Jean-Baptiste Dumas, "The Equivalents of Simple Substances"

Excerpted from *Annales de Chimie* [3], 55 (1859), 129–210.[1]

If I have thought it necessary to revise the equivalents of the simple substances, it was ... because these figures seem to open new and important horizons to natural philosophy by the regular relationships which they reveal.

When we bring together the results obtained for the simple substances and then compare two series or natural families of the radicals in organic chemistry, such as the ammonium- and methylium-derivatives, we find the deepest analogy between them. Thus we have:

				(In the horizontal lines)
Fluor	19	Nitrogen	14	
Chlorine	35.5	Phosphorus	31	common difference = 5
Bromine	80	Arsenic	75	
Iodine	127	Antimony	122	
Magnesium	12	Oxygen	8	
Calcium	20	Sulphur	16	
Strontium	43.75	Selenium	39.75	common difference = 4
Barium	68.5	Tellurium	64.5	
Lead	103.5	Osmium	99.5	
Ammonium	18	Methyl	15	
Methylammonium	32	Ethyl	29	
Ethylammonium	46	Propyl	43	common difference = 3
Propylammonium	60	Butyl	59	
etc.		etc.		

When the radicals of mineral chemistry, as well as those of organic chemistry, are arranged according to their equivalent weight on a straight line for one and the same family, those for two comparable families are parallel lines.

This analogy raises doubt concerning the nature of the simple substances and would seem to justify so many bold estimates of the probability of decomposing them that I believe it will be useful to say what I think in this respect, while pointing out the network of ideas on which the analogy itself is based.

Today, many chemists follow the course of accepted opinions and do not imagine the fortunate mixture of boldness and prudence with which Lavoisier in his time established the classification of those substances that he had to call simple because the chemical forces were incapable of decomposing them. He put them into five categories. ...

While establishing the existence of thirty-two substances that are indecomposable by the means then known and, therefore, considering them chemically simple, he (Lavoisier) also introduced the existence of a class of still simpler substances. Of these, five in number, he makes a special class under the title: Simple substances that belong to all three realms (i.e., mineral, vegetable, animal) and can thus be considered as the elements of all substances. They are: light, heat, oxygen, nitrogen, and hydrogen.

I summarize:

The compounds of the three realms are reduced by analysis to a number of radicals that can be classified into natural families. The characters of these families show incontestable analogies; but the radicals of mineral chemistry differ from those of organic chemistry by the fact that, if they are composited, at least they are so stable that all known forces are incapable of bringing about their decomposition.

Nevertheless, this analogy between the radicals of mineral chemistry and those of organic chemistry certainly justifies the question whether the first are composite substances like the second. We must add that the analogy does not give any indication of the means for the decomposition and also that if that decomposition should ever be carried out, it will be by the use of forces or reactions we cannot even imagine now.

As radicals of mineral chemistry, the equivalents of the simple substances all seem to be multiples of a certain unit that would be equal to 0.5 or 0.25 of the equivalent weight of hydrogen.

When the equivalents of radicals of some family, of mineral or of organic chemistry, are arranged in a series, the first term determines the chemical character of all the substances in the series.

Ammonium is represented again in all its essential qualities by the ammonium compounds. Methylium gives its form and behavior to all the radicals of alcohols and ethers. The type of fluorine reappears in chlorine, bromine, and iodine; the type of oxygen in sulphur, selenium, and tellurium; that of nitrogen in phosphorus, arsenic, antimony; that of titanium in tin, of molybdenum in tungsten, etc.

This can be expressed as follows: call a the first member of a progression and d its rate; then in each equivalent $(a + nd)$, a gives the fundamental chemical character and determines the genus, while nd determines only the place in the series and establishes the species.

[1] [Copied from Eduard Farber, Ed., *Milestones of Modern Chemistry*, Basic Books, New York, 1966, pp 12-14. Translation by Farber. —CJG]