VI. *On a gaseous Compound of carbonic Oxide and Chlorine.* By John Davy, *Esq.* *Communicated by Sir* Humphry Davy, *Knt. LL. D. Sec. R. S.*

Read February 6, 1812.

Since the influence of electricity and solar light, as chemical agents, are analogous in many respects, and as the former produces no change in a mixture of carbonic oxide and chlorine, it was natural to infer the same respecting the latter. M. M. Gay Lussac and Thenard assert that this is the case; they say that they have exposed a mixture of carbonic oxide and chlorine, under all circumstances, to light, without observing any alteration to take place:* Mr. Murray has made a similar statement.†

Having been led to repeat this experiment, from some objections made by the last mentioned gentleman to the theory of my brother, Sir Humphry Davy, concerning chlorine, I was surprised at witnessing a different result.

The mixture exposed, consisted of about equal volumes of chlorine and carbonic oxide; the gasses had been previously dried over mercury by the action of fused muriate of lime, and the exhausted glass globe into which they were introduced from a receiver with suitable stopcocks, was carefully dried. After exposure for about a quarter of an hour to bright

* Recherches Physico-Chimiques, Tom. II. p. 150.

† Nicholson's Journal, Vol. XXX. p. 227.

sunshine, the colour of the chlorine had entirely disappeared; the stopcock belonging to the globe, being turned in mercury recently boiled, a considerable absorption took place, just equal to one-half the volume of the mixture, and the residual gas possessed properties perfectly distinct from those belonging either to carbonic oxide or chlorine.

Thrown into the atmosphere, it did not fume. Its odour was different from that of chlorine, something like that which one might imagine would result from the smell of chlorine combined with that of ammonia, yet more intolerable and suffocating than chlorine itself, and affecting the eyes in a peculiar manner, producing a rapid flow of tears and occasioning painful sensations.

Its chemical properties were not less decidedly marked, than its physical ones.

Thrown into a tube full of mercury containing a slip of dry litmus paper, it immediately rendered the paper red.

Mixed with ammoniacal gas, a rapid condensation took place, a white salt was formed, and much heat was produced.

The compound of this gas and ammonia was a perfect neutral salt, neither changing the colour of turmeric or litmus; it had no perceptible odour, but a pungent saline taste; it was deliquescent, and of course very soluble in water; it was decomposed by the sulphuric, nitric, and phosphoric acids, and also by liquid muriatic acid; but it sublimed unaltered in the muriatic, carbonic, and sulphureous acid gasses, and dissolved without effervescing in acetic acid. The products of its decomposition collected over mercury were found to be the carbonic and muriatic acid gasses; and in the experiment with concentrated sulphuric acid when accurate results could be

obtained, these two gasses were in such proportions, that the volume of the latter was double that of the former.

I have ascertained by repeated trials, both synthetical and analytical, that the gas condenses four times its volume of the volatile alkali, and I have not been able to combine it with a smaller proportion.

Tin fused in the gas in a bent glass tube over mercury, by means of a spirit lamp, rapidly decomposed it; the liquor of Libavius was formed; and when the vessel had cooled, there was not the least change of the volume of the gas perceptible; but the gas had entirely lost its offensive odour, and was merely carbonic oxide; for like carbonic oxide it burnt with a blue flame, afforded carbonic acid by its combustion, and was not absorbable by water.

The effects of zinc, antimony, and arsenic heated in the gas, were similar to those of tin; compounds of these metals and chlorine were formed, and carbonic oxide in each experiment was liberated equal in volume to the gas decomposed. In each instance the action of the metal was quick; the decomposition being completed in less than ten minutes; but though the action was rapid, it was likewise tranquil, no explosion ever took place, and none of the metals became ignited or inflamed.

The action even of potassium heated in the gas was not violent. But from the great absorption of gas, and from the precipitation of carbon indicated by the blackness produced, not only the new gas, but likewise the carbonic oxide, appeared to be decomposed.

The white oxide of zinc heated in the gas quickly decomposed it, just as readily indeed as the metal itself; there was

the same formation of the butter of zinc; but instead of carbonic oxide being produced, carbonic acid was formed; and as usual, there was no change of volume.

The protoxide of antimony fused in the gas rapidly decomposed it; the butter of antimony and the infusible peroxide were formed; there was no change of the volume of the gas, and the residual gas was carbonic oxide.

Sulphur and phosphorus sublimed in the gas, produced no apparent change; the volume of the gas was unaltered, and its characteristic smell was undiminished.

Mixed with hydrogene or oxygene singly, the gas was not inflamed by the electric spark, but mixed with both, in proper proportions, viz. two parts in volume of the former and one of the latter to two parts of the gas, a violent explosion was produced, and the muriatic and carbonic acid gasses were formed.

The gas transferred to water was quickly decomposed, the carbonic and muriatic acids were formed, as in the last experiment, and the effect was the same even when light was excluded.

From the mode of the formation of the gas and the condensation that takes place at the time, from the results of the decomposition of its ammoniacal salt, and from the analysis of the gas by metals and metallic oxides, it appears to be a compound of carbonic oxide and chlorine condensed into half the space which they occupied separately.

And from its combining with ammonia, and forming with this alkali a neutral salt, and from its reddening litmus, it seems to be an acid. It is similar to acids in other respects; in decomposing the dry sub-carbonate of ammonia, one part

in volume of it, expelling two parts of carbonic acid gas; and in being itself not expelled from ammonia by any of the acid gasses, or by acetic acid. Independent of these circumstances, were power of saturation to be taken as the measure of affinity, the attraction of this gas for ammonia must be allowed to be greater than that of any other substance, for its saturating power is greater; no acid condenses so large a proportion of ammonia; carbonic acid only condenses half as much, and yet does not form a neutral salt. The great saturating and neutralizing powers of this gas are singular circumstances, and particularly singular when compared with those of muriatic acid gas.

In consequence of its being decomposed by water, I have not been able to ascertain whether it is capable of combining with the fixed alkalies. Added to solutions of these substances it was absorbed, and carbonic acid gas was disengaged by an acid.

I have made the experiment on the native carbonates of lime and barytes, but the gas did not decompose these bodies. This indeed might be expected, since quick-lime, I find, does not absorb the gas: a cubic inch of it, exposed to the action of lime in a tube over mercury, was only diminished in two days to nine-tenths of a cubic inch, and no further absorption was afterwards observed to take place. But even this circumstance does not demonstrate that the gas has no affinity for lime, and is not capable of combining with it; for on making a similar experiment with carbonic acid, substituting this gas for the new compound, the result was the same; in two days only about one-tenth of a cubic inch was absorbed.

Though the gas is decomposed by water, yet it appears to

be absorbed unaltered by common spirits of wine, which contains so considerable a quantity of water; it imparted its peculiar odour to the spirit, and its property of affecting the eyes; five measures of the spirit condensed sixty measures of the gas.

It is also absorbed by the fuming liquor of arsenic, and by the oxymuriate of sulphur.

The former appeared to require for saturation ten times its own volume; six measures of the liquor condensed about sixty of the gas. The liquor thus impregnated was thrown into water, and a pretty appearance was produced by the sudden escape of bubbles of the gas; had not its intolerable smell convinced me that the gas was unaltered, I should not have conceived that it could pass through water undecomposed.

I cannot account for the assertion of M. M. Gay Lussac and Thenard and of Mr. Murray, that oxymuriatic gas does not, when under the influence of light, exert any action on carbonic oxide: I was inclined at first to suppose that the difference between their results and mine, might be owing to their not having exposed the gasses together to bright sunshine; but I have been obliged to relinquish this idea, since I have found that bright sun-shine is not essential, and that the combination is produced in less than twelve hours by the indirect solar rays, light alone being necessary.

The formation of the new gas may be very readily witnessed, by making a mixture of dry carbonic oxide and chlorine in a glass tube over mercury: if light be excluded, the chlorine will be absorbed by the mercury, the carbonic oxide alone remaining; but if bright sun-shine be immediately admitted when the mixture is first made, a rapid ascension of

the mercury will take place, and in less than a minute the colour of the chlorine will be destroyed, and in about ten minutes the condensation will have ceased, and the combination of the two gasses will be complete.

It is requisite that the gasses should be dried for forming this compound; if this precaution is neglected, the new gas will be far from pure; it will contain a considerable admixture of the carbonic and muriatic acid gasses, which are produced in consequence of the decomposition of hygrometrical water. Indeed there is considerable difficulty in procuring the new gas tolerably pure; a good air pump is required, and perfectly tight stop-cocks, and dry gasses, and dry vessels.

I have endeavoured to procure the gas, by passing a mixture of carbonic oxide and chlorine through an earthen-ware tube heated to redness; but without success.

The specific gravity of the gas may be inferred from the specific gravities of its constituent parts jointly with the condensation that takes place at their union. According to CRUICKSHANK, 100 cubic inches of carbonic oxide weigh 29,6 grains, and according to Sir HUMPHRY DAVY, 100 of chlorine are equal to 76,37 grains: hence as equal volumes of these gasses combine, and become so condensed as to occupy only half the space they before filled, it follows that 100 cubic inches of the new compound gas are equal to 105,97 grains. Thus this gas exceeds most others as much in its density as it does in its saturating power.

To ascertain whether chlorine has a stronger affinity for hydrogene than for carbonic oxide, I exposed a mixture of the three gasses in equal volumes to light. Both the new compound and muriatic acid gas were formed, and the affinities

were so nicely balanced, that the chlorine was nearly equally divided between them. And that the attraction of chlorine for both these gasses is nearly the same, appears to be confirmed by muriatic acid not being decomposed by carbonic oxide, or the new gas by hydrogene.

The chlorine and carbonic oxide are, it is evident from these last facts, united by strong attractions; and as the properties of the substance as a peculiar compound are well characterized, it will be necessary to designate it by some simple name. I venture to propose that of phosgene, or phosgene gas; from φως, light, and γινομαι, to produce, which signifies formed by light; and as yet no other mode of producing it has been discovered.

I have exposed mixtures consisting of different proportions of chlorine and carbonic acid to light, but have obtained no new compound.

The proportions in which bodies combine appear to be determined by fixed laws, which are exemplified in a variety of instances, and particularly in the present compound. Oxygene combines with twice its volume of hydrogene and twice its volume of carbonic oxide to form water and carbonic acid, and with half its volume of chlorine to form euchlorine; and chlorine reciprocally requires its own volume of hydrogene and its own volume of carbonic oxide to form muriatic acid and the new gas.

This relation of proportions is one of the most beautiful parts of chemical philosophy, and that which promises fairest, when prosecuted, of raising chemistry to the state and certainty of a mathematical science.