



XLVII. On the quantity of carbon in carbonic acid, and on the nature of the diamond

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To cite this article: William Allen Esq. F.L.S. & William Hasledine Pepys Esq. (1808) XLVII. On the quantity of carbon in carbonic acid, and on the nature of the diamond , Philosophical Magazine Series 1, 29:116, 315-324, DOI: [10.1080/14786440808563745](https://doi.org/10.1080/14786440808563745)

To link to this article: <http://dx.doi.org/10.1080/14786440808563745>



Published online: 18 May 2009.



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in which we do not discover any mutual relations of parts, or of distinct forms to the subsistence of other parts or forms. They are not formed by gradual growth. Their period of duration appears to have no fixed limit. Their particles unite by mutual attractions; and after separation by external force, are found to reunite as perfectly as before such separation. They are chiefly distinguished one from another by variety of colour, difference of transparency and opacity, weight, hardness, ductility, fusibility in heat, difference of mutual attractions; by the sound caused in their concussion, their smell and taste, their peculiarity of fracture, and by the regularity of solid forms which they are severally found to assume, after solution, in assignable degrees of temperature. The ordinary visible characteristics, colour, gloss, fracture, &c., recorded by Werner; the crystalline forms enumerated by Haüy; the weight and mutual attractions ascertained by various philosophers and chemists, are to be found collected together in several modern Treatises on Mineralogy, and should accompany the reference to each specimen in the Catalogue of the National Museum.

XLVII. *On the Quantity of Carbon in Carbonic Acid, and on the Nature of the Diamond.* By WILLIAM ALLEN, Esq. F.L.S. and WILLIAM HASLEDINE PEPPYS, Esq.

[Continued from p. 227.]

Second Experiment on Diamond,

THERMOMETER 48° Fahrenheit, barometer 30·08. Oxygen gas made as usual, left a residuum of 3 parts in 100.

Eleven small diamonds, weighing 4·01 grains, were put into the tray. We began with 49·84 cubic inches of oxygen; and every thing being properly adjusted, kept the platina tube red-hot for a quarter of an hour, and during this time the gas was passed from one gasometer to the other, as in the former experiments. When the tubes, &c. were cooled down to the temperature of the room, all the
gas

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gas was transferred to gasometer No. 1. and the volume was exactly the same as before the experiment. On examining the tray, all the diamonds were entirely consumed, and not a vestige left.

Lime water absorbed 57·5 parts from 100.

The test for oxygen 39·5

Residuum	-	3
<hr/>		
800		

Correction for temperature.

60°	0·103	49·84
48	12	1·23
<hr/>		
12 diff.	1·236 add for temp.	51·07
<hr/>		

Correction for pressure.

30 : 30·08 :: 57·07 : 61·20.

The volume of gas at the mean was therefore 51·20 cubic inches.

100 : 57·60 :: 51·20 : 29·44.

Then 29·44 cubic inches of carbonic acid gas were produced.

100 : 47·26 :: 29·44 : 13·91.

13·91 : 4·01 :: 100 : 28·82.

Then, according to this experiment, 100 grains of carbonic acid contain 28·82 diamond.

Calculation by oxygen.

100 : 33·82 :: 29·44 : 9·95 grains of oxygen consumed
4·01 of diamond

13·96

Calculation by carbonic acid 13·91

·05 difference.

13·96 : 4·01 :: 100 : 28·72.

Then, calculating by the weight of oxygen employed, 100 grains of carbonic acid contain 28·72 diamond.

The precipitate in lime water from the gas produced in the combustion of diamond, appeared to us denser than that from the combustion of charcoal.

In

In order to see how far the weight of the precipitate of carbonate of lime would agree with the results of the foregoing experiments, we drew off 20.5 cubic inches of the gas which had been thus altered by the combustion of diamond in the last experiment by the register H, and received it in bottles over mercury; then admitting lime water, we obtained a copious precipitate of carbonate of lime, which being dried at the temperature of 212° Fahrenheit, weighed 12 grains.

But as the 20.5 cubic inches require the same corrections to bring them to the mean temperature and pressure; we say, as the actual volume of all the gas is to its correction, so is the quantity drawn off to that which it would have been at the mean :

49.84 : 51.20 :: 20.50 : 21.06, the volume after the corrections were made.

Then, to find how much carbonic acid was contained in these 21.06 cubic inches, we state it thus: As the total quantity of gas after the experiment is to the total weight of carbonic acid gas found by calculation, so is the quantity of gas experimented upon to the weight of carbonic acid gas which it ought to have contained,

51.20 : 13.91 :: 21.06 : 5.72 grains.

Every 100 grains of precipitated carbonate of lime contain 44 grains of carbonic acid; 12 grains were procured in our experiment.

100 : 44 :: 12 : 5.28

Therefore the carbonic acid contained in our precipitate of 12 grains weighed 5.28; by calculation it should have weighed 5.72; this is as near as we had a right to expect from the difficulty of collecting the precipitate.

Stone Coal.

Upon the suggestion of our mutual friend Professor Davy, we next examined the results of the combustion of stone coal and plumbago; thermometer 57° Fahrenheit, barometer 29.65.

The stone coal from Wales, employed by maltsters, is well known to contain little or no maltha or mineral pitch, and to burn without flame.

A portion

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A portion of this coal was placed under sand in a crucible, and exposed to a strong heat for one hour; 4 grains of it thus prepared were put into the tray: our oxygen left a residuum of 5 parts in 100, and we began with 49·84 cubic inches as usual. The tray being placed in the platina tube was heated to redness for about 10 minutes. When the gas was first passed, we thought we saw a flash in the glass tubes. On suffering the whole to cool the quantity of gas still remained the same, and the tray being drawn out contained only ·5 of a grain unconsumed. From the gas thus charged with 3·5 grains of coal,

Lime water absorbed	53 parts from 100.
The tests for oxygen	39
Residuum	- 8 or an increase of 3.

100

Correction for temperature.

60°	0·103	49·84
57	3	·30
<hr/>		<hr/>
3 diff.	0·309 add for temp.	50·14

Correction for pressure.

30 : 29·65 :: 50·14 : 49·55.

The quantity of oxygen at the mean was therefore 49·55 cubic inches.

100 : 53 :: 49·55 : 26·26.

Consequently 26·26 cubic inches of carbonic acid gas were produced.

100 : 47·26 :: 26·26 : 12·41 grains.

12·41 : 3·50 :: 100 : 28·20.

Then, according to this experiment, 100 grains of carbonic acid gas contain 28·20 of coal.

Calculation by oxygen.

100 : 33·82 :: 26·26 : 8·88 grains of oxygen consumed.

3·50 coal

12·38

Calculation.

Calculation by carbonic acid	12.41
by oxygen	12.38
difference	<u>.03</u>

Here, contrary to what happened in other experiments, the calculation by carbonic acid rather exceeds that by oxygen :

$$12.58 : 3.50 :: 100 : 28.27.$$

Calculating therefore by oxygen, 100 grains of carbonic acid contain 28.27 of coal.

Experiment with Plumbago.

Thermometer 44° Fahrenheit, barometer 29.94.

4 grains of plumbago, from a very fine specimen belonging to Dr. Babington, were put into the tray. Our oxygen left a residuum of 2 parts in 100, and we began with 49.84 cubic inches. The tray, with its contents, being placed in the platina tube, was heated to redness for a quarter of an hour, and the gas made to pass over it several times. When all was cool, the original quantity was neither increased nor diminished, and on withdrawing the tray we found only .2 of a grain of oxide of iron ; so that this specimen of plumbago contains only 5 per cent. oxide of iron.

The gas being now examined,

Lime water absorbed 55 parts from 100

The tests for oxygen 42

Residuum - 3 or an increase of 1 per cent.

100

Correction for temperature.

60°	0.103	49.84
44	16	1.64
<u>16 diff.</u>	<u>1.648</u>	<u>51.48</u>

Correction for pressure.

$$30 : 29.94 :: 51.48 : 51.37.$$

The quantity of oxygen at the mean would be 51.37 cubic inches,

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$$100 : 55 :: 51.37 : 28.25.$$

Therefore 28.25 cubic inches of carbonic acid gas were produced.

$$100 : 47.26 :: 28.25 : 13.35 \text{ grains.}$$

$$13.35 : 3.8 :: 100 : 28.46.$$

Then, according to this experiment, 100 grains of carbonic acid contain 28.46 of the carbonaceous part of the plumbago.

Calculation by oxygen.

$$100 : 33.82 :: 28.25 : 9.55 \text{ grains of oxygen consumed} \quad 3.80 \text{ plumbago.}$$

$$13.35$$

Calculation by carbonic acid 13.35

First Experiment on Animal Charcoal.

Thermometer 60° Fahrenheit, barometer 30.23.

Muscular fibre distilled in a coated glass retort left a black shining coal, 4 grains of which were put into the tray. Our oxygen left a residuum of 2 parts in 100. The tray and its contents being placed in the platina tube, was heated to redness for 8 minutes. The first time the gas was passed, a lambent flame filled the whole length of the glass tube, and the gas became turbid or milky.. It was passed frequently through the heated tube, but we observed no repetition of the flashes.. Hence we conjecture, that if the diamond had contained hydrogen we should probably have had a similar appearance. After the experiment all the apparatus was, as usual, perfectly tight, and the volume of gas unaltered. On examining the platina tray a minute portion of charcoal remained, and a quantity of saline matter adhered to it so firmly, that it became difficult to ascertain the quantity of carbon consumed, and we forbore to make the calculation ; we however examined the gas.

Lime water absorbed 40 parts from 100

The tests for oxygen 54

Residuum 6 or an increase of 4 per cent.

$$100$$

Second

Second Experiment on Animal Charcoal.

Thermometer 59° Fahrenheit, barometer 29·45.

Some of the animal charcoal of last experiment was heated to redness under sand for one hour. 4 grains were placed in the platina tray; and as we were so much embarrassed in the last experiment with the saline matter which adhered to the tray, we exactly balanced it with its contents. Our oxygen, made as usual, left a residuum of 2 parts in 100, and we began with 49·84 cubic inches. When every thing was adjusted, and the platina tube red-hot, on passing the oxygen, flashes resembling lightning ran along the glass tube; and this was repeated 5 or 6 times. The whole of the gas became very cloudy, exhibiting a turbid milky appearance. The tube was rendered white-hot by the combustion of the carbonaceous matter in oxygen. The fire was kept up about 8 minutes, and the gas passed several times. When all was cool, we could observe no alteration in the volume of gas by the register. The tray contained a mixture of salts; and, being weighed, was lighter by 3·2 grains. This loss was not wholly carbon, for it is well known that animal substance contains a variety of salts, as phosphates, muriates, &c., some of which, though not volatile in a low red heat, might be decomposed and dissipated in the intense white heat produced by the combustion of the carbonaceous matter in oxygen; and we accordingly found the internal parts of the gasometers and tubes very slightly covered with a sort of efflorescence. On examining the gas after the experiment,

Lime water absorbed	41 parts from 100
The tests for oxygen	55
Residuum	4 or an increase of 2.

100

Correction for temperature.

60°	49·84
59	·10 add for temp.
1 diff. or 0·103	49·94

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Correction for pressure.

$$30 : 29.45 :: 49.94 : 49.02.$$

The quantity of oxygen at the mean would therefore be 49.02 cubic inches.

$$100 : 41 :: 49.02 : 20.09$$

The carbonic acid gas produced was therefore 20.09 cubic inches.

$$100 : 47.26 :: 20.09 : 9.49$$

and this carbonic acid weighed 9.49 grains.

Now the coal in the tray had lost 3.2 grains; but as the whole of this was not carbon, but part of it volatile saline matter, &c., we shall endeavour to estimate the carbon by the experiment on plumbago. When 13.35 grains of carbonic acid contained 3.80 grains of carbon,

$$13.35 : 3.80 :: 9.49 : 2.70.$$

The quantity of carbonic acid produced in this experiment, therefore, contained 2.70 grains of carbon.

Loss 3.20

Carbon 2.70

Leaves .50 for volatile saline matter, &c.

So that, this being granted, the present experiment agrees with the foregoing.

In two of our first experiments with box-wood charcoal, the calculations gave us in one case 29.75 parts of carbon in 100 of carbonic acid, and in the other 30.68; but we were not then fully aware of the absorption of water by charcoal, which rendered the quantity of real carbon employed less than indicated by the weight. Also in another experiment, in which 4 grains of diamond were consumed, the calculation gave us 29.96 per cent. of diamond in carbonic acid; but apprehending that a slight degree of inaccuracy had crept into this experiment, we have not detailed it with the rest; but we have thought it right to give a simple statement of matters of fact; in no one instance have we endeavoured to strain or accommodate these to suit any particular theory, being fully aware that every experiment, carefully made and faithfully recorded, will remain an immutable truth to the end of time, while hypotheses are constantly

constantly varying, and even the most beautiful theories are liable to change.

The experiments above related give us the following results :

	By carbonic acid.	By oxygen.
Box-wood charcoal	28·92	28·77
1st expt. diamond	28·95	28·81
2d expt. diamond	28·82	28·72
Stone coal	- 28·20	28·27
Plumbago	- 28·46	28·46
	<hr/> 5)143·35	<hr/> 5)143·03
mean	<hr/> 28·67	<hr/> 28·60

Hence we conclude that 100 grains of carbonic acid contains 28·60 of carbon, which does not greatly differ from the results of the experiments of Smithson Tennant, esq. on the nature of diamond.—See Phil. Trans. 1797.

This gentleman made his experiment in the following manner: A quarter of an ounce of nitrate of potash was rendered somewhat alkaline by exposure to heat, in order that it might more readily absorb carbonic acid; it was then put into a gold tube with $2\frac{1}{2}$ grains of diamond; and being subjected to heat, the diamond was converted into carbonic acid, by uniting with the oxygen contained in the nitric acid. The carbonic acid thus produced combined with the potash; and on pouring a solution of muriate of lime into a solution of this salt, he obtained a precipitate of carbonate of lime: this being decomposed by muriatic acid, gave as much carbonic acid gas as occupied the space of 10·1 ounces of water. The thermometer was at 55° Fahrenheit, the barometer 29·80. In a second experiment he procured a larger quantity, or equal to 10·3 ounces of water.

If we therefore consider an ounce of water as consisting of 480 grains, and a cubic inch of water equal to 253 grains, and then make the proper corrections for temperature and pressure, one of his experiments will give about 27 per cent. the other about 27·80 for the carbon in carbonic acid, which is somewhat less than our estimate; but the difference may easily be accounted for, from the different methods employed.

The experiments of Guyton, as detailed in the *Annales de Chimie*, vol. xxxi. page 76, are liable to very strong objections ; but at the same time the candid manner in which he has related every circumstance merits considerable praise. It is impossible, however, not to observe, that the quantity of gas before and after the experiment could not, from the construction of his apparatus, be very rigorously ascertained. We object also to nitrous gas as a test for oxygen ; and as it is acknowledged that the wooden support included in the oxygen gas took fire, the product of carbonic acid must have been influenced by it ; so that, if no chance of error had existed in estimating the carbonic acid gas from the residuum after barytic water had absorbed a part, still the result would not have been satisfactory.

The experiments which we have had the honour of laying before this society prove several important points :

1st. That the estimate given by Lavoisier, of 28 parts of carbon in every 100 parts of carbonic acid, is very nearly correct ; the mean of our experiments makes it 28.60.

2dly. That the diamond is pure carbon ; for, had it contained any notable proportion of hydrogen, it must have been discovered, either by detonating with the oxygen, as in the case of animal charcoal, or by diminishing the quantity of oxygen gas.

3dly. That well burnt charcoal contains no sensible quantity of hydrogen ; but if exposed to the air for a few hours it absorbs moisture, which renders the results uncertain.

4thly. That charcoal can no longer be considered as an oxide of carbon, because, *when properly prepared*, it requires quite as much oxygen for its combustion as the diamond. This is also the case with stone coal and plumbago.

5thly. It appears that diamond and all carbonaceous substances (as far as our present methods of analysis are capable of demonstrating their nature) differ principally from each other in the state of aggregation of their particles. Berthollet has well remarked, that in proportion as this is stronger, decomposition is more difficult : and hence the variety of temperatures required for the combustion of different inflammable substances.