THE THEORIES OF CHEMISTRY

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649719938

The Theories of Chemistry by Edgar F. Smith

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

www.triestepublishing.com

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Trieste

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By

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PHILADELPHIA
THE JOHN C. WINSTON CO.
1913

PREFACE

This volume represents a desire on the part of the writer to place in the hands of his students a concise account of the development of the numerous theories of chemistry. It is his purpose to use it as a text-book, to be supplemented by lectures. And it is further hoped that the material presented may serve as a basis for more extended study. No claim is made for originality. It is an old, old story—many times told—gathered from innumerable and even forgotten sources, to which most cordial acknowledgments are here made for all borrowed facts and statements. The writer is likewise under many obligations to Miss Sarah P. Miller, Ph.D., Girls' High School, Philadelphia, for the skill and patience she has shown in condensing hundreds of pages of manuscript into the present compact form, and superintending the proof-reading and press work with the utmost fidelity and care.

THE THEORIES OF CHEMISTRY.

The Grecian philosophers were the first persons who undertook an explanation of the creation and destruction of nature. The chief aim of the pre-Socratic philosophy was to account for natural phenomena. Every individual on viewing nature and the phenomena of nature regarded that one thing as the original of all other things, which to him seemed to be the most remarkable. Thus, Thales considered water to be the protoype, because he knew that without it life was impossible. Pythagoras said numbers were the cause of all things, for the reason that on considering the movements of heavenly bodies in accordance with mathematical laws numbers seemed to him to be most important and impressed him most deeply. Heraclitus said fire was the cause of all things, and Anaximander declared it to be matter. In the opinion of Empedocles matter consisted of four elements: earth, air, fire and water.

Aristotle maintained that there was an ur-substance at the basis of all things. This ur-substance could not be annihilated—it made all things possible. It had potentiality, but it was not real or actual. It possessed four fundamental properties. It was warm, cold, moist and dry. The union of any two of these properties gave rise to one of the four elements of Empedocles. Thus, earth was dry plus cold; fire was dry plus warm; water was moist plus cold; and air was moist plus warm. Differences in the material world were thus ascribed to the properties inherent in matter. Aristotle thought

there was a fifth element, which he called ousia-ether. It penetrated everything.

These ideas of Aristotle and Empedocles are thought to have been borrowed from even earlier sources. In other words, there were men before them who entertained similar notions.

Alchemy added many substances to the list of elements (earth, air, fire, water and ousia-ether) previously mentioned, in order to account for the properties of the metals. Geber introduced sulphur and mercury into the list. These he considered the basis of the metals. This is the first attempt to explain differences in substances by assuming a peculiar composition. Albertus Magnus, Roger Bacon, Raymond Lully, Arnold Villanovanus and a host of alchemists accepted, in the main, this thought of Geber. Basil Valentine thought salt was an element. To the alchemist sulphur represented the properties of alterability, decomposability and combustibility. Mercury represented metallicity, which was the cause of metallic luster and malleability. Salt stood for the property that resisted fire.

During the age of alchemy, the first attempts were made to convert the base metals into gold or silver. The belief in the "transformation or transmutation of the metals" held a powerful charm and led the men of this period to labor incessantly, by every conceivable means, in order to attain this end.

Later Paracelsus declared that the three elements, sulphur, mercury and salt, were not only the ingredients

of metals but also of all bodies, animal and vegetable alike. Paracelsus viewed disease as a disturbance of the proper proportion and correct "make-up" of these elements; hence he strove to eliminate the disturbance by external means, and in so doing became the founder of the school of iatro-chemists. This school made two great mistakes. It attempted to account for all life processes by chemical means, and it set a too narrow limit upon the domain of chemistry.

The greatest of the iatro-chemists were Paracelsus, Libavius and van Helmont, all of whom believed in the transmutation of metals, by means of the philosopher's stone, and in the *elixir vitæ*. The latter objected to the idea of the earth being an element.

The man who bitterly opposed Aristotle's teachings, who placed chemistry upon a scientific basis and who freed it from the shackles of "gold-making" and "healing" and the old doctrines of the constitution of matter, was Robert Boyle (1626–1691). He taught that all compounds in nature were derived from an ur-substance; that the many differences existing in these compounds were due to the varying properties of the minutest particles of this ur-substance, and that the varying forms and sizes of these particles, their movements, their positions at rest and their positions relative one to the other exercised a very marked influence upon the differences existing in these bodies or compounds. "These minutest particles," said Boyle, "consisted of substances extremely difficult to decompose." They entered into and came out of the compounds without sustaining any alterations

or changes whatsoever; hence these minutest particles were elements in the sense of that term as understood to-day. According to Boyle, chemical union consisted in the attraction of these minutest particles (the corpuscula—the constituents) one to the other, and chemical decomposition occurred when one of the two constituents of a compound had a greater attraction, a greater affinity for a third than for the one with which it was combined.

Boyle knew that increase in weight followed combustion. He had verified this by heating lead in a closed retort, but he was so thoroughly imbued with the dominant ideas of his time, namely, that increase in weight was due to the interpenetration of fire matter (union with fire), that it was not possible for him to clearly comprehend the nature of the substance governing this increase in weight. Mark, that *Robert Boyle weighed*. He called attention in 1662 to facts regarding the elasticity of air, and asserted that the volume occupied by a given mass of gas under different pressures is inversely as the pressure.

Hooke (1635–1665), in England, observed that saltpeter when heated gave out something capable of supporting combustion. His experiments are recorded in a little pamphlet, entitled "Micrographia."

Mayow, another Englishman (1645–1679), said that the spirit of saltpeter and the *spiritus nitroaerus* of air were one and the same, and it was this spirit which combined with lead and iron when they burned in air.

These germs of the correct idea of combustion, introduced by Hooke and Mayow, were doomed to pass into oblivion; for a German named Becher (1635–82) was