Pressure.	Vol. CO_2 at 0° & 760 millims. = 1.	Vol. CO_2 at 6°·62 and 31·06 at. = 1.	Temperature.	
at.			°	
31·06	0·02589	1·0000	6·62	
31·06	0·03600	1·3905	63·83	...(B)
31·06	0·04160	1·6068	100·64	

Pressure.	Vol. CO_2 at 0° and 760 millims. = 1.	Vol. CO_2 at 6°·01 and 40·06 at. = 1.	Temperature.	
at.			°	
40·06	0·01744	1·0000	6·01	
40·06	0·02697	1·5464	63·64	...(C)
40·06	0·03161	1·8123	100·60	

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 :—

$$\alpha = 0{\cdot}005499 \text{ from } 6^{\circ}{\cdot}05 \text{ to } 63^{\circ}{\cdot}79$$
$$\alpha = 0{\cdot}005081 \text{ from } 63^{\circ}{\cdot}79 \text{ to } 100^{\circ}{\cdot}1$$

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

$$\alpha = 0{\cdot}006826 \text{ from } 6^{\circ}{\cdot}62 \text{ to } 63^{\circ}{\cdot}83$$
$$\alpha = 0{\cdot}005876 \text{ from } 63^{\circ}{\cdot}83 \text{ to } 100^{\circ}{\cdot}64$$

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

$$\alpha = 0{\cdot}009481 \text{ from } 6^{\circ}{\cdot}01 \text{ to } 63^{\circ}{\cdot}64$$
$$\alpha = 0{\cdot}007194 \text{ from } 63^{\circ}{\cdot}64 \text{ to } 100^{\circ}{\cdot}60$$

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

$$\alpha = 0{\cdot}003629$$

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. CO_2 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	... (A)
366·8	99·73	31·65	
256·8	13·70	31·18	
256·8	40·66	35·44	... (B)
256·8	99·75	44·29	

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

$$\alpha = 0{\cdot}004604 \text{ from } 13^{\circ}{\cdot}70 \text{ to } 40^{\circ}{\cdot}63$$
$$\alpha = 0{\cdot}004367 \text{ from } 40^{\circ}{\cdot}63 \text{ to } 99^{\circ}{\cdot}73$$

And from series B :—

$$\alpha = 0{\cdot}005067 \text{ from } 13^{\circ}{\cdot}70 \text{ to } 40^{\circ}{\cdot}66$$
$$\alpha = 0{\cdot}004804 \text{ from } 40^{\circ}{\cdot}66 \text{ to } 99^{\circ}{\cdot}75$$

The coefficient at 13°·70 and 1 atmosphere is

$$\alpha = 0{\cdot}003513$$

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—

$$\frac{0{\cdot}004367}{0{\cdot}004604} = 0{\cdot}9485, \qquad \frac{0{\cdot}04804}{0{\cdot}05067} = 0{\cdot}9481.$$

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 $\frac{1}{3\frac{1}{7}}$ 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 $\frac{1}{10}$ 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. Werniche.—On the changes which take place in temperature at the passage of an electric current from one metal to another, by Dr. Heinr. 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 Förhandlingar*.—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

determination of the places of deviation in telegraph lines, by Fr. Schaak.—Experiments on the plasticity of ice, by Prof. F. Pfaff. These experiments have been minutely described under our heading "Science in Germany."—On the behaviour of certain fluorescent bodies towards oleum ricini, by Ch. Horner.—On a new source of magnetism, by Donato Tommasi.—No. 6: On the temporary course of the polarisation current, by Prof. J. Bernstein.—On the objections raised against Weber's law by Tait, Thomson, and Helmholtz, by C. Neumann.—Researches in spectrum analysis, by R. Bunsen. This paper will also appear in detailed extract under our heading "Science in Germany."—On the evidence of alternation of electricity by means of flames, by F. Fuchs.—On the variations in the phases of light when reflected from glass, by P. Glan (second paper).—On the theory of laying and examining submarine telegraph lines, by W. Siemens.—Researches on the magnetism of steel rods, by C. Fromme.—On the permanently magnetic moments of magnetic rods and Häcker's formula: $T = p \sqrt[3]{Q} \times \sqrt[3]{l}$, by L. Külp.—On the influence of the texture of iron on its magnetism, by the same.—On the passage of gases through thin layers of liquids, by F. Exner.

THE *Naturforscher*, June.—From this part we note the following papers:—On some phenomena of interference in circular nets, by M. Soret.—On the simultaneous formation of two microscopic minerals, by H. Fischer.—On the distortion of the images reflected from the surface of water, with reference to some phenomena observed on Lake Leman, by Ch. Dufour.—On the power of diffusion in the soil of fields, by M. Grandeau.—On the tenor of carbonic acid in the soil-gases of Klausenburg, by J. von Fodor.—On the formation of the "terra rossa" from the shells of Globigerina, by M. Neumayr.—On a strange dimorphism among walnut trees (*Juglans regia*), by F. Delpino.—On the exhalation of carbonic acid by different animals, by Rud. Pott.—On a new source of magnetism, by Donato Tommasi.—On some physical properties of collodion films, by E. Gripon.—On the influence of oxygen upon life; experiments made with frogs which were placed in an atmosphere of nitrogen for some time, by E. Pflüger.—On the action of coloured light upon the assimilation of the mineral matter in plants, by Rud. Weber.—On the principle of the dispersion of energy, by A. Fick.—Light and electro-magnetism, by Ludw. Boltzmann.—On the nitro compounds of the fatty series, by Victor Meyer (a long paper taken from Liebig's *Annalen der Chemie*).—On hearing with two ears, by F. P. le Roux.—On the adaption-power of fresh-water molluscs breathing by lungs, by Th. von Siebold.

Journal of the Franklin Institute, June.—The following are the principal original articles in this number:—"The Centennial Exhibition," with three plates.—"Account of some Experiments made for the purpose of comparing the indication of Cassella's Air Metres," by C. B. Richards, M.E.; these experiments were adverse to the trustworthiness of the metres.—"Sympathetic Vibration," by H. A. Rowland, C.E.—"A new Vertical-Lantern Galvanometer," by Prof. G. F. Barker.—"The rapid Corrosion of Iron in Railway Bridges," by W. Kent.—"Molecular Changes in Metals," by Prof. R. H. Thurston.

Proceedings of the Bristol Naturalists' Society. New edition, vol. i. Part 2.—The first thing that strikes one on opening this part of the Bristol Society's *Proceedings* is the number of *errata*, there being a list of about eighty mistakes which have been allowed to slip into this and the previous number; this is very bad. The following are the titles of the papers contained in this part:—"On Fish Remains in the Bristol Old Red Sandstone," by S. Martyn, M.D.; "On *Ceratodus Forsteri*," by W. W. Stoddart, F.G.S.; "On the Physical Theory of Under-currents and of Oceanic Circulation," by W. Lant Carpenter, B.A., B.Sc.; "Bristol Rotifers: their Haunts and Habits," by C. Hudson, LL.D.; "Notes on Trias Dykes," by E. B. Tawney, F.G.S.; "Notes on the Radstock Lias," by E. B. Tawney, F.G.S.; "On the Geological Distribution of some of the Bristol Mosses," by W. W. Stoddart, F.G.S.; "A Contribution to the Theory of the Microscope and of Microscopic Vision. After Dr. E. Abbe, Professor in Jena," by H. E. Fripp, M.D.; "The Geology of the Bristol Coal-field (Part II.)," by W. W. Stoddart, F.G.S.; "The Land and Fresh-water Mollusca of the Bristol District," by A. Leipner; "Notes on Bristol Fungi," by C. E. Broome, F.L.S.; "The Rainfall in Bristol during 1874," by G. F. Burder, M.D.

THE numbers of the *Nuovo Giornale Botanico Italiano* for January—July 1875 give evidence of the impulse given to the study of lichens by the recent theory as to their compound and parasitic nature. We have in these numbers two elaborate papers on this subject, based on careful elaborate research, and both well illustrated, but coming to opposite conclusions. A. Borzì adopts the theory of Schwendener and Sachs that the gonidia of lichens have no genetic affinity with the hyphæ, but that the latter are of the nature of ascomycetous fungi parasitic on the former. G. Arcangeli, on the other hand, inclines to the views of Nylander and Tulasne that many algæ belonging to the families Protococcaceæ, Nostocaceæ, and Rivularieæ, are nothing but special forms of the gonidia of lichens; but that the gonidia are true lichen-organs. Prof. Caruel has a short note on the so-called viviparous leaves of *Begonia*, in which he shows that the adventitious buds are in reality metamorphosed hairs. Prof. Beccari has some remarks on the Rafflesiaceæ, supplementary to Dr. Hooker's monograph of the order in De Candolle's "Prodromus." He makes five species of *Rafflesia*—*R. Arnoldii*, *R. Titan*, *R. Patma*, *R. Rochussenii*, and *R. Cumingii*, besides a doubtful one, *R. Horsfieldii*; four of *Hydnora*, viz., *H. africana*, *H. abysinica*, *H. bogociensis*, *H. triceps*; and one *Prosopanche*—*P. Burmeisterii* (*Hydnora americana*). These three numbers contain, in addition, many other useful and important papers.

Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie, July 15.—This number contains an article on the calculation of the arithmetical mean of constant quantities, by Herr Wilczek, and another on the ventilation of the St. Gothard Tunnel.

Bulletin of the Essex Institute, 1874 (Salem, U.S.)—A notable incident in the history of this excellent American Society during 1874, was a visit from the late Rev. C. Kingsley, who delivered a lecture on Westminster Abbey, and in whose honour a reception was afterwards held. The following are the principal scientific papers in the *Bulletin*:—Mr. F. W. Putnam, one of the most active members of the Society, contributes the following:—"Rare Fishes taken in Salem, Beverly, and Marblehead Harbours;" "On Black Fish taken in Salem Harbour;" "Notice of a Skull from shell-bed, in Rock Island;" "On Teeth of a large Shark, probably *Carcharis* (*Prionodon*) *lamia*;" "On the Shell-heaps at Eagle Hill;" "Notice of some important Discoveries of the Hayden Exploring Expedition;" "Remarks on a Collection of living specimens of Fishes and Cray pikes from Mammoth Cave." Other papers are:—"Notes on the Mammals of portions of Kansas, Colorado, Wyoming, and Utah," by J. A. Allen; "On the Fertilisation of Flowers," by E. S. Morse; "Notes on examination of four species of Chitons," by W. H. Dall; "On the Change of Colour in Leaves in Autumn," by E. C. Bolles; "On the Theory of Evolution," by E. S. Morse; "Lists of Birds observed from Sacramento to Salt Lake City," by R. Ridgway.

THE *Gazzetta Chimica Italiana*, fasc. v., contains the following papers:—On the oxidation of sulphur, by E. Pollacci. The author describes some interesting experiments he made with flowers of sulphur which he oxidised into sulphuric acid in a number of different ways.—Researches on the products of the action of urea upon asparagine and on aspartic acid, by J. Guareschi.—Preliminary note upon parabanic and oxaluric acids, by the same.—On the vegetation of *Oxalis acetosella*, *Rumex acetosa*, and *acetosella* in a soil which contains no potash, by M. Mercadante.—Account of experiments made with artificial soils and of the anomalies observed in the plants obtained.—On some properties of ferric orthophosphate, by F. Sestini.—Extract of some memoirs read at the Academy of Sciences at Bologna on researches on the poisonous alkaloids, by F. Selmi. These were on some new distinguishing properties and some newly discovered reactions.—There is the usual number of extracts from other journals.

Kongl. Vetenskaps Akademiens Fördhandlingar (Stockholm), Feb. 10.—This part contains the following papers:—On the introduction of elliptic functions into astronomical problems, by H. Gylden.—Hepaticæ Pyranaicæ circa Luchon crescentes, by J. E. Zetterstedt.—Researches on the chemical composition of magnetic iron ore, by G. Lindström.—On the Oniscoideæ of North America, by A. Stuxberg.—On some new Lithiobiæ of the same country, by the same.—On a Lithobius borealis Meinert, found in Sweden, by the same.—Researches on the Syrphus butterfly in its three states of development, by F. Trybom (with plate).—On the Arachnidæ of Gotland and Öland, by G. F. Neuman.—On old ore deposits and their present uses, by O. Gumaelius.