CHAPTER 1

SIMPLE SUBSTANCES

The [49] antiphlogiston revolution accomplished by Lavoisier is the starting point for the discoveries which constitute modern chemistry. The discoveries seem to have had as their principal effect and, according to most chemists, as their true object, the triumph, in completeness and precision, of the atomic notion of a mixt.

Although it contributed indirectly to this work in making possible all the subsequent research, the law of the *conservation of mass* in chemical combination did not have any direct influence on the notion of a mixt. It did not do the same as the theory of combustion and the creation of a new chemical nomenclature intimately connected with this theory, because they fixed the notion of a *chemically simple substance.*

The ancient alchemists supposed that all substances were formed from the same elements, few in number, but variously combined. Given this point of departure, the transmutation of the various substances that nature offers us seemed possible. For many substances, this transformation was easily accomplished. It was never senseless to think along these lines.[1]

The scientific renaissance was at first careful not to condemn these attempts. Bacon[2] assigns [50] as the purpose of the new physics: "to give to silver the colour of gold or a more considerable weight ..., or transparency to some non-diaphanous stone, or tenacity to glass."

However, the continual and resounding failures of the alchemists, persevering with the transmutation of metals, was to open[3] the eyes of the physicists. Without denying that all substances might be composed of the same elements few in number, Boyle[4] was the first who dared proclaim that, in certain cases, elementary corpuscles might unite in a particularly intimate fashion, and "form a new body

1 pour beaucoup de corps, cette transmutation s'accomplissait aisément; il n'était nullement insensé d'en poursuivre pour tous l'achèvement.

2 Bacon, *Novum Organum*, pars ædificans.

3 *désiller.*

4 Boyle, *The sceptical Chymist*, Part. II. [The following quotation is essentially the latter part of the longer extract quoted in Pt. 1, Ch. 2, here translated directly into modern English from Duhem's French rendering, which is somewhat different from his earlier translation.]

endowed with an individuality as real as that of the elementary corpuscles before their union; neither fire, nor any known method of analysis, can further divide this body in such a manner as to separate the corpuscles which have combined to form it; nor can the same methods subdivide these [corpuscles] into other particles."

We have seen Lémery, then Stahl, then de Venel adopt Boyle's idea and apply it to metals which preserve their individuality through the hottest fires and the most complicated chemical transformations. It is this idea that inspired the school of Lavoisier to define the chemically simple substance.

It is no longer a philosophical question whether material is reducible to a single principle or a small number of principles present in all substances. All cases of a substance which has resisted all known means of analysis are called *simple substances*, and the chemist declares himself satisfied when he has resolved a substance into a certain number of such simple substances.

Such a substance is always merely *provisionally* simple; indecomposable today, it might yield tomorrow to another method of analysis. Potash and caustic soda were such substances until the day came when the voltaic pile allowed Humphrey Davy to realise the [51] predictions of Lavoisier and isolate potassium and sodium.

"We would contradict all we have just revealed," says Lavoisier[5], "if we were to devote ourselves to the great discussions of the principles constituting bodies and of the elementary molecules. We are here content to regard as simple all those substances that we have not been able to decompose, all that we obtain as the last result of chemical analysis. Perhaps those substances which are simple for us will one day be decomposed in their turn, and we are probably close to this time for siliceous clay and for the fixed alkalis; but our imagination should not outstrip the facts, and we have not had to say more than nature teaches us."

Much later, Lavoisier writes[6]: "All that can be said about the number and nature of the elements is confined, in my opinion, to purely metaphysical discussions, which propose to resolve indefinite problems that are susceptible of infinitely many solutions, none of which accords, in all probability, with nature. I will therefore be content to say that, if by the term 'element' we intend to designate the simple and invisible molecules of which bodies are composed, it is probable that we know nothing of them. But if, on the other hand, we attach to the term 'element' or 'principle of bodies' the idea of the last term reached by analysis, all the substances that we are still unable to decompose by any means are for us elements. This does not assure us that substances that we regard as simple might not be composed of two or more principles, but since [52] these principles are never separated, or rather since we have no means of separating them, they behave as far as we are concerned

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5 Lavoisier, *Mémoire sur la nécessité de réformer et perfectionner la nomenclature de la Chimie*, read to the Public Assembly of the Royal Academy of Science on 18 April, 1787.—In: *Méthode de nomenclature chimique*, proposed by de Morveau, Lavoisier, Berthollet, and de Fourcroy, Paris, 1787.

6 Lavoisier, *Traité élémentaire de Chimie*, Discours préliminaire (3rd. edition, vol. I, p. xvi).

like simple substances and we should not suppose them to be compounded until such time as observation and experience have furnished us with proof to that effect."

"We cannot therefore claim," Lavoisier says in another place[7], "that what we today regard as simple is in fact so. All we are able to say is that such a substance is a recognised term of contemporary chemical analysis, which according to our present state of knowledge cannot be further subdivided. Presumably the earths will soon cease to be counted as simple substances ..."

The provisional and empirical character of the definition of simple substance leaves the field free to the philosopher whose hypotheses, more powerful than the practice of chemical analysis, claim to decompose substances which have resisted all reagents. Some of these hypotheses on the unity of material have long enjoyed favour, such as the theory of Prout, which has it that all substances are formed from condensed hydrogen and which stole the adherence of the illustrious J.-B. Dumas. Moreover, the interest that they have engendered, in these latter years, by research relating to *agentaurum* clearly shows that chemists have retained, with Bacon, the hope "of giving to silver the colour of gold or a more considerable weight." Certainly, the idea of simple substances that these chemists created differs little from the notion of a mixt decomposable only with difficulty, defined by Boyle, Lémery and Stahl.

7 Lavoisier, *Traité élémentaire de Chimie*, 3rd. edition, vol. I, p. 194.

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