III. *On a New Combustible Gas.* By THOMAS THOMSON, M. D.
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IT has been generally known for several years, that, when the acetic acid formed by the distillation of wood is rectified, there is obtained a transparent spirituous liquor, analogous in many respects to alcohol, though very different in others. This liquid has received the name of *pyroxylic spirit*. It is manufactured by Messrs TURNBULL and RAMSAY of Glasgow. I have been in the habit for several years of employing it for combustion in lamps instead of alcohol. It is a good deal cheaper, and raises just as good a heat as alcohol; for I can make the small platinum crucible, which I use for drying the products of analysis, red-hot by means of a pyroxylic spirit lamp in a few minutes.

Pyroxylic spirit is as limpid and colourless as alcohol. Its specific gravity, when well rectified, is 0.812. It has an agreeable smell, not, however, quite free from that of naphtha. Its taste is very disagreeable, owing, I believe, to a small portion of naphtha, or empyreumatic oil, which it holds in solution, and from which we cannot free it by any known process. A set of experiments on pyroxylic spirit by Messrs MACAIRE and MARCET was published in the *Bibliothèque Universelle* for October 1823. These gentlemen have described several of its properties, and subjected it to an analysis, from which it appears that, like alcohol, it is composed of hydrogen, carbon and oxygen, though the atomic proportions are different.

My object, in this short paper, is to give an account of a new gaseous substance which I accidentally obtained about a year

ago, when I attempted to substitute pyroxylic spirit for alcohol in some processes which I had occasion to perform during a set of experiments on protoxide of chromium, in which I was at that time engaged. The gas in question may be easily procured by the following process.

Put into a flask a mixture of $1\frac{1}{2}$ ounce of muriatic acid, half an ounce of the nitric acid of commerce, and half an ounce of pyroxylic spirit, all by measure. By means of a perforated cork insert a bent glass-tube into the mouth of the flask. The cork must fit so tight, that nothing can escape from the flask except through the tube. Heat the mixture over a spirit lamp till it begin to effervesce, and till the colour of the liquid changes to red. The flask must then be withdrawn from the lamp, and the extremity of the bent tube plunged into a mercurial trough. The gas issues in torrents for five or six minutes, and may be collected in any quantity, in glass jars, previously filled with mercury, and inverted on the trough. From the quantity of materials stated above, I think at least 200 cubic inches of the gas are extricated.

The gas, as it comes over, acts with considerable energy on the mercury ; both calomel and corrosive sublimate being formed in abundance. But this is owing to the presence of some chlorine, with which the gas, as it issues from the flask, is mixed. For when we transfer the gas into a clean jar, it may be left for any length of time on the trough, without acting in the least on the mercury, or changing its volume.

The gas thus obtained possesses the following characters :

1. It is transparent and colourless, and possesses the mechanical properties of common air.

2. Its smell is exceedingly pungent and disagreeable ; but so peculiar, that I can compare it to nothing else. It acts with

considerable energy upon the eyes and nose, occasioning a flow of tears, and exciting considerable pain in the eyes.

3. It is combustible, and burns with a lively bluish-white flame.

4. Water absorbs it pretty rapidly : one volume of water, in my trials, absorbed five volumes of the gas. The water acquires a pungent taste, and the peculiar smell of the gas. But it does not alter the colour of litmus or cudbear paper.

5. One volume of oil of turpentine absorbs thirty volumes of the gas ; the oil assumes a light-green colour, and resembles cajeput ; but still retains its peculiar odour.

6. The gas is neither absorbed by acids nor alkalies. Hence it possesses neither acid nor alkaline properties.

7. When common air or oxygen gas is mixed with this gas, the usual red fumes of nitrous acid appear, and the volume of the mixture is diminished. It is not, therefore, a homogeneous substance, but contains mixed with it a considerable proportion of nitrous gas. I endeavoured to determine the proportion of nitrous gas in 100 volumes, by mixing it with determinate quantities of oxygen gas over mercury. The diminution of volume was noted, and two-thirds of that diminution reckoned as nitrous gas. This method of proceeding is not susceptible of perfect accuracy, because the nitrous acid formed acts upon the mercury. But as the action is not rapid, and the time of each experiment short, I do not think that the error thence arising could amount to so much as 5 per cent. Five experiments made in this way did not absolutely agree with each other. But the discordancy did not exceed 4 per cent. A mean of the whole gave the amount of nitrous gas in 100 volumes of the new gas, 63 volumes, or rather more than three-fifths of the whole.

I tried to determine the proportion of nitrous gas over water, by causing the water to absorb the new inflammable gas, and then agitating the residual gas in a solution of protosulphate of iron. But this method yields no good results. The new in-

flammable gas has the property of greatly increasing the absorbability of the nitrous gas in water; so much so, that a gas, which, when analysed over mercury, was found to contain 63 per cent. of nitrous gas, if it was agitated in water, as long as that liquid continued to absorb it, left no more than 7.5 per cent. of nitrous gas. I abide, therefore, by the analysis over mercury, which, from numerous comparative experiments, cannot deviate very far from the truth.

100 volumes of the gas, after being washed in water, and in a solution of protosulphate of iron, left 8 per cent. of azotic gas.

Thus it appears, that the gas extricated from a mixture of aqua regia and pyroxylic spirit, is a mixture of

New inflammable gas,.....	29
Nitrous gas,.....	63
Azotic gas,.....	8

100

Whether these proportions be constant, I cannot venture to determine. But I analysed gas obtained in ten different processes, without finding any deviation in the proportions of its constituents. I found the specific gravity the same in gas from two different processes.

8. The specific gravity of the gas was taken in a flask which had been twice exhausted, and filled each time with hydrogen gas. It was 1.945, the specific gravity of common air being reckoned unity.

It is easy to calculate the specific gravity of the pure inflammable gas in this mixture.

Let A = volume of nitrous and azotic gas ;

a = specific gravity of a mixture of 63 volumes nitrous and 8 azotic gas ;

B = volume of inflammable gas ;

x = specific gravity of inflammable gas ;

c = specific gravity of the mixed gas.

We have, from a well-known hydrostatical property of gases,

$$x = \frac{(A + B) c - A a}{B}.$$

In the present case,

$$A = 71 ; a = 1.03384 ;$$

$$B = 29 ; c = 1.945.$$

$$\text{Consequently, } x = \frac{(100)1.945 - 71 \times 1.03384}{29} = 4.1757 ;$$

4.1757 considerably exceeds the specific gravity of chloro-carbonic acid, or the phosgene gas of Dr DAVY, which is 3.4722.

9. I found by repeated trials, that the new inflammable gas, (the nitrous gas being removed by means of oxygen gas and potash), requires for complete combustion twice its volume of oxygen gas. The mean of five experiments gave 12 volumes inflammable gas, and 24.38 volumes of oxygen gas consumed, when an electric spark was passed through the mixture over mercury. The only products after the combustion were calomel and carbonic acid gas.

When the detonation of the mixture of the inflammable gas and oxygen was made over a little water, holding nitrate of silver in solution, the liquid became milky, owing to the formation of chloride of silver. It is obvious from these facts, that two of the constituents of the gas are *chlorine* and *carbon*.

A mixture of 12 volumes of gas, and 24.38 volumes of oxygen, left, after detonation over mercury, 15.43 volumes of carbonic acid gas. This is a mean of four experiments, which did not agree very well with each other ; two of them giving only 13.89 volumes of carbonic acid, and the other two 15.98 volumes. I made twelve additional experiments, with a view of getting results more to be depended on. But the mean of the whole scarcely differed from 15.43, and the same discordancy appeared in the new as in the old experiments.

The result of the analysis seems to be, that 12 volumes of the gas consume 24 volumes of oxygen, and form 16 volumes of carbonic acid gas.

The 16 volumes of carbon would require 16 volumes of oxygen to convert them into carbonic acid gas. The 8 remaining volumes of oxygen, must have united to hydrogen; and they would require 16 volumes of hydrogen gas to convert them into water.

Thus it appears, that the gas contains equal volumes of carbon vapour and hydrogen gas; 1 volume of the gas requires for complete combustion 2 volumes of oxygen, and it forms $1\frac{1}{3}$ volume of carbonic acid gas. The remaining 0.66 volume of oxygen must have combined with $1\frac{1}{3}$ volume of hydrogen, and formed water. Hence a volume of the gas contains

$1\frac{1}{3}$ volume of carbon vapour,	} condensed into one volume.
$1\frac{1}{3}$ volume of hydrogen gas,	

Specific gravity of $1\frac{1}{3}$ volume of carbon vapour,	0.5555
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$1\frac{1}{3}$ volume of hydrogen gas,	0.0926

Total,	-	-	0.6482
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This subtracted from 4.1757, (the specific gravity of the gas), leaves 3.5275; which must be the weight of chlorine gas contained in a volume of the combustible gas. Now the specific gravity of $1\frac{1}{3}$ volume of chlorine gas is 3.3333.

The gas seems to be a compound of

$1\frac{1}{3}$ volume carbon vapour,	} condensed into one volume.
$1\frac{1}{3}$ volume hydrogen gas,	
$1\frac{1}{3}$ volume chlorine gas,	

These added together make a specific gravity of 3.9814.

This is lighter than the gas was found by experiment by about $\frac{1}{21}$ st part. But there is some uncertainty about the actual

specific gravity, as it depends upon the proportion of nitrous gas, a proportion not determined with perfect accuracy.

I am disposed to consider it as not unlikely, that the proportion of nitrous gas may have been rather underrated. On that supposition, I think it very probable, that the true constituents of a volume of the gas are,

1 volume carbon vapour,	0.4166
1 volume hydrogen gas,	0.0694
$1\frac{1}{2}$ volume chlorine gas,	3.7500
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	4.2361

This would make the specific gravity of the gas 4.2361 ; which only exceeds the specific gravity found by about $\frac{1}{7}$ th part. A difference certainly not greater than might be looked for in determining the quantity of nitrous gas mixed with it.

The gas, then, is a compound of

1 atom hydrogen,	0.125
1 atom carbon,	0.750
$1\frac{1}{2}$ atom chlorine,	6.750
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	7.625

and its atomic weight is 7.625.

It contains only half the carbon and hydrogen, but $1\frac{1}{2}$ times the chlorine which exists in a volume of chloro-carbonic acid.

As it will be requisite to distinguish this new inflammable gas by a name, perhaps the term *sesqui-chloride of carbo-hydrogen*, may be employed as giving an accurate idea of its composition.

The discovery of this gas was gratifying to me, for a reason which it may be worth while to explain. In the "*First Principles of Chemistry*," vol. i. p. 249, I pointed out a remarkable property of the compound of one atom carbon and one atom hydrogen. This compound we may distinguish by the name *carbo-hydrogen*, since the appropriate term *carburetted hydrogen* has been un-

luckily applied to a different combination. Carbo-hydrogen has the property of forming a variety of gases and vapours, differing from each other in the number of integrant particles of carbo-hydrogen, which a single volume of the gas or vapour contains. The gas described in this paper (abstracting the chlorine), contains only one integrant particle of carbo-hydrogen in a volume; olefiant gas contains two integrant particles. One of the oleaginous liquids obtained by condensing oil-gas, which has been examined by Mr FARADAY in an insulated state, but which had been previously detected in oil gas, in the state of vapour, by Mr DALTON, contains three integrant particles. Sulphuric ether vapour (abstracting the water) contains four integrant particles; while the vapour of naphtha contains six integrant particles. The following table exhibits the atomic weights, and specific gravities, of these gases and vapours.

	Atomic Weight.	Specific Gravity.
Simple carbo-hydrogen gas, -	0·875.....	0·4861
Olefiant gas, or deuto-carbo-hydrogen,	1·75	0·9722
Oil-gas vapour, or trito-carbo-hydrogen,	2·625.....	1·4583
Ether vapour, or tetarto-carbo-hydrogen,	3·5.....	1·9444
Naphtha vapour of hexa-carbo-hydrogen,	5·25	2·9166

The existence of the simple carbo-hydrogen was merely hypothetical, till the discovery of sesqui-carbo-hydrogen has given us an example of its actual existence. Thus the only doubtful part of this reasoning has been shewn to be actually correct. This circumstance gives an importance to the discovery of sesqui-carbo-hydrogen, to which it would not otherwise be entitled.