A

SYSTEM

OF

CHEMISTRY.

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CHEMISTRY.

IN FIVE VOLUMES.

By THOMAS THOMSON,

M.D. F.R.S.E.

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PART II.

CHEMICAL EXAMINATION
OF NATURE.

HAVING, in the First Part of this Work, given a very full detail of the principles of Chemistry, and a description of the different Substances with which it is necessary for the Chemist to be acquainted, I propose, in this Second Part, to take a view of the different substances as they exist in nature, constituting the material world, that we may ascertain how far the science of chemistry will contribute towards explaining their nature, and accounting for the different changes which they produce on each other. Now the different substances of which the material world, as far as we have access to it, is composed, may be very conveniently arranged under the five following heads:

1. The Atmosphere,
2. Waters,
3. Minerals,
4. Vegetables,
5. Animals.

These five divisions will form the subject of the five following Books.

BOOK I.

OF THE

ATMOSPHERE.

Book I.

THE atmosphere is that invisible elastic fluid which surrounds the earth to an unknown height, and encloses it on all sides. It received its name from the Greeks, in consequence of the vapours which are continually mixing with it. When the chemist turns his attention to the atmosphere, there are two things which naturally engage his attention: First, to ascertain the substances of which it is composed; and, secondly, to trace the changes to which it is liable. I shall therefore divide this Book into two Chapters. In the first, I shall examine the component parts of the atmosphere; and, in the second, examine the changes to which it is liable, under the title of METEOROLOGY.

CHAP. I.

COMPOSITION OF THE ATMOSPHERE.

Opinions of the ancients.

NEITHER the properties nor the composition of the atmosphere seem to have occupied much of the attention of the antients. Aristotle considered it as one of the four elements, situated between the regions of *water* and *fire*, and mingled with two *exhalations*, the *dry* and the *moist;* the first of which occasioned thunder, lightning, and wind; while the second produced rain, snow, and hail. The ancients, in general, seem to have considered the blue colour of the sky as essential to the atmosphere; and several of their philosophers believed that it was the constituent principle of other bodies, or at least that air and other bodies are mutually convertible into each other *. But these opinions continued in the state of vague conjectures, till the matter was explained by the sagacity of Hales, and of those philosophers who followed his illustrious career.

* Thus Lucretius:

Semper enim quodcunque fluit de rebus, id omne
Aeris in magnum fertur mare: qui nisi contra
Corpora retribuat rebus, recreetque fluenteis,
Omnia jam resoluta forent, et in aera versa.
Haud igitur cessat gigni de rebus et in res
Recidere assidue, quoniam fluere omnia constat. *Lib.* v. 274.

Book I.

Discoveries of the moderns.

It was not till the time of Bacon, who first taught mankind to investigate natural phenomena, that the atmosphere began to be investigated with precision. Galileo introduced the study by pointing out its weight; a subject which was soon after investigated completely by Torricelli, Paschal, &c. Its density and elasticity were ascertained by Boyle and the Florence Academicians. Mariotte measured its dilatability; Hooke, Newton, Boyle, Derham, pointed out its relation to light, to sound, and to electricity. Newton explained the effect produced upon it by moisture; from which Halley attempted to explain the changes in its weight indicated by the barometer. But a complete enumeration of the discoveries made upon the atmosphere in general belongs to *pneumatics*; a science which treats professedly of the mechanical properties of air.

Component parts of the atmosphere.

The knowledge of the component parts of the atmosphere did not keep pace with the investigation of its mechanical properties. The opinions of the earlier chemists concerning it are too vague and absurd to merit any particular notice. Boyle, however, and his contemporaries, put it beyond doubt that the atmosphere contained two distinct substances. 1. An elastic fluid distinguished by the name of *air*. 2. Water in the state of vapour. Besides these two bodies, it was supposed that the atmosphere contained a great variety of other substances, which were continually mixing with it from the earth, and which often altered its properties, and rendered it noxious or fatal. Since the discovery of carbonic acid gas by Dr Black, it has been ascertained that this elastic fluid always constitutes a part of the atmosphere. The constituent parts of the atmosphere therefore are,

1. Air, 3. Carbonic acid gas,
2. Water, 4. Unknown bodies.

These shall form the subject of the four following Sections. But before proceeding to ascertain their properties, and the proportion in which they exist in air, it will be worth while to endeavour to calculate the amount of the whole of the atmosphere which surrounds the earth. This will put it in our power to state the amount of its different constituent parts, and of course to see how far the quantities of each agree with the different chemical theories which have been maintained concerning the influence of these bodies on the different kingdoms of nature.

Its absolute quantity.

Mechanical philosophers have demonstrated, that the weight of a column of the atmosphere, whose base is an inch square, is equal to a column of mercury of the same base, and balanced by the atmosphere in the barometical tube. Now let us suppose the mean height of the barometer to amount to nearly 30 inches. Let R denote the radius of the earth, r the height of the mercury in the barometer, π the ratio between the circumference of a circle and its diameter. The solidity of the earth is $\frac{4\pi R^3}{3}$; the solidity of the sphere composed of the earth, and a quantity of mercury surrounding it equal to the weight of the atmosphere, is $\frac{4\pi (R+r)^3}{3}$. Consequently the solidity of the hollow sphere of mercury equal to the weight of the atmosphere is $\frac{4\pi (R+r)^3}{3} - \frac{4\pi R^3}{3} = 4\pi \left(R^2 r + r^2 R + \frac{r^3}{3}\right)$, or, neglecting the terms containing r^2 and r^3,

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$4 \pi R^2 r$. This formula, by substituting for π, R^2, and r, their known values, gives the solidity of the hollow sphere of mercury in cubic feet. But a cubic foot of mercury is nearly equal to 13,5000 avoirdupois ounces. Hence the mean weight of the atmosphere amounts to about 1,911,163,227,258,181,818 lbs. avoirdupois.

SECT. I.

OF AIR.

Air an elastic fluid.

THE word AIR seems to have been used at first to denote the atmosphere in general; but philosophers afterwards restricted it to the elastic fluid, which constitutes the greatest and the most important part of the atmosphere, excluding the water and the other foreign bodies which are occasionally found mixed with it. For many years all permanently elastic fluids were considered as air, from whatever combinations they were extricated, and supposed to possess exactly the same properties with the air of the atmosphere. It is true, indeed, that Van Helmont suspected that elastic fluids possessed different properties; and that Boyle ascertained that all elastic fluids are not capable of supporting combustion like air. But it was not till the discoveries of Cavendish and Priestley had demonstrated the peculiar properties of a variety of elastic fluids, that philosophers became sensible that there existed various species of them. In consequence of this discovery, the word *air* became generic, and was applied by Priestley, and the British and Swedish philosophers in general, to all permanently elastic fluids, while the air of the atmosphere was distinguished by the epithets of *common* or *atmospheric* air: but Macquer thought proper to apply the term *gas*, first employed by Van Helmont, to all permanently elastic fluids except common air, and to confine the term *air* to this last fluid. This innovation was scarcely necessary; but as it has now been generally adopted, it will be proper to follow it. By the word *air*, then, in this Section, I mean only common *air*, or the fluid which forms by far the greatest part of the atmosphere.

The foreign bodies which are mixed or united with air in the atmosphere are so minute in quantity compared to it, that they have no very sensible influence on its properties. We may therefore consider atmospheric air, when in its usual state of dryness, as sufficiently pure for examination.

Specific gravity.

1. Air is an elastic fluid, invisible indeed, but easily recognized by its properties. Its specific gravity, according to the experiments of Sir George Shuckburgh, when the barometer is at 30 inches, and the thermometer between 50° and 60°, is usually reckoned 1·000: It is 816 times lighter than water. One hundred cubic inches of air weigh 31 grains troy.

Density.

But as air is an elastic fluid, and compressed at the surface of the earth by the whole weight of the incumbent atmosphere, its density diminishes according to its height above the surface of the earth. From the experiments of Paschal, Deluc, General Roy, &c. it has been ascertained, that the density diminishes in the ra-

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tio of the compression. Consequently the density decreases in a geometrical progression, while the heights increase in an arithmetical progression.

Bouguer had suspected, from his observations made on the Andes, that at considerable heights the density of the air is no longer proportional to the compressing force *; but the experiments of Saussure junior, made upon Mount Rose, have demonstrated the contrary †.

Colour.

2. Although the sky is well known to have a blue colour, yet it cannot be doubted that air itself is altogether colourless and invisible. The blue colour of the sky is occasioned by the vapours which are always mixed with air, and which have the property of reflecting the blue rays more copiously than any other. This has been proved by the experiments which Saussure made with his *cyanometer* at different heights above the surface of the earth. This instrument consisted of a circular band of paper, divided into 51 parts, each of which was painted with a different shade of blue; beginning with the deepest mixed with black, to the lightest mixed with white. He found that the colour of the sky always corresponds with a deeper shade of blue the higher the observer is placed above the surface; consequently, at a certain height, the blue will disappear altogether, and the sky appear black; that is to say, will reflect no light at all. The colour becomes always lighter in proportion to the vapours mixed with the air. Hence it is evidently owing to them ‡.

Composition.

3. For many ages air was considered as an element

* *Mem. Par.* 1753. p. 515. † *Jour. de Phys.* xxxvi. 98.
‡ Saussure, *Voyages dans les Alpes*, iv. 288.

or simple substance. For the knowledge of its component parts, we are indebted to the labours of those philosophers in whose hands chemistry advanced with such rapidity during the last forty years of the 18th century. The first step was made by Dr Priestley in 1774, by the discovery of oxygen gas. This gas, according to the prevailing theory of the time, he considered as air totally deprived of phlogiston ; azotic gas, on the other hand, was air saturated with phlogiston. Hence he considered common air as oxygen gas combined with an indefinite portion of phlogiston, varying in purity according to that portion ; being always the purer the smaller a quantity of phlogiston it contained.

While Dr Priestley was making experiments on oxygen gas, Scheele proceeded to the analysis of air in a different manner. He observed that the liquid sulphurets, phosphorus, and various other bodies, when confined along with air, have the property of diminishing its bulk ; and this diminution always amounts to a certain proportion, which he found to be between a third and a fourth part of the whole. The residuum was unfit for supporting flame, and was not diminished by any of the processes which diminish common air. To this residuum he gave the name of *foul air*. From these experiments, he concluded that air is a compound of two different elastic fluids : namely, *foul air*, which constitutes more than two thirds of the whole, and *another air*, which is alone capable of supporting flame and animal life. This last air he extricated from nitre by heat, from the black oxide of manganese, and from other substances, and gave it the name of *empyreal air*. He showed that a mixture of two parts of foul air and