

the hind limb the mere act of extension is sufficient stimulus to call forth a definite amount of response which takes the form of a simple contraction, but that if the limb be held until this reflex act has passed off there is no consciousness on the part of the brain that the limb is in an unusual position, and consequently no volition is exerted to remove it.

It cannot be objected to this experiment that the stoppage of the circulation in the hind limbs has diminished their irritability because the frog A has perfect control over his; and, moreover, the vigour with which the reflex acts are executed in B precludes this idea. Again, it might be said that the stoppage of the respiration by the urari, and consequent supply of ill-aerated blood to the brain has injured the volition of the animal; to meet this, two counter experiments have been tried: in one a frog was gagged so as to keep its mouth open for some hours, and in the other a frog was kept under well-aerated water for two hours (a period equal to the duration of the chief experiment), and in neither case did the frogs seem to suffer any inconvenience whatever, least of all did they lose their volition.

In order to investigate the action of urari on the spinal cord, two similar frogs were taken as before; but previously to being ligatured they were pithed and had their brains destroyed; they were then suspended, and the state of the cord, as manifested by reflex action, tested; dilute sulphuric acid was used as stimulus; the numbers represent quarter seconds.

	h. m.	A*	B
α	3 30	9	8
	3 35	7	6
	3 40	8	6

A* Lost blood.

	h. m.	Urari was given to B.	
β	3 40	8	5
	4 15	8	7
	4 20	8	6
	4 25	8	8
	4 30	8	9

	h. m.	A second dose to B.	
γ	4 35	7	14
	4 40	8	26
	4 45	7	22
	4 50	9	27 Not strong.
	4 55	7	60 Weak.
	5 0	9	No action after 220.
	5 5	8	

From this it would appear that the first effect of urari is to make the action of the cord uncertain, then to delay the reflex action, and finally to destroy it entirely. The table has been divided into three parts, α, β, and γ, which seem to represent in a tolerably typical manner the three stages into which the phenomena are always divisible; sometimes the animal recovered after the stage γ.

This short account of the above experiments is intended as a preliminary notice. I am continuing investigations on mammals, and purpose hereafter to publish a more complete account of my results.

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P.S.—Since writing the above my attention has been called to a paper by Dr. J. Steiner, in *Reichart's und Du Bois-Raymond's Archiv* for July. He investigates the action of urari on Invertebrates and fishes, and finds that among the latter its effect is to destroy volition before the peripheral motor fibres are attacked.

WEATHER AND EPIDEMICS OF SCARLET FEVER IN LONDON DURING THE PAST THIRTY-FIVE YEARS*

THIS paper gives the results of an investigation, the purpose of which was to determine whether the seasonal influence of weather on deaths from scarlet fever, as shown by the curve constructed from the figures of thirty years, would present itself if the period were broken up and curves constructed for the several smaller periods embraced in the long one. In other words, the object was to determine whether, in the case of a disease which is strongly epidemic, the obedience to seasonal

* Abstract of a paper read by Dr. Arthur Mitchell at the general meeting of the Scottish Meteorological Society, July 13.

influences, would exhibit a steadiness and uniformity of character, such as is presented in the case of pulmonary diseases. In London there have been six epidemics of scarlet fever during the last thirty-five years, reaching their maxima in 1844, 1848, 1854, 1859, 1863, and 1870. Curves were constructed representing the average weekly deaths from scarlet fever for each of the six periods embracing these epidemics. These curves were then compared with the curve for the thirty years, 1845-74, the leading features of which are that it is above the average from the beginning of September to the end of the year, and below the average during the rest of the year; and that the period of highest death-rate is from the beginning of October to the end of November, when it rises to about 60 per cent. above the average, and the period of lowest death-rate in March, April, and May, when it is about 33 per cent. below the average.

On comparing the curves for the six short portions of the thirty-five years, each dealing only with four, five, or six years, with the general curve for the long period of thirty years, a remarkable similarity is found to occur. They are all substantially the same curve. The description of the general curve given above applies almost literally to every one of the six curves for short periods, and indeed so close is the correspondence that they all cross their mean almost in the same week of the year. In every case the maximum occurs in October and November, and the only point of difference among them is that while the general curve rises at the maximum period to 60 per cent. above the average, during the first epidemic it rose only to 40 per cent., and in one or two of the others it rose to 80 per cent. above the average. The steady obedience to climatic influences in the fatality from a disease so decidedly epidemic as scarlet fever is very remarkable, and the more so inasmuch as no other disease, with the single exception of typhoid fever, attains to its maximum fatality in London under the conditions of weather peculiar to October and November.

PHYSICAL PROPERTIES OF MATTER IN THE LIQUID AND GASEOUS STATES*

II.

Law of Gay-Lussac.—That the law of Gay-Lussac in the case of the so-called permanent gases, or in general terms of gases greatly above their critical points, holds good at least at ordinary pressures, within the limits of experimental error, is highly probable from the experiments of Regnault; but the results I have obtained with carbonic acid will show that this law, like that of Boyle, is true only in certain limiting conditions of gaseous matter, and that it wholly fails in others. It will be shown that not only does the coefficient of expansion change rapidly with the pressure, but that, *the pressure or volume remaining constant, the coefficient changes with the temperature.* The latter result was first obtained from a set of preliminary experiments, in which the expansion of carbonic acid under a pressure of seventeen atmospheres was observed at 4°, 20°, and 54°; and it has since been fully confirmed by a large number of experiments made at different pressures and well-defined temperatures. These experiments were conducted by the two methods commonly known as the method of constant pressure and the method of constant volume. The two methods, except in the limiting conditions, do not give the same values for the coefficient of expansion; but they agree in this respect, that at high pressures the value of that coefficient changes with the temperature. While I have confined this statement to the actual results of experiment, I have no doubt that future observations will discover, in the case, at least, of such gases as carbonic acid, a similar but smaller change in the value of the co-efficient for heat at low pressures. The numerous experiments I have made on this subject will shortly be communicated in detail to the Society; and for the present I will only give the following results:—

Expansion of Heat of Carbonic Acid Gas under high pressures.

Pressure.	Vol. CO ₂ at 0 ^o and 760 millims. = 1.	Vol. CO ₂ at 6 ^o 05 and 22'26 at. = 1.	Temperature.*
at.			
22'26	0'03934	1'0000	6'05
22'26	0'05183	1'3175	63'79
22'26	0'05909	1'5020	100'10

* "Preliminary Notice of further Researches on the Physical Properties of Matter in the Liquid and Gaseous States under varied conditions of Pressure and Temperature." Paper read before the Royal Society by Dr. Andrews, F.R.S., Vice-President of Queen's College, Belfast. Continued from p. 301.

Pressure. at.	Vol. CO ₂ at 0° & 760 millims. = 1.	Vol. CO ₂ at 6°.62 and 31°.06 at. = 1.	Temperature.
31°.06	0.02589	1.0000	6°.62
31°.06	0.03600	1.3905	63°.83
31°.06	0.04160	1.6068	100°.64

... (B)

Pressure. at.	Vol. CO ₂ at 0° and 760 millims. = 1.	Vol. CO ₂ at 6°.01 and 40°.06 at. = 1.	Temperature.
40°.06	0.01744	1.0000	6°.01
40°.06	0.02697	1.5464	63°.64
40°.06	0.03161	1.8123	100°.60

... (C)

Taking as unit 1 vol. of carbonic acid at 6°.05 and 22°.26 atmospheres, we obtain from series A the following values for the coefficient of heat for different ranges of temperature:—

$$\alpha = 0.005499 \text{ from } 6°.05 \text{ to } 63°.79$$

$$\alpha = 0.005081 \text{ from } 63°.79 \text{ to } 100°.1$$

From series B, with the corresponding unit volume at 6°.62 and 31°.06 atmospheres, we find:—

$$\alpha = 0.006826 \text{ from } 6°.62 \text{ to } 63°.83$$

$$\alpha = 0.005876 \text{ from } 63°.83 \text{ to } 100°.64$$

And in like manner from series C with the unit volume at 6°.01 and 40°.06 atmospheres:—

$$\alpha = 0.009481 \text{ from } 6°.01 \text{ to } 63°.64$$

$$\alpha = 0.007194 \text{ from } 63°.64 \text{ to } 100°.60$$

The co-efficient of carbonic acid under one atmosphere referred to a unit volume at 6° is

$$\alpha = 0.003629$$

From these experiments it appears that the co-efficient of expansion increases rapidly with the pressure. Between the temperatures of 6° and 64° it is once and a half as great under 22 atmospheres, and more than two and a half times as great under 40 atmospheres, as at the pressure of 1 atmosphere. Still more important is the change in the value of the co-efficient at different parts of the thermometric scale, the pressure remaining the same. An inspection of the figures will also show that this change of value at different temperatures increases with the pressure.

Another interesting question, and one of great importance in reference to the laws of molecular action, is the relation between the elastic forces of a gas at different temperatures while the volume remains constant. The experiments which I have made in this part of the inquiry are only preliminary, and were performed not with pure carbonic acid, but with a mixture of about 11 volumes of carbonic acid and 1 volume of air. It will be convenient, for the sake of comparison, to calculate, as is usually done, the values of α from these experiments; but it must be remembered that α here represents no longer a coefficient of volume, but a coefficient of elastic force.

Elastic force of a mixture of 11 vol. CO₂ and 1 vol. air heated under a constant volume to different temperatures.

Vol. CO ₂ .	Temperature.	Elastic Force. at.
366.1	13°.70	22.90
366.2	40°.63	25.74
366.2	99°.73	31.65
256.8	13°.70	31.18
256.8	40°.66	35.44
256.8	99°.75	44.29

... (A)

... (B)

From series A we deduce for a unit at 13°.70 and 22°.90 atmospheres:—

$$\alpha = 0.004604 \text{ from } 13°.70 \text{ to } 40°.63$$

$$\alpha = 0.004367 \text{ from } 40°.63 \text{ to } 99°.73$$

And from series B:—

$$\alpha = 0.005067 \text{ from } 13°.70 \text{ to } 40°.66$$

$$\alpha = 0.004804 \text{ from } 40°.66 \text{ to } 99°.75$$

The coefficient at 13°.70 and 1 atmosphere is

$$\alpha = 0.003513$$

It is clear that the changes in the values of α , calculated from the elastic forces under a constant volume, are in the same direction as those already deduced from the expansion of the gas under a constant pressure. The value of α increases with the pressure, and it is greater at lower than at higher temperatures. But a remarkable relation exists between the coefficients in the present case which does not exist between the coefficients obtained from the expansion of the gas. The values of α , deduced for the same range of temperature from the elastic forces at

different pressures, are directly proportional to one another. We have, in short—

$$\frac{0.004367}{0.004604} = 0.9485, \quad \frac{0.04804}{0.05067} = 0.9481.$$

How far this relation will be found to exist under other conditions of temperature and pressure will appear when experiments now in progress are brought to a conclusion.

Law of Dalton.—This law, as originally enunciated by its author, is, that the particles of one gas possess no repulsive or attractive power with regard to the particles of another. "Oxygen gas," he states, "azotic gas, hydrogenous gas, carbonic acid gas, aqueous vapour, and probably several other elastic fluids may exist in company under any pressure and at any temperature without any regard to their specific gravities, and without any pressure upon one another." The experiments which I have made on mixtures of carbonic acid and nitrogen have occupied a larger portion of time than all I have yet referred to. They have been carried to the great pressure of 283.9 atmospheres, as measured in glass tubes by a hydrogen manometer, at which pressure a mixture of three volumes carbonic acid and four volumes nitrogen was reduced at 7°.6 to $\frac{3}{7}$ of its volume without liquefaction of the carbonic acid. As this note has already extended to an unusual length, I will not now attempt to give an analysis of these experiments, but shall briefly state their general results. The most important of these results is the *lowering of the critical point by admixture with a non-condensable gas*. Thus in the mixture mentioned above of carbonic acid and nitrogen, no liquid was formed at any pressure till the temperature was reduced below -20° C. Even the addition of only $\frac{1}{15}$ of its volume of air or nitrogen to carbonic acid gas will lower the critical point several degrees. Finally, these experiments leave no doubt that the law of Dalton entirely fails under high pressures, where one of the gases is at a temperature not greatly above its critical point. The anomalies observed in the tension of the vapour of water, when alone and when mixed with air, find their real explanation in the fact that the law of Dalton is only approximately true in the case of mixtures of air and aqueous vapour at the ordinary pressure and temperature of the atmosphere, and do not depend, as has been alleged, on any disturbing influence produced by a hygroscopic action of the sides of the containing vessel. The law of Dalton, in short, like the laws of Boyle and Gay-Lussac, only holds good in the case of gaseous bodies which are at feeble pressures and at temperatures greatly above their critical points. Under other conditions these laws are interfered with; and in certain conditions (such as some of those described in this note) the interfering causes become so powerful as practically to efface them.

SCIENTIFIC SERIALS

Poggendorff's Annalen der Physik und Chemie, Nos. 5 and 6.—These parts contain the following papers:—No. 5: On the variations in the phases of light when reflected from glass, by P. Glan; account of experiments made in the physical laboratory of Berlin University, under the direction of Prof. Helmholtz.—On some remarkable growths of quartz crystals on calcareous spar from Schneeberg in Saxony, by Aug. Frenzel of Freiberg, and G. vom Rath of Bonn.—Mineralogical researches, by G. vom Rath. This paper treats of pseudomorphous monticellite from Pesmeda, on the Monzoni Mountain in Tyrol, of rhombic sulphur, of calcareous spar from Ahren (Tyrol), and of a peculiar specimen of quartz from Japan.—On a method to determine extra currents electroscopically, by Dr. F. Fuchs.—On the electric conduction resistance of air, by A. Oberbeck.—On the absorption and refraction of light in metallic opaque bodies, by W. Wernicke.—On the changes which take place in temperature at the passage of an electric current from one metal to another, by Dr. Heinrich Buff.—On the isodynamical planes round a vertical magnetic rod, and their application in an investigation of iron ore deposits, based upon magnetic measurements, by Rob. Thalén.—A paper on the same subject, by Th. Dang. Both these papers are from the *Kongl. Vetenskaps Föreläsningar*.—Spectroscopic Notes, by J. Norman Lockyer: On the evidence of variation in molecular structure, and On the molecular structure of vapours in connection with their densities. These Notes are translated from the Proceedings of the Royal Society, June 11, 1874.—On the distribution of heat in the normal spectrum, by G. Lundquist.—On the time of attraction and repulsion of electro-magnets, by Dr. Schneebeli.—On the mathematical