

II.—*On the Absorption of Chlorine in Water.*

By HENRY E. ROSCOE, B.A., PH.D.

AT the beginning of this century, Dalton and Henry set up the hypothesis, that the amounts of gas dissolved by a liquid vary as the pressure under which the absorption takes place. As, however, this relation between the absorbed gas and the pressure could not be deduced from Dalton and Henry's own experiments, and still less from the later ones of Saussure, it has been regarded by chemists as an ungrounded hypothesis, until Professor Bunsen,* in his late research, showed that it had a foundation in a true law.

A series of very careful experiments which Dr. Carius and Dr. Schönfeld have carried out with the absorptiometer described by Bunsen, not only give fresh proofs of the exactitude of the law, but show beyond doubt that it is applicable to gases of very great solubility.

It thus appears of great interest to examine the absorptiometrical relations of gases at the limits of the temperatures at which the same are capable of entering into chemical combination with the solvent. Dr. Schönfeld has examined sulphurous acid in this respect, and has found that the law is followed even at temperatures which ap-

* Phil. Mag., Feb. and March 1855; Ann. Ch. Pharm. xciii. 1.

proach the point where this acid forms a crystalline hydrate with the solvent.

In the following research I shall describe the absorptiometrical relation which exists between chlorine and water at temperatures approaching that at which hydrate of chlorine is formed. As the absorption-coefficient of this gas has already been accurately determined at Schönfeld, I have been able to confine myself to the examination of mixtures of gas of known composition containing chlorine.

The first mixture of gases examined was that evolved by the electrolysis of concentrated hydrochloric acid. The electrolysis was conducted in a small flask of about 100 cubic centimeters' capacity, filled with hydrochloric acid, into which two poles of conducting carbon dipped. A glass tube, with the upper end drawn out, was fastened on to the neck of the flask by means of a caoutchouc ring, and through the tube were melted two platinum wires, which communicated below with the carbon poles and above with the battery. The gas, obtained by a current of four of Bunsen's elements, was washed by passing through a series of bulbs containing water, blown on a glass tube and placed in an oblique position.

The composition of the gas thus obtained by electrolysis must first be determined. For this purpose the gas was dried over fused chloride of calcium, and led into a tube of known capacity, drawn out at both ends, until there could be no doubt that the last traces of atmospheric air were driven out. After accurate observation of the temperature and pressure, the tube filled with the mixture of gas was closed with the necessary precautionary measures, and one end opened under a solution of iodide of potassium; and in order to effect the rise of the liquid, this was done at a lower temperature than that at which the gas was collected. The iodide of potassium was immediately absorbed, and a quantity of iodine, equivalent to the free chlorine present, was separated out.

From this free iodine the amount of chlorine present in the tube was determined by Bunsen's volumetric method.* Two experiments with gas collected at separate occasions gave—

I.	II.
† $\alpha = 0.0024869$	$\alpha = 0.002443$
$t = 92.0$	$t = 67.0$
$t_1 = 59.9$	$t_1 = 58.3$
$n = 5$	$n = 2$

* Ann. Ch. Pharm. lxxxvi. 265; Chem. Soc. Qu. J. vi. 90.

† The signification of the various letters will be seen by reference to the original research.

From these numbers the volume of chlorine V reduced to 0° C. and 0.76 pressure of mercury contained in the tubes used in the experiments, is found in cubic centimeters by means of the formula—

$$(1) \quad \frac{\alpha (nt - t_1) \text{ Cl}}{0.0031823 \text{ l.}} = V$$

in which 0.0031823 is the weight in grms. of 1 cubic centimeter of chlorine at 0° C. and 0.76 pressure of mercury.

The first experiment gave 16.24; the second, 87.36 cub. cent. chlorine at 0° C. and 0.76 pressure of mercury.

If the total capacity of the tube be called C , the barometric pressure at the time of closing P , and the temperature during the same time T , the total volume of gas reduced to 0° C. and 0.76 contained in the tube is found by the following formula :—

$$(2) \quad \frac{C \cdot P}{(1 + 0.00366 T) 0.76} = V_1$$

For Experiments (1) and (2) the following values were found :—

	I.		II.
C . .	34.81	✓ . .	190.24
P . .	0 ^m .7415	. . .	0 ^m .7265
T . .	11 ^o .6 C.	. . .	11 ^o .1 C.

This gives the total volume of the first tube 32.58; of the second, 174.65. If, now, the respective volumes of chlorine found by graduation be subtracted from the total volumes, the volume of hydrogen gas present in the mixture will be obtained.

The composition of the two mixtures of gas was, therefore,—

	I.	II.	Calculated.
Chlorine . .	49.85	50.02	50.00
Hydrogen . .	50.15	49.98	50.00
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00

As the liquid subjected to electrolysis only contained hydrochloric acid and water, the products of decomposition formed could only contain chlorine, hydrogen, oxygen, or the oxides of chlorine or hydrogen. The absence of *free* oxygen can be safely inferred from the experiments just cited, for every volume of oxygen which is set free by the electrolysis of water is necessarily accompanied by *two* volumes of hydrogen, whilst chlorine and hydrogen are set free in equal volumes by the electrolysis of hydrochloric acid. If, therefore, water were decomposed in the above manner, the analysis would not

have shown equal volumes of chlorine and hydrogen, but an excess of the latter, which, as already stated, was not the case. For the same reason, peroxide of hydrogen cannot be formed in the decomposition, as the presence of this body would cause a still greater proportional excess of hydrogen.

It only remains, therefore, to be shown, that in the mixed gas no oxygen-compounds of chlorine are present. Let us in the first place, to take a particular case, examine if the gas could contain hypochlorous acid. 2 vols. of hypochlorous acid consist of 2 vols. of chlorine and 1 vol. of oxygen; 1 vol. of oxygen is equivalent to 2 vols. of chlorine, and sets free in the volumetric process exactly as much iodine as 2 vols. of chlorine. This process leaves it, therefore, quite undecided whether 4 vols. of chlorine or 2 vols. of hypochlorous acid were present; and further, because in the electrolytic decomposition of 4 vols. of hydrochloric acid, as in electrolytic formation of 2 vols. of hypochlorous acid, exactly the same amount, 4 vols., of hydrogen, must be set free, it is clear that the volumetric process will always show equal volumes of chlorine and hydrogen, whether the gas be rendered impure by the presence of hypochlorous acid or not. The question as to the presence of this latter gas is, however, easily answered, when a direct estimation of chlorine with solution of silver is made together with a volumetric determination. The silver determination shows only the amount of chlorine, and not the oxygen of the hypochlorous acid, and therefore may give only half as large an amount of chlorine as the volumetric process. The two following experiments show that the amount of chlorine found by the volumetric method agrees so exactly with that found by the silver determination, that the absence of hypochlorous acid may be certainly deduced. By similar reasoning, the absence of all other volatile oxides of chlorine can be proved.

Three tubes were filled with the gas as formerly described. The first was opened under iodide of potassium, and analysed by the volumetric process; the two others were opened under tolerably concentrated sulphurous acid, by means of which the whole of the chlorine was reduced to hydrochloric acid and precipitated in presence of excess of nitric acid as chloride of silver.

The elements for the first tube were—

$$\alpha = 0.0024869 \quad n = 2 \quad t_1 = 59.3 \quad t = 76.1$$

$$\text{and} \quad T = 14^\circ.7 \quad P = 0^m.7464 \quad C = 43.20$$

From these are obtained—

- I. Volume of chlorine at 0° C. and 0·76 found by
the volumetric process 20·290 cc.
II. Ditto ditto calculated 20·131 „

The elements for the second tube were—

- Weight of chloride of silver 0·3980
„ silver (with ash) 0·0031

and $T=14^{\circ}\cdot7$ $P=0\cdot7464$ $C=66\cdot70$

From these are obtained—

- I. Reduced volume of chlorine found by silver
determination 31·26 cc.
II. Ditto ditto calculated 31·018 „

The elements for the third tube were—

- Weight of chloride of silver 0·3834
„ silver (in ash) 0·0024

and $T=14^{\circ}\cdot07$ $P=0\cdot7464$ $C=64\cdot27$

From these are obtained—

- I. Reduced volume of chlorine found by silver
determination 30·034 cc.
II. Ditto ditto calculated 29·949 „

After all these experiments and considerations, it may be fairly concluded that the electrolytic gas really consists of a pure mixture of equal volumes of chlorine and hydrogen.

As the absorption-coefficients of chlorine and hydrogen for water are known, a simple volumetric determination of an aqueous solution, saturated at a particular temperature with the gaseous mixture, is all that is required to determine if chlorine obeys the law of absorption, and if so, up to what distance from the point at which hydrate of chlorine is formed. For if α represent the absorption-coefficient of chlorine, P the barometer pressure, v the volume of chlorine, and v_1 the volume of hydrogen contained in the mixed gas, which is passed through a volume h of water until it is saturated, the amount of chlorine V dissolved in the water must have the following value if the law of absorption is applicable :—

$$(3) \quad \frac{h \cdot \alpha \cdot Pv}{0\cdot76 (v + v_1)} = V.$$

It will be as well to give here for reference the absorption-coefficients for chlorine and water (α) as found by Dr. Schönfeld:—

0° C.	Coefficient.	0° C.	Coefficient.	0° C.	Coefficient.
10. . . .	2·5852	21. . . .	2·1148	31. . . .	1·7104
11. . . .	2·5413	22. . . .	2·0734	32. . . .	1·6712
12. . . .	2·4977	23. . . .	2·0322	33. . . .	1·6322
13. . . .	2·4543	24. . . .	1·9912	34. . . .	1·5934
14. . . .	2·4111	25. . . .	1·9504	35. . . .	1·5550
15. . . .	2·3681	26. . . .	1·9099	36. . . .	1·5166
16. . . .	2·3253	27. . . .	1·8695	37. . . .	1·4785
17. . . .	2·2828	28. . . .	1·8295	38. . . .	1·4406
18. . . .	2·2405	29. . . .	1·7895	39. . . .	1·4029
19. . . .	2·1984	30. . . .	1·7499	40. . . .	1·3655
20. . . .	2·1565				

Three experiments,* made at different temperatures with the same volume (9·834 cc.) of saturated solution, gave the following results:—

(1)	(2)	(3)
$n = 2\cdot$	$n = 1\cdot$	$n = 1\cdot$
$t_1 = 48\cdot9$	$t_1 = 10\cdot0$	$t_1 = 5\cdot5$
$t = 58\cdot6$	$t = 67\cdot6$	$t = 60\cdot3$
$T = 14^{\circ}\cdot4$	$T = 21^{\circ}\cdot0$	$T = 25^{\circ}\cdot0$
$\alpha = 0\cdot0024430$		

Calculated
from formula (3).

Hence the vol. chlorine at 0° C. and 0·76 at 14°·4 is	14·70	..	11·65
„ „ „ „ „	21°·0	„	12·643
„ „ „ „ „	25°·0	„	11·99
			9·36

These figures show that the amounts of chlorine found in the saturated solution differed considerably from the amount which should be contained therein according to the law of absorption.

Let us now proceed to the consideration of the causes which might possibly effect this increased absorption of chlorine. It has been already shown that the gas employed in the experiments did not contain any amount of oxides of chlorine which could possibly produce this greatly increased coefficient of absorption. It is, however, quite possible that chlorine should act towards water as it does towards so many bases, and a formation of hydrochloric acid and

* It is almost unnecessary to state, that all the experiments on mixtures of chlorine and hydrogen were conducted in a darkened room, a candle being the only light present.

oxide of chlorine take place. It is possible that the compounds thus formed were not present in the gaseous mixture, because they were retained in solution by the liquids with which they came in contact. Such a partial decomposition of the water by chlorine into hydrochloric and hypochlorous acids would most satisfactorily account for the above irregularities. This question may be easily settled by an experiment founded upon the law of absorption. If we suppose that when chlorine is dissolved in water, hydrochloric acid and any volatile oxide of chlorine is formed, it is easily seen that not only the volumetric process, but also a direct silver determination, must give exactly the same results as would be found if the liquid contained only free chlorine. A totally different result will, however, be obtained if any gas which obeys the law of absorption—as, for instance, carbonic acid—be passed into a saturated solution of chlorine in water. If merely chlorine be present, it will be driven out by a stream of carbonic acid, and replaced by this gas in the proportion of their relative absorption-coefficients.

If, on the contrary, hydrochloric acid and a volatile oxide of chlorine are present together with free chlorine, the chlorine and oxides of chlorine will be driven out in an amount different from that of the hydrochloric acid, which, when dissolved in a large quantity of water, is not volatile. Thus a relation between the components will be brought about, by which the volumetric and silver determinations cannot give like results, because the original relation by which the hydrochloric and hypochlorous acids are present in the proportion capable of forming chlorine and water, does not now exist.

The following experiment, in which a stream of carbonic acid was passed in the dark through a solution of chlorine freshly prepared without access of light, shows that after the current of gas had passed through for three hours, the amounts of chlorine obtained by volumetric and silver determinations agreed exactly. The gas was first passed into a bottle containing the chlorine solution, next into a second bottle containing distilled water, and the resulting solution in both bottles was examined.

ANALYSIS FROM THE FIRST BOTTLE.

Volumetric method—

$$\alpha = 0.0024869$$

$$(1) \quad n=2 \quad t_1=50.5 \quad t=72.0$$

$$(2) \quad n=2 \quad t_1=53.4 \quad t=71.0$$

THE ABSORPTION OF CHLORINE IN WATER.

21

Silver determination—

(1)	Chloride of silver	.	.	.	0·2617
	Silver	.	.	.	0·0010
(2)	Chloride of silver	.	.	.	0·2443
	Silver	.	.	.	0·0050

These elements give—

		(1)	(2)
Reduced volume of chlorine found by the			
volumetric method	.	20·421	19·962
Ditto	ditto silver determination	20·517	19·599

ANALYSIS FROM THE SECOND BOTTLE.

Volumetric method—

$$\alpha = 0·0024869$$

(1)	$n=2$	$t_1=46·8$	$t=71·9$
(2)	$n=2$	$t_1=48·0$	$t=71·7$

Silver determination—

(1)	Chloride of silver	.	.	.	0·2701
	Silver	.	.	.	0·0012
(2)	Chloride of silver	.	.	.	0·2594
	Silver	.	.	.	0·0005

These elements give—

		(1)	(2)
Reduced volume of chlorine found by the			
volumetric method	.	21·185	20·836
Ditto	ditto silver determination	21·346	20·303

The supposition of a decomposition of water by chlorine to account for the observed phenomena is, therefore, likewise unfounded.

As an objection might be raised to this experiment, that the oxides of chlorine are not volatile enough to be carried over from their solution by a foreign gas, I have examined the action of carbonic acid on a mixture of oxides of chlorine. The mixture of all the various oxides of chlorine, which is obtained by heating chlorate of potash with concentrated sulphuric acid, was dissolved in water, and a known volume of the solution submitted to volumetric analysis; this volume was found to be equivalent to 50·3 burette divisions of normal iodine solution. A rapid stream of carbonic acid was then passed through the solution, which, after fifteen minutes, was again volumetrically analysed, and the same volume of solution was found to be equal to

24·0 divisions; after the current of gas had passed for thirty minutes more, the same volume corresponded to only 3·7 divisions. The rapidity with which the values of the volumetric determinations decreased with the amount of gas passed through, shows how easily the oxides of chlorine are expelled from their solutions by other gases, and hence the former objection is entirely removed.

A similar result is arrived at when the mixture of hydrogen and chlorine, after being washed, is allowed to saturate a volume of water. It is here also easy to show that no oxides of chlorine have passed over, for in the following experiment the same amount of chlorine was obtained by volumetric and by silver determination :—

Chlorine and hydrogen absorbed in 9·843 cc. of water at 38° and 0^m·7339 pressure :

Volumetric method—

$$\alpha = 0\cdot0024430$$

$$(1) \quad n=1 \quad t_1=31\cdot8 \quad t=72\cdot4$$

$$(2) \quad n=1 \quad t_1=31\cdot9 \quad t=72\cdot0$$

Silver determination—

$$(1) \quad \begin{array}{llll} \text{Chloride of silver} & . & . & . \\ \text{Silver} & . & . & . \end{array} \quad \begin{array}{l} 0\cdot1117 \\ 0\cdot0016 \end{array}$$

$$(2) \quad \begin{array}{llll} \text{Chloride of silver} & . & . & . \\ \text{Silver} & . & . & . \end{array} \quad \begin{array}{l} 0\cdot1087 \\ 0\cdot0048 \end{array}$$

Mean reduced volume of chlorine from volumetric method

Ditto ditto silver determination

In order that no possible cause may be left undetermined, I have examined the action of free hydrochloric acid upon the solution of chlorine. It was possible that the formation of hydrochloric acid from the hydrogen and chlorine might induce a larger absorption of chlorine, and thus the phenomena be explained. It was, however, found that the presence of hydrochloric acid lessened, instead of increasing, the absorption-coefficient of chlorine.

Water containing $\frac{1}{126}$ th of its bulk of concentrated hydrochloric acid was saturated with chlorine at 14° and 0^m·7366 pressure, and the absorption-coefficient calculated according to the formula,—

$$(4) \quad \frac{\alpha (nt - t_1) \text{ Cl } 0\cdot76}{0\cdot0031823 \cdot I \cdot h.}$$

The experiment gave, when $h=9.834$ —

$$\begin{array}{llll} (1) & n=2 & t_1=62.1 & t=74.9 \\ (2) & n=2 & t_1=60.0 & t=73.9 \end{array} \quad \alpha=0.0024869$$

Hence the

$$\begin{array}{llll} \text{Coefficient obtained is} & . & . & . & 1.9786 \\ \text{Coefficient for pure water} & . & . & . & 2.3911 \end{array}$$

One assumption alone remains after all these experiments, namely, that near the temperature at which the formation of hydrate of chlorine begins, the atoms of chlorine exert an attraction on those of the other gas present, and on the water, similarly to the law of Mariotte at the point of condensation, and that thereby the accuracy of the law of absorption is lessened. In order to form an idea of the amount of this molecular disturbance, it is possible to calculate the volume of chlorine which, for any given temperature, does not obey the law of absorption. The equations for this calculation are obtained from the volumes of chlorine which are absorbed in water, firstly for pure chlorine, and secondly for a known mixture of this gas with hydrogen. Let V be the reduced volume of chlorine absorbed in h volumes of water when pure chlorine is used; V_1 the volume of chlorine dissolved in h_1 volumes of water when the mixed gas is used; v the amount of chlorine in the mixed gas; v_1 the volume of hydrogen in the latter; P the observed barometric pressure; y the reduced volume of chlorine obeying the law of absorption, which is contained in the unit of water; x the reduced volume of chlorine which, by reason of the molecular action, is supposed to be withdrawn from the law of absorption.

The following equations give the values of x and y :—

$$(5) \quad V = hy + hx$$

$$(6) \quad V_1 = \frac{h_1 y P v}{0.76 (v + v_1)} + h_1 x$$

or,

$$(7) \quad x = \frac{V}{h} - y$$

$$(8) \quad y = \frac{\frac{V}{h} - \frac{V_1}{h_1}}{1 - \frac{Pv}{0.76 (v + v_1)}}$$

By means of these formulæ, the values of x and y for various temperatures have been calculated from the following determinations :—

Chlorine and Hydrogen—

$$\alpha = 0.0024869 \quad h_1 = 9.834$$

I.	T° = 13°·5	P = 0.7431	n = 2	t ₁ = 39.2	t = 53.85
II.	T° = 14°·3	P = 0.7414	n = 2	t ₁ = 48.9	t = 58.6
III.	T° = 21°·0	P = 0.7402	n = 1	t ₁ = 10.0	t = 67.6
IV.	T° = 25°·0	P = 0.7431	n = 1	t ₁ = 5.5	t = 60.3
V.	T° = 30°·0	P = 0.7320	n = 1	t ₁ = 4.8	t = 53.2
VI.	T° = 38°·0	P = 0.7339	n = 1	t ₁ = 31.85	t = 72.2

Hence for—

13°·5	.	.	y = 1.7831	x = 0.6496
14°·3	.	.	y = 1.7641	x = 0.6291
20°·1	.	.	y = 1.6721	x = 0.4880
21°·0	.	.	y = 1.6287	x = 0.4861
25°·0	.	.	y = 1.5984	x = 0.3589
30°·0	.	.	y = 1.3633	x = 0.3866
38°·0	.	.	y = 1.0625	x = 0.3771

In order to determine whether the amount of this molecular disturbance was dependent upon the nature of the gas with which the chlorine is in contact, mixtures of known volumes of chlorine and carbonic acid were examined, and in a similar manner the values of x and y calculated from the experiments.

The great difficulty of mixing a known volume of chlorine with a known volume of another gas was overcome by the following simple arrangement:—A large glass tube of about 80 to 150 cubic centimetres' capacity was drawn out, the glass thickened at either end, and pieces of glass rod ground to fit air-tight into the apertures. The capacity of the tube was then accurately determined, and it was afterwards completely filled with carbonic acid and closed. The tube thus filled was opened under a saturated solution of chlorine freshly prepared in the dark, and a part of the carbonic acid driven out by the saturated solution. The tube containing the mixture of chlorine, water, and carbonic acid gas, was next well shaken in a water-bath of known temperature, and one of the stoppers partly opened to allow the excess of gas to escape. By means of this agitation, the statical equilibrium of absorption was established between the chlorine and carbonic acid dissolved in the water, and the chlorine and carbonic acid present in the free gas.

An effect of this process was an increased volume of free gas. This increased volume was allowed to escape, and thereby the original pressure obtained, and the agitation and other operations were repeated until no more gas was evolved, and the pressure remained

constant; or in other words, until the equilibrium ensued. The free and absorbed gas must be present in a proportion which may be calculated from the law of absorption. This proposition is found by the formulæ 1 and 2 used in the former case. The experiments were made in the following manner:—After the tube had been completely agitated, it was weighed in order to obtain the volume of water employed, and the amount of dissolved chlorine was determined by the volumetric method. The chlorine contained in the gas was also estimated in the same way, the tube being cooled with ether and opened under iodide of potassium. A deduction was also made for chlorine contained in the residual water, the volume of which was found by a second weighing after the volumetric examination of the water. By these observations, all the data for the calculation of x and y are given.

To obtain from a series of experiments the values of x and y , the same formulæ were used, viz.

$$y = \frac{\frac{V}{h} - \frac{V_1}{h_1}}{1 - \frac{0.76(v+v_1)}{Pv}}; \quad x = \frac{V}{h} - y$$

where $\frac{V}{h}$ is, as before, the volume of pure chlorine dissolved in the unit of water; $\frac{V_1}{h_1}$ the volume of chlorine dissolved in the unit of water from the mixed gases chlorine and carbonic acid, v the volume of chlorine in the gas, and v_1 the volume of carbonic acid.

Two experiments thus conducted with varying volumes of chlorine, carbonic acid, and water, at the same temperature, show very closely approximative results:—

EXPERIMENT I.

$$T=29^{\circ}.5 \quad P=0.7428$$

Capacity of tube=82.62 cc.;

Weight of tube empty=16.745;

Weight of tube, water, and gas=33.005;

Volumetric analysis of the solution: $n=1$; $t_1=3.5$; $t=70.8$;

Weight of tube and residual water=17.192;

Volumetric analysis of the gas: $n=2$; $t_1=44.8$; $t=64.8$.

From these elements we obtain—

$$V_1=15.098 \quad v=18.120 \quad h_1=16.265 \quad v+v_1=67.455$$

Hence,

$$y=1.141; \quad x=0.6287.$$

EXPERIMENT II.

$$T=29^{\circ}5 \quad P=0.7514$$

Capacity of tube, and weight of tube empty, same as I.

Weight of tube and solution = 34.69 ;

Volumetric analysis of the solution : $n=2$; $t_1=58.0$; $t=68.0$;

Weight of tube and residual HO = 17.160 ;

Volumetric analysis of the gas : $n=2$; $t_1=48.0$; $t=68.1$.

From these elements we obtain—

$$V_1=17.455 \quad v=19.939 \quad h_1=17.945 \quad v+v_1=64.775$$

Hence,

$$y=1.1456 \quad x=0.6241.$$

The following table shows the values of x and y for various temperatures, as calculated from the experiments with chlorine and carbonic acid :—

13°·5	...	$y=1.7940$	...	$x=0.5955$
14°·4	...	$y=1.7948$	...	$x=0.5963$
17°·5	...	$y=1.7990$	...	$x=0.4599$
20°·5	...	$y=1.4024$	...	$x=0.7638$
22°·0	...	$y=1.3129$	...	$x=0.7605$
25°·0	...	$y=1.2214$	...	$x=0.7191$
29°·0	...	$y=1.1022$	...	$x=0.6675$
29°·5	...	$y=1.1438$	...	$x=0.6264$
36°·0	...	$y=0.8230$	...	$x=0.6283$

Mean value of x for all the experiments, 0.6399.

From these experiments it is clear that, for the same temperature, the amount of chlorine not obeying the law of absorption, varies with the nature of the other absorbed gas, and that the absorption-coefficient of chlorine is also altered by this circumstance. It is seen from the first table of the coefficients for chlorine and hydrogen, that the amount of chlorine present as not obeying the law, diminishes as the temperature increases from the point at which hydrate of chlorine is formed. In the determinations with carbonic acid and chlorine, on the other hand, this diminution is not seen at the temperature at which the experiments were made.