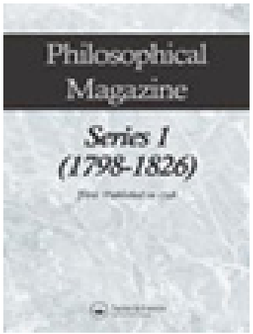


Philosophical Magazine Series 1

ISSN: 1941-5796 (Print) 1941-580x (Online) Journal homepage: http://www.tandfonline.com/loi/tphm12

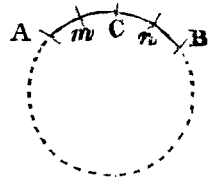
LXXV. On the origin of the Atomic Theory

William Higgins

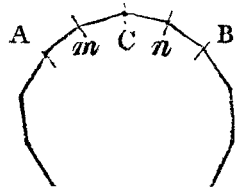
To cite this article: William Higgins (1816) LXXV. On the origin of the Atomic Theory , Philosophical Magazine Series 1, 48:223, 363-371, DOI: 10.1080/14786441608637687

To link to this article: http://dx.doi.org/10.1080/14786441608637687

The following is the demonstration above referred to.—"In the arc AB of a circle take a small part, AC, which suppose to be a straight line. But if AC is a straight line, CB, which is equal to it, must be a straight line. For the same reason *nm*, which includes the point in which AC and CB are joined, is also a straight line; and therefore the whole arc AB is a straight line, which is evidently absurd. Therefore no part of a circle is a straight line.—Q. E. D."



But let AC be a part of a regular polygon; then it is evident that all the conditions required by the above demonstration are fulfilled, and yet the figure is composed of straight lines.—Besides, when it is assumed that a circle is composed of small straight lines, the magnitude of each line is supposed to be infinitely small when compared with that of the circle of which it forms a part. Therefore the proposition does not appear to admit of a geometrical demonstration. But if such an assumption be necessary in the investigation of theorems, there can be no good reason for rejecting it, unless it can be proved that no part of a circle can be a straight line.



June 5, 1816. T. T.

LXXV. *On the Origin of the Atomic Theory.* *By* WILLIAM HIGGINS.

To Mr. Tilloch.

SIR,— YOU will oblige me and every lover of justice by inserting in your impartial Magazine the following remarks on an article relating to the *Atomic Theory*, published in the first volume, part second, of the fourth and fifth editions of the *Encyclopædia Britannica*, which article was written by Dr. Thomson.

The Doctor commences by stating, that the most eminent of the Greek philosophers supposed the ultimate elements of matter to consist of atoms or particles incapable of further division or diminution; and that this doctrine was adopted by Sir Isaac Newton, and by many celebrated philosophers since his time. This is perfectly correct; but they had not the most distant idea of its application to chemistry in the sense in which I had taken it up.

The Doctor proceeds by giving a sketch of the progress of chemistry

chemistry as it passed through the hands of different philosophers. He particularizes Cullen, Black, Cavendish, and Priestley, whom we must ever revere with grateful feelings for their successful labours in the field of science.

To each of those philosophers, except Dr. Cullen, who was before my time, I had the pleasure of presenting a copy of my "Comparative View of the Antiphlogistic and Phlogistic Theories," printed in the year 1788, and published early in the year 1789.

In writing this work, happily for chemistry, arose during my investigation of the two antagonist theories the Atomic System, or more properly speaking the doctrine of Definite Proportions, in which the elementary particles of matter are capable of uniting so as to form atoms and molecules*.

My atomic theory of chemistry is so mathematically correct, that all visionary hypotheses fell prostrate before it, and it was from it *alone* that the phlogistic doctrine received its fatal blow.

When I published the above work, I was the only person in Great Britain that adopted the antiphlogistic doctrine: and the attention of the philosophical world was so anxiously engaged in the controversy itself, that the novel mode of investigation which I made use of, was at the time in a great measure overlooked: and indeed I was not much surprised at it, for the science was not at that time sufficiently ripe for so unusual a style of reasoning. However, some of the Reviewers of the day took some notice of it, as the following extract, taken from the fourth volume of the Analytical Review, page 178, will show:

"This is the first original publication (my Comparative View) which has appeared in the English language in defence of the antiphlogistic system of chemistry, which is here very ably maintained by Mr. Higgins." It then proceeds with the division of the work, and the questions discussed in it. "In the discussion of this subject Mr. Higgins shows a degree of acuteness in argumentation, and an intimate acquaintance with the present state of chemistry, which prove him to be eminently qualified for the task he has undertaken. In addition to those requisites, we find that he has actually repeated most of the leading experiments; which valuable circumstance places his book in a much higher rank than that of a mere collection of facts and deduc-

* The terms ultimate, particle, atom, and molecule, are indiscriminately used by Thomson and Dalton. An ultimate particle is the last division of elementary matter—an atom is a compound of two particles in every proportion—and a molecule is the compound of two atoms according to the strict nomenclature of my doctrine. Those distinctions will prevent confusion; they will be found to accord with the language of definite proportions, and the internal structure of compounds.

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tions. His style and arrangement is strong and perspicuous, although we here and there meet with inaccuracies which denote he is not yet familiarized to the art of composition. The chemical reader will readily form an idea of the facts contained in the sections whose titles we have enumerated. They consist in a great measure of those which we have already mentioned in an account of the French edition of Kirwan on Phlogiston*: the statements however are very different, and the elucidations both of theory and matter of fact are in many instances original and striking. We do not therefore hesitate to recommend this performance of Mr. Higgins, as a work well deserving the attention of chemists: but as it would lead us too far into chemical disquisition to follow him step by step in the enumeration of facts and display of arguments which cannot be abridged, we shall conclude this article by another quotation; in which as much appears to be said and done to establish the composition of water against the late experiments of Dr. Priestley as the present state of the subject appears capable of."

In about twelve months after my book appeared, Dr. Priestley was the only phlogistian in England, and he retained his old tenets to the last moment of his life. I do not recollect the exact time Dr. Black recanted, it was after Kirwan. Mr. Kirwan, the formidable champion of the phlogistic doctrine, renounced it as soon as he read my book, and declared in the presence of many philosophical gentlemen now living in Dublin, that it was that work alone induced him to change his opinion, and that nothing the French philosophers brought forward had any influence on him; this appears from his notes in answer to the French at the end of the English translation.

Dr. Thomson tells us in the fourth volume of his Annals, p. 54, that it was the answer of the French chemists to Mr. Kirwan's Essay on Phlogiston that decided this memorable controversy. Nothing can be so incorrect or so unjust as this assertion: for the answer was published before I wrote; and from the foregoing statement, which is a true one, it is evident that it produced little or no effect; and it appears by the extract from the Analytical Review that my demonstrations were considered as original at the time I had written†. These were my principal motives for introducing the foregoing subjects.

But to return to the outlines of the Doctor's history. He attributes, and very justly, the first rudiments of analytical che-

* This edition contains the answer of the French chemists to that work; and that is one of my principal reasons for inserting it here, as will immediately appear.

† It alludes to the Atomic System.

mistry

mistry to the labours of Margraaf, Bergman, and Scheele. Kirwan, Bergman, and Wenzel distinguished themselves by the analyses of the salts. They ascertained that salts and all compound bodies are united constantly in the same proportions of their constituents.

The foregoing philosophers had written long before me; and I challenge Dr. Thomson to produce a single page from their respective works that relates to the atomic theory, or, in other words, to the definite proportions in which elementary particles unite so as to form atoms and molecules.

From the foregoing philosophers the Doctor passes to Richter, who analysed saline bodies with still greater accuracy than his predecessors. He ascertained the quantity of the earths and alkalies necessary to saturate 100 parts of different acids. As the labours of this chemist do not relate to the atomic theory, I consider it unnecessary to attend to them minutely.

Had Dr. Thomson been a faithful and unprejudiced historian, he would have had the candour to mention my *Comparative View*, and the discovery of the atomic theory, before he brought forward the labours of Richter, which were subsequent to mine.

Next in the order of this curious history, Proust (no doubt a chemist of considerable merit) is introduced. From the great attention which he paid to metallic oxides, he was able to prove that every metal is capable of forming a certain determinate number of oxides, and no more. "Thus, zinc unites but to one dose of oxygen; consequently there is but one oxide of that metal: iron, arsenic and antimony form two each: tin forms three."

In my *Comparative View*, written many years before the work of Proust, it will be found that I considered metals in general to be capable of uniting to different doses of oxygen, and that the force of union was in the inverse ratio of the number of doses which they took in*. I mention these circumstances merely to show that I developed principles only, for I had not attended to the different doses of oxygen to which the different metals were capable of uniting. These circumstances ought to have been mentioned: but this would frustrate the Doctor's purpose, that of bringing Dalton in as an original discoverer of the atomic theory.

"Such was the state of the subject," continues the Doctor, "when Mr. Dalton turned his attention to the combinations of bodies with each other, about the year 1804." Mr. Dalton's first volume of the Atomic Theory made its appearance in 1808.

* I refer to my Comparative View, or to my Atomic Theory, on this subject.

The

The Doctor acknowledges with *wonderful* candour, that it was known at this period that hydrogen unites only in one proportion with oxygen; that carbon, sulphur, and phosphorus unite in two proportions; and so he goes on enumerating other combinations long known before this period.

It would be needless to follow the Doctor through all his details, most of them being well known; and many misrepresentations are brought forward, in order to prepare the way for his ingenious friend to take possession of the Atomic System.

The proportions in which inflammable substances and oxygen are found to unite, such as 1 and 1, or 1 and 2, &c. by weight, "led Mr. Dalton to the *lucky idea* that the atoms of bodies unite together; that the atom of each body has a determinate weight, and that this weight regulates the proportion in which bodies combine. Let us suppose, for example, that water is formed by the union of one atom of oxygen with one atom of hydrogen; it follows, as the oxygen in water is eight times that of the hydrogen, that the weight of the atom of oxygen is to that of an atom of hydrogen as 8 to 1. So that if we represent the weight of an atom of hydrogen by 1, that of an atom of oxygen will be 8." The Doctor adduces many more examples of this kind, which first appeared in my *Comparative View*, as shall be presently shown.

"But Mr. Dalton," continues the Doctor, "not satisfied with this simple and luminous explanation, which threw a new and strong light around chemical combinations, which afforded the means of correcting and checking chemical experiments hitherto conducted without any guide, and promised in time to introduce mathematical precision and mathematical reasoning into a science which hitherto has been able only to boast of analogical and probable conclusions —— contrived a set of symbols to represent the different elements, and make the nature of the combinations which they form obvious to the eye of the most careless reader." An engraved specimen of those symbols is given, so far as they relate to the ultimate particles of hydrogen, azote, carbon, sulphur, phosphorus, and oxygen. The symbols representing the inflammable particles or bases are united to those representing particles of oxygen in the proportion in which they are capable individually of combining with that element, that is, either 1 and 1, 1 and 2, 1 and 3, or 4, &c.

These diagrams, if diagrams I can call them, are much more correct than Dalton's*. They correspond with the proportions of elementary particles represented by diagrams so as to constitute the same compound atoms in my Comparative View, ex-

* See his work, or my Atomic Theory, where the original symbols are given.

cept

cept in those of sulphurous and sulphuric acids, which are represented in erroneous proportions, as I had shown in the above work, and lately confirmed by additional experiments in my *Atomic Theory*. There is another error in this table of diagrams or symbols which I cannot pass over; that is, the leaving out an intermediate state of the combination of azote and oxygen between the nitrous and nitric acids, which I represented as containing one of azote and four of oxygen. Thus the Doctor takes a stride from 1 and 3 of those elements to 1 and 5. He falls into the same error respecting some metallic oxides. But probably those gentlemen had a motive to differ from me, *right or wrong*.

"It would be easy," continues the Doctor, "to multiply these symbols much further; but the preceding specimen is sufficient, we conceive, to make the use of them understood, and even to make Mr. Dalton's doctrine more simple to those who are still strangers to it."

I agree with the Doctor; and I will go still further, by saying that they develop the whole essence and spirit of the Atomic System.

I will now proceed so far, in as concise a manner as possible, on what I advanced on the very same subject in the year 1788, twenty years before Dalton published his first volume.

The Union of Oxygen and Hydrogen.

1. Two volumes of hydrogen unite to one volume of oxygen, and in no other proportion whatever.

2. The two volumes of hydrogen contain the same number of ultimate divisions or particles that is contained in the one of oxygen, notwithstanding the difference of their specific gravities; and this difference depends on the size of their respective particles.

3. Hydrogen and oxygen unite chemically,—a single ultimate particle of the one to a single ultimate particle of the other,—to constitute an atom of water. A diagram representing this combination, with numbers representing the energy or force of union of its elements, was given.

Have not the foregoing facts clearly shown the weight of an atom of water?

Sulphur and Oxygen.

1. An ultimate particle of sulphur unites to a single ultimate particle of oxygen, and the compound constitutes an atom of sulphurous acid gas; and as oxygen gas suffers no material diminution by the union, and as pure sulphurous acid gas is but twice the weight of oxygen, it was presumed that the ultimate particle

particle of sulphur was of the same weight with that of the oxygen, and consequently that the size of the calorific atmosphere of the acid atom was as large as that of the ultimate particle of oxygen before the union.

A diagram representing this combination, with numbers expressive of the force of union comparatively with that of the constituents of water, is given.

2. An ultimate particle of sulphur is capable of uniting to two ultimate particles of oxygen, and the compound is an atom of sulphuric acid. These are the definite proportions in which those two elements can unite.

3. The two portions of oxygen are united with less energy in the sulphuric acid than the one proportion in sulphurous acid. A diagram with numbers representing this difference was introduced.

Metals and Oxygen.

The ultimate particles of some metals,—I instanced iron,—attract oxygen with greater force than those of sulphur or hydrogen do. This superiority of force was also expressed by numbers.

The relative forces with which the foregoing inflammable bases attracted oxygen, and the diminution of this force by double doses of oxygen, enabled me to calculate the changes and different phænomena which are produced by metallic subtances when exposed to the action of sulphuric acid, dilute sulphuric acid, and sulphurous acid. It enabled me not only to point out the absurdity of the phlogistians, but also the errors of the antiphlogistians themselves. What I here assert will be found verified in my *Comparative View*, or in my *Atomic Theory*.

Azote and Oxygen.

1. One ultimate particle of azote and one of oxygen chemically united constitute an atom of the gaseous oxide of azote.

2 When united to two of oxygen an atom of nitrous gas is formed.

3. When the particle of azote is united to three particles of oxygen an atom of the red nitrous acid is formed.

4. When the azote unites to a fourth particle of oxygen an atom of the straw-coloured nitrous acid is the result.

5. When united to a fifth particle of oxygen an atom of nitric acid is formed. These are the definite proportions of oxygen and azote.

All the foregoing distinct compounds of azote and oxygen, and the different forces with which they retain their oxygen, are re-

presented by diagrams; the energy of union gradually and regularly diminishes from the *minimum* to the *maximum* state of oxygenation. Each of the atoms of even the nitrous and nitric acids in the liquid mass are distinct from one another, as being surrounded with their respective atmospheres of caloric.

When the foregoing compounds produced by the union of azote and oxygen are mixed, a partial decomposition takes place, and the oxygen is divided between them; but that which contains 1 and 2 can take none from 1 and 3, but it will take from 1 and 4, and 1 and 5, or 1 and 3 can take from 1 and 5, but not from 1 and 4.

Nothing could be more easy than to deduce the weight of those atoms from the relative weights of their constituent gases.

This arrangement and calculation of the force of union of the constituent elements of the nitrous gas, of nitrous acid and nitric acid, enabled me at that remote period to demonstrate with mathematical accuracy all the chemical effects produced on those acids by inflammable bodies, which were not understood before.

Nitrous Acid and Potash.

A single atom of nitrous or nitric acid unites to a single atom of potash, and this molecule is surrounded with an atmosphere of caloric which renders each molecule in the saline mass independent of each other. This holds good with respect to all other saline substances.

Metals and Oxygen.

The ultimate particles of a metal unite with different doses of oxygen: the first dose is retained with greater force than the second; and this last with greater force than a third dose. Tin was adduced as an example in my Comparative View.

Metals and Acids.

Metals, or rather their oxides, unite with acids atom and atom so as to form molecules, and the force of union depends on the kind of metal. I have shown that the metals first unite to oxygen, and that their ultimate particles are supplied with it at the expense of the water, or of a portion of the acid itself. To illustrate this point diagrams were produced.

The precipitation of some metals in their metallic state from their solution in acids by other metals had been explained upon strict mathematical principles, by means of diagrams, and each ultimate particle was allowed its full force and effect in the operation, agreeably to the laws of the atomic doctrine. When one metal precipitates another metal from its solution in a *semi* state of

of oxidation, it is because the precipitant has less capacity for oxygen than the precipitated: this was also explained on the atomic principle.

The foregoing short sketch comprehends nearly the whole of the atomic theory, or of definite proportions. Its application in chemical researches is a secondary business. No theory can be confined to the labours of its author. The great excellence of a doctrine depends on its capability of being universally applied throughout the whole range of chemical science,—a task too great for any individual.

[To be continued.]

LXXVI. *Observations of the late Solar Eclipse.* By S. Groombridge, *Esq.*

To Mr. Tilloch.

Sir,—I request you will be pleased to insert the following observations of the late solar eclipse, in the Philosophical Magazine; which, from its extensive circulation, will enable those who have observed the same phases of the eclipse to compare the different results.

19th of November A.M., mean time.

8h	4′	29″	immersion of moon's disc 6′ 9″ from vertex.	
8	10	58	vertical distance of cusps 10′ 32″.	
8	15	2	west cusp from upper limb of sun ..	12′ 50″
8	21	46	.. ..	15 21
8	27	48	.. .. lower limb of sun ..	15 28
8	33	48	.. ..	14 39
8	46	2	.. ..	14 21
8	49	42	south limb of moon from south limb of sun	10 37
8	52	34	.. ..	9 55
8	56	18	occultation of the largest spot.	
8	58	26	.. .. second large spot.	
8	59	28	.. .. third large spot.	
9	2	6	south limb of moon from south limb of sun	8′ 1″
9	7	4	east cusp from south limb of sun ..	14 14
9	9	8	south limb of moon from south limb of sun	6 25
9	11	56	east cusp from south limb of sun ..	9 16
9	15	54	.. ..	6 25
9	17	48	.. ..	5 16
9	20	20	.. ..	4 8
9	22	14	south limb of moon from south limb of sun	3 40
			Becomes cloudy.	
10	12	50	vertical distance of cusps 17′ 7″.	
10	19	18	emersion of moon's disc 12′ 19″ from south limb.	