ſtandard for this purpoſe are extremely arbitrary, and vary not only in different kingdoms, but even in different provinces of the ſame kingdom, and in different cities of the ſame province. This variation is of infinite conſequence to be well underſtood in commerce and in the arts; but, in chemiſtry, it is of no moment what particular denomination of weight be employed, provided the reſults of experiments be expreſſed in convenient fractions of the ſame denomination. For this purpoſe, until all the weights uſed in ſociety be reduced to the ſame ſtandard, it will be ſufficient for chemiſts in different parts to uſe the common pound

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pound of their own country as the unit or ſtandard, and to expreſs all its fractional parts in decimals, inſtead of the arbitrary diviſions now in uſe. By this means the chemiſts of all countries will be thoroughly underſtood by each other, as, although the abſolute weights of the ingredients and products cannot be known, they will readily, and without calculation, be able to determine the relative proportions of theſe to each other with the utmoſt accuracy; ſo that in this way we ſhall be poſſeſſed of an univerſal language for this part of chemiſtry.

With this view I have long projected to have the pound divided into decimal fractions, and I have of late ſucceeded through the aſſiſtance of Mr Fourche balance-maker at Paris, who has executed it for me with great accuracy and judgment. I recommend to all who carry on experiments to procure ſimilar diviſions of the pound, which they will find both eaſy and ſimple in its application, with a very ſmall knowledge of decimal fractions *.

As

* Mr Lavoiſier gives, in this part of his work, very accurate directions for reducing the common ſubdiviſions of the French pound into decimal fractions, and *vice verſa*, by means of tables ſubjoined to this 3d part. As theſe inſtructions, and the table, would be uſeleſs to the Britiſh chemiſt, from the difference between the ſubdiviſions of the French and Troy pounds, I have omitted them, but have ſubjoined in the appendix accurate rules for converting the one into the other.—E.

As the ufefulnefs and accuracy of chemiftry depends entirely upon the determination of the weights of the ingredients and products both before and after experiments, too much precifion cannot be employed in this part of the fubject; and, for this purpofe, we muft be provided with good inftruments. As we are often obliged, in chemical proceffes, to afcertain, within a grain or lefs, the tare or weight of large and heavy inftruments, we muft have beams made with peculiar nicenefs by accurate workmen, and thefe muft always be kept apart from the laboratory in fome place where the vapours of acids, or other corrofive liquors, cannot have accefs, otherwife the fteel will ruft, and the accuracy of the balance be deftroyed. I have three fets, of different fizes, made by Mr Fontin with the utmoft nicety, and, excepting thofe made by Mr Ramfden of London, I do not think any can compare with them for precifion and fenfibility. The largeft of thefe is about three feet long in the beam for large weights, up to fifteen or twenty pounds; the fecond, for weights of eighteen or twenty ounces, is exact to a tenth part of a grain; and the fmalleft, calculated only for weighing about one gros, is fenfibly affected by the five hundredth part of a grain.

Befides thefe nicer balances, which are only ufed for experiments of refearch, we muft have

P p others

others of lefs value for the ordinary purpofes of the laboratory. A large iron balance, capable of weighing forty or fifty pounds within half a dram, one of a middle fize, which may afcertain eight or ten pounds, within ten or twelve grains, and a fmall one, by which about a pound may be determined, within one grain.

We muft likewife be provided with weights divided into their feveral fractions, both vulgar and decimal, with the utmoft nicety, and verified by means of repeated and accurate trials in the niceft fcales; and it requires fome experience, and to be accurately acquainted with the different weights, to be able to ufe them properly. The beft way of precifely afcertaining the weight of any particular fubftance is to weigh it twice, once with the decimal divifions of the pound, and another time with the common fubdivifions or vulgar fractions, and, by comparing thefe, we attain the utmoft accuracy.

By the fpecific gravity of any fubftance is underftood the quotient of its abfolute weight divided by its magnitude, or, what is the fame, the weight of a determinate bulk of any body. The weight of a determinate magnitude of water has been generally affumed as unity for this purpofe; and we exprefs the fpecific gravity of gold, fulphuric acid, &c. by faying, that gold is nineteen times, and fulphuric acid twice the weight of water, and fo of other bodies.

It

It is the more convenient to aſſume water as unity in ſpecific gravities, that thoſe ſubſtances whoſe ſpecific gravity we wiſh to determine, are moſt commonly weighed in water for that purpoſe. Thus, if we wiſh to determine the ſpecific gravity of gold flattened under the hammer, and ſuppoſing the piece of gold to weigh 8 *oz.* 4 *gros* 2½ *grs.* in the air *, it is ſuſpended by means of a fine metallic wire under the ſcale of a hydroſtatic balance, ſo as to be entirely immerſed in water, and again weighed. The piece of gold in Mr Briſſon's experiment loſt by this means 3 *gros* 37 *grs.*; and, as it is evident that the weight loſt by a body weighed in water is preciſely equal to the weight of the water diſplaced, or to that of an equal volume of water, we may conclude, that, in equal magnitudes, gold weighs 4893½ *grs.* and water 253 *grs.* which, reduced to unity, gives 1.0000 as the ſpecific gravity of water, and 19.3617 for that of gold. We may operate in the ſame manner with all ſolid ſubſtances. We have rarely any occaſion, in chemiſtry, to determine the ſpecific gravity of ſolid bodies, unleſs when operating upon alloys or metallic glaſſes; but we have very frequent neceſſity to aſcertain that of fluids, as it is often the only means of judging of their purity or degree of concentration.

This

* Vide Mr Briſſon's Eſſay upon Specific Gravity, p. 5.—A.

This object may be very fully accomplished with the hydrostatic balance, by weighing a solid body; such, for example, as a little ball of rock cristal suspended by a very fine gold wire, first in the air, and afterwards in the fluid whose specific gravity we wish to discover. The weight lost by the cristal, when weighed in the liquor, is equal to that of an equal bulk of the liquid. By repeating this operation successively in water and different fluids, we can very readily ascertain, by a simple and easy calculation, the relative specific gravities of these fluids, either with respect to each other or to water. This method is not, however, sufficiently exact, or, at least, is rather troublesome, from its extreme delicacy, when used for liquids differing but little in specific gravity from water; such, for instance, as mineral waters, or any other water containing very small portions of salt in solution.

In some operations of this nature, which have not hitherto been made public, I employed an instrument of great sensibility for this purpose with great advantage. It consists of a hollow cylinder, *Abcf*, Pl. vii. fig. 6. of brass, or rather of silver, loaded at its bottom, bcf, with tin, as represented swimming in a jug of water, *lmno*. To the upper part of the cylinder is attached a stalk of silver wire, not more than three fourths of a line diameter, surmounted by

a

a little cup *d*, intended for containing weights; upon the ſtalk a mark is made at *g*, the uſe of which we ſhall preſently explain. This cylinder may be made of any ſize; but, to be accurate, ought at leaſt to diſplace four pounds of water. The weight of tin with which this inſtrument is loaded ought to be ſuch as will make it remain almoſt in equilibrium in diſtilled water, and ſhould not require more than half a dram, or a dram at moſt, to make it ſink to *g*.

We muſt firſt determine, with great preciſion, the exact weight of the inſtrument, and the number of additional grains requiſite for making it ſink, in diſtilled water of a determinate temperature, to the mark: We then perform the ſame experiment upon all the fluids of which we wiſh to aſcertain the ſpecific gravity, and, by means of calculation, reduce the obſerved differences to a common ſtandard of cubic feet, pints or pounds, or of decimal fractions, comparing them with water. This method, joined to experiments with certain reagents *, is one of the beſt for determining the quality of waters, and is even capable of pointing out differences which eſcape the moſt accurate chemical analyſis. I ſhall, at ſome future period,

* For the uſe of theſe reagents ſee Bergman's excellent treatiſe upon the analyſis of mineral waters, in his Chemical and Phyſical Eſſays.—E.

period, give an account of a very extenfive fet of experiments which I have made upon this fubject.

Thefe metallic hydrometers are only to be ufed for determining the fpecific gravities of fuch waters as contain only neutral falts or alkaline fubftances; and they may be conftructed with different degrees of ballaft for alkohol and other fpiritous liquors. When the fpecific gravities of acid liquors are to be afcertained, we muft ufe a glafs hydrometer, as reprefented Pl. vii. fig. 14 †. This confifts of a hollow cylinder of glafs, *a b c f*, hermetically fealed at its lower end, and drawn out at the upper into a capillary tube *a*, ending in the little cup or bafon *d*. This inftrument is ballafted with more or lefs mercury, at the bottom of the cylinder introduced through the tube, in proportion to the weight of the liquor intended to be examined: We may introduce a fmall graduated flip of paper into the tube *a d*; and, though thefe degrees do not exactly correfpond to the fractions of grains in the different liquors, they may be rendered very ufeful in calculation.

What is faid in this chapter may fuffice, without farther enlargement, for indicating the means

† Three or four years ago, I have feen fimilar glafs hydrometers, made for Dr Black by B. Knie, a very ingenious artift of this city.—E.

means of afcertaining the abfolute and fpecific gravities of folids and fluids, as the neceffary inftruments are generally known, and may eafily be procured: But, as the inftruments I have ufed for meafuring the gaffes are not any where defcribed, I fhall give a more detailed account of thefe in the following chapter.

CHAP.

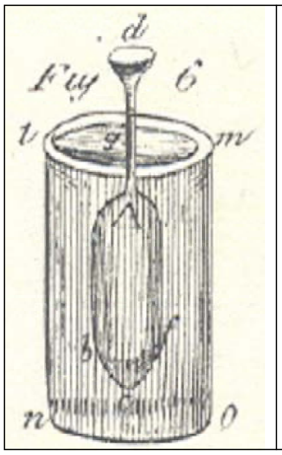

Figure 6. Plate VII.

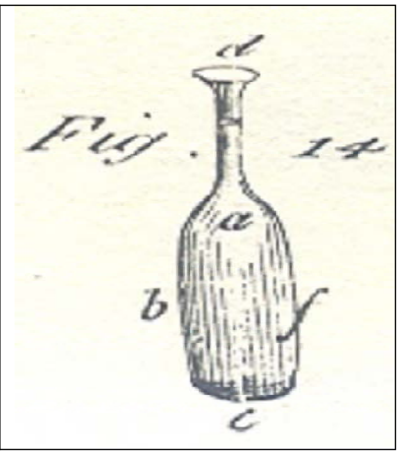

Figure 14. Plate VII.